A Model of Patent Trolls

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Abstract

This paper develops a model of patent trolls to understand various litigation strategies employed by nonpracticing entities. The main ingredient of the model is an information externality generated by an earlier litigation outcome for subsequent litigation outcomes. We show that when an NPE faces multiple potential infringers who use related technologies, it can gain a credible threat to litigate even when it has no such credibility vis-a-vis any single potential infringer in isolation. The option value created by successful litigation for the NPE against subsequent defendants through Bayesian updating renders a credible litigation threat against the initial defendant. We discuss policy implications including the adoption of the British system of "loser-pays" fee shifting.

Keywords: patent portfolios, patent litigation, non-practicing entities, patent troll

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1 Introduction

The patent system is designed to protect and promote innovation by granting innovators exclusive rights to commercially exploit their inventions for a limited period of time. However, patent law does not require that only the inventor enforce the patent. Patents can be transferred to other parties and be enforced by whoever owns them (Lemley and Melamed 2013). Recently, the emergence of non-practicing entities (NPEs) as a major driver of patent litigation has spawned a heated debate on their role in the overall patent system and their impacts on innovation. NPEs, also derisively called "patent trolls," are a new organizational form whose sole purpose is to use patents primarily to obtain license fees rather than to support the development of technology.\(^1\) They amass patents not for the purpose of commercializing a new product, but to litigate and demand licensing fees.

The proponents of NPEs emphasize potential positive roles of NPEs. They argue that NPEs help small independent inventors monetize their intellectual property (IP) rights against potential misappropriation by established companies, thereby inducing more innovation by small inventors. In contrast, the opponents are concerned that NPEs simply raise the costs of innovation and can drag the innovation process. Due to their business models, they seek patents to pursue "freedom to litigate" rather than "freedom to operate." The value of a patent thus can be based on the “exclusion value” rather than the “intrinsic value” when it is held by NPEs (Chien 2010). More importantly, the recent surge in the number of lawsuits initiated by patent trolls became a cause for concern for businesses and policy-makers alike.\(^2\) One recent statistic shows that patent trolls are responsible for 67 percent of all patent lawsuits (Morton and Shapiro 2014). Bessen, Ford, and Meurer (2011) estimate that trolls cost the economy $500 billion over the last twenty years, mostly in the IT industry.

This paper develops a model of patent trolls to understand various litigation strategies employed by nonpracticing entities. The main ingredient of the model is information externality generated by an earlier litigation outcome for subsequent litigation outcomes.

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\(^1\)NPEs are also called patent asserting entities (PAEs).

\(^2\)Even President Obama expressed his concern about the harmful effects of patent trolls in his speech. See Reuters, "Obama Says Patent Reform Needs to Go Farther," February 14, 2013.
We show that when an NPE faces multiple potential infringers who use related technologies, it can gain credible threat to litigate even when it has no such credibility vis-a-vis any single potential infringer in isolation. The option value created by successful litigation for the NPE against subsequent defendants through Bayesian updating renders a credible litigation threat against the initial defendant.

Lemley and Melamed (2013) point out that patent trolls do not employ a unitary business model and there are at least three different troll business models. They are "lottery-ticket" trolls that aim big established firms with an uncertain shot at a big payout, "bottom-feeder" trolls that rely on the high cost of patent litigation, and "patent aggregators."

Our paper formalizes how the exclusion value is created by the credible threat to litigate and explores its implications for NPEs' litigation strategies. For instance, consider bottom-feeder trolls who search for "quick, low-value settlements for a variety of patents." The logic is that the defendants prefer to settle for small amounts of money rather than pay the high cost of patent litigation that could easily run into millions. However, high litigation costs cut for both ways and the logic begs the question of why defendants would consider the litigation threat by bottom feeders seriously. Given the considerable litigation costs compared to meager payout, why don't they ignore the threat and consider it credible? We do not rely on reputation story, but rather provide a theory of litigation credibility based on information externalities. We show that an NPE may have a patent portfolio that is not strong enough to make its litigation threat credible in isolation, but in the presence of multiple defendants the litigation threat becomes credible due to its option value for other future defendants. As pointed out by Lemley and Melamed (2013), "the universe of technology users against which a troll might assert patents is ... potentially much larger than the group of competitors against which a practicing entity is likely to assert its patents."

To understand the role of information externalities in patent litigation, consider the following simple numerical example. First, consider a situation in which an NPE faces only one PE that uses its patented technology. Let the PE’s profit be 20 and if the NPE is successful against the PE in its litigation, it can extract half of the PE’s profit via Nash bargaining with the threat of injunction. The probability that the PE’s patent is valid and infringed by the PE is given by 1/4, and the legal costs for each party is 4. Then the expected payoff from litigation for the NPE is given by \((1/4) \times 10 - 4 = -1.5 < 0\), and the

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3Lemley and Melamed (2013).
NPE’s litigation threat is not credible. Now suppose that there are two PEs with the same profit level of 20. For simplicity, these two PEs are not competing each other, but assumed to use the same technology. This implies that the infringement by the two PEs is perfectly correlated.\textsuperscript{4} In this case, litigation against one PE reveals perfect information about the infringement by the other PE. Thus, if the NPE wins against one PE, it has a credible threat to litigate against the remaining PE and can extract 10 for sure. This implies that the NPE’s threat against the first PE is credible because $\left(\frac{1}{4}\right) \times (10 + 10) - 4 = 1 > 0$. The NPE and the targeted PE will settle out of court to save litigation costs. With Nash bargaining, the NPE will be able to receive a licensing fee of 5 from the targeted PE due to the presence of another PE that offers an additional option value for the initial litigation.

We thus show how the presence of other potential infringers enhances the credibility of the patent holder’s litigation threats and enables him to "double dip." However, note that the NPE no longer has any credible threat against the remaining PE once it extracts the licensing fee from the first PE. This simple example also suggests that the NPE may have higher incentives to acquire patent portfolios for the purpose of litigation vis-a-vis PEs. Suppose that the target firm is randomly selected because the two firms are symmetric. Then, each firm’s expected licensing cost is 2.5. As a result, each PE will have incentives to bid up to 2.5 if the patent is up for sale whereas the NPE has incentives to bid up to 5. Acquiring the patent in this example is like providing a public good between the PEs because if one PE acquires the patent, the other PE benefits as much because the acquiring PE will not have any credible threat against the other PE. This type of provision of public good problem can also explain the emergence of defensive aggregators.

Hovenkamp (2013) is related to our paper in that he considers the NPE’s incentives to litigate and the credibility of litigation threat. However, the mechanism by which the NPE gains credibility with weak patents is very different. He develops a dynamic model of predatory litigation that relies on the NPE’s litigious reputation and behavioral type of "impressionable" PEs which are easily intimidated by the NPE’s predatory litigation behavior. In contrast, we do not assume any asymmetric information about firms’ types and our main results are driven by informational externalities across litigation suits. Lemus and Temnyalov (2014) analyze the role of patent asserting entities (PAEs) on litigation and

\textsuperscript{4}According to the legal principle of "res judicata," a matter that has been judged on the merits may not, generally, be relitigated.
innovation incentives. To address this issue, they consider a model in which PAE is allowed to acquire patents from practicing entities, and compare the equilibrium in such a set-up to a situation in the absence of the PAE. They identify two effects created by the PAE that are immune to counter-litigation: enhanced patent monetization effect and loss of the value of defensive patent portfolios. They show that when the former effect dominates the latter, PAEs can enhance innovation incentives and social welfare. The main focus of their paper, however, is different from ours and can be complementary to ours in understanding the tactics and roles of NPEs/PAEs in the overall patent system. They are concerned with the price of patent acquisition by the PAE and how this in turn changes the returns to R&D. We are more interested in the litigation strategies of NPEs and focus on litigation externalities, which are absent in their model.

Choi (1998) considers the implications of information externality in patent litigation, but in a different context. He considers a setting in which a patent holder is the incumbent facing multiple potential entrants. Launching a patent suit in face entry can be a risky proposition for the incumbent because of potentially harmful information that would invite further entry if its patent is invalidated. He explores the implications of such information revelation on entry dynamics and show that the nature of the entry game can be one of either waiting or preemption depending on the strength of the patent. However, the nature of information revelation in Choi (1998) is different from ours because the patent holder is a practicing entity and the issue is entry dynamics rather than extraction of rents by NPEs.

Che and Yi (1993) and Daughety and Reinganum (1999) are also closely related to our paper in that they consider strategic implications of information that comes out of the initial litigation for the subsequent litigation and settlement outcomes. Che and Yi (1993) consider a situation in which a single defendant faces multiple plaintiffs and once a precedent is set, it can have a lasting effect on successive trial outcomes. Daughety and Reinganum (1999) consider an incomplete information model in which an initially uninformed plaintiff makes a menu of settlement demands of the informed defendant who faces other potential plaintiffs. They consider implications of information revelation to outsiders from the existing negotiation, and analyze incentives that one of both participants may have to limit the transmission of that information. They show that the possibility that there are other plaintiffs the defendant might face improves the current plaintiff’s
bargaining position as the outcome of the current case may invite further follow-on suits. As a result, the defendant may be willing to pay "hush money" to keep the negotiation outcome confidential. In our model, we consider a symmetric information structure and the fact that the patent holder has many defendants enhances the bargaining position. Our work thus differs from theirs both in important features of the model and in the questions analyzed.

The remainder of the paper is organized in the following way. In Section 2, we set up a simple model of patent litigation with information externality. To illustrate the main idea, we consider one NPE that can assert its patent portfolio against multiple NPEs in a pre-determined order, and analyze the implications of multiple PEs on the credibility of litigation threat. In section 3, we endogenize the NPE’s target choice and derive optimal sequence of litigation targets. We show that the choice of the first target is mainly driven by the nature of informational externality. Section 4 analyzes when extends our analysis to an environment in which multiple infringers compete with each other. Section 5 explores policy implications of the British cost shifting rule under which the loser pays all legal expenses. Section 6 extends the basic model in several directions and checks the robustness of the main results in the basic model. Section 7 closes the paper with concluding remarks. The proofs for lemmas and propositions are relegated to the Appendix.

2 Benchmark Model

Model Set-up. We consider a situation in which one NPE or patent troll intends to assert its patent portfolio against multiple PEs. The NPE has a patent portfolio of size $S$, which translates into an infringement probability of $\theta \in [0, 1]$ for any PE. This infringement parameter can be interpreted as the strength of the NPE’s patent portfolio. For simplicity, let us assume that there are two PEs, firm 1 and firm 2, and the NPE is negotiating sequentially with each of them. To illustrate the nature of informational externality across litigation cases, we first assume that the sequence is pre-determined in the benchmark model.

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5Suppose that the probability that the PE’s product infringes a particular patent is $q$ and this probability is the same and independent of each other across patents. Then, the probability that the PE’s product will infringe at least one patent is given by $\theta = 1 - (1 - q)^S$, where $S$ is the number of patents held by the NPE. More generally, the probability of infringing will depend not only on the NPE’s patent portfolio size, but also on the patent quality.
This would be the case if PEs are entering the market sequentially over time. However, in the next section, we consider a scenario in which both PEs are already in the market and the NPE can endogenously choose which PE to approach first when the PEs are asymmetric. The PEs are not competing with each other, but they use related technologies. This means that the litigation outcome for one firm does not affect the other firm’s profitability through competitive effects. Nonetheless, the litigation outcome for one PE may have implications for the likelihood of the other PE’s infringement on the NPE’s patent portfolio when they use related technologies. Recently, for instance, many industries have evolved by integrating technologies from a variety of different scientific disciplines. The interdisciplinary approach and convergence of technologies have made it commonplace for the same type of related technologies to be adopted in the previously separate industries, blurring the boundaries of traditional industries and creating new ones. Consider the convergence of broadcasting and telephone industries. Traditionally, they represented very different forms of communications in many dimensions, including the mode of transmission and the nature of communication. As a result, they were considered separate industries. Digital convergence now enables both person-to-person communication services and broadcast content with similar technologies. We represent this technological overlap between the two firms with a parameter $\rho \in [0, 1]$.

More specifically, there are four possible litigation outcomes if there are patent suits against both PEs: $(I, I), (I, NI), (NI, I)$, and $(NI, NI)$, where $I$ and $NI$ respectively denote infringement and no infringement. The probabilities of each event are given by:

\[
\begin{align*}
\Pr(I, I) &= \theta^2 + \rho \theta (1 - \theta) \\
\Pr(I, NI) &= \Pr(NI, I) = (1 - \rho) \theta (1 - \theta) \\
\Pr(NI, NI) &= (1 - \theta)^2 + \rho \theta (1 - \theta)
\end{align*}
\]

We can interpret $\rho$ as a correlation coefficient in litigation outcomes across the PEs. If $\rho = 1$, there is perfect correlation between the litigation outcomes. At the other extreme, if $\rho = 0$, the litigation outcomes are independent. As a result, the litigation outcome for one party does not reveal any information about the likelihood of the litigation outcome for another party. More generally, the updated beliefs about one firm’s infringement probability given

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6 The order would be inconsequential if the two PEs are symmetric.
7 We consider the case with competition in the next section.
the litigation outcome for another firm is given by

\[
\Pr(I|I \text{ for the other firm}) = \frac{\Pr(I,I)}{\Pr(I)} = \theta + \rho(1-\theta) \equiv \bar{\theta}
\]

\[
\Pr(I|NI \text{ for the other firm}) = \frac{\Pr(I,NI)}{\Pr(NI)} = (1-\rho)\theta \equiv \tilde{\theta}
\]

Figure 1 below shows how the infringement probability can be updated depending on the outcome of litigation for the other party. The gap between the two lines, \(\bar{\theta} - \tilde{\theta}\), represent the updating in beliefs depending on the outcome of litigation, and is given by \(\rho\). As expected, a higher \(\rho\) leads to more information revelation from litigation on the infringing probability of other firms.

![Figure 1: Updating of infringement probability](image)

**Litigation with unrelated technologies.** Now let us analyze the NPE’s incentives to litigate against the PEs. Each firm’s operating profit without litigation is given by \(\pi_i\), where \(i = 1, 2\) and \(\pi_1 \leq \pi_2\). Litigation incurs a cost of \(L > 0\) for each involved party. In isolation or with unrelated technologies, the NPE has a credible incentive to litigate against firm \(i\) if and only if

\[
\theta \frac{\pi_i}{2} \geq L.
\]  

(1-i)

The NPE wins the infringement case against firm \(i\) with probability \(\theta\). In this case, the NPE and firm \(i\) Nash bargain with equal bargaining power and the NPE receives half of the profits of firm 2. If the PE wins, it retains its entire market profit as it is not infringing on the NPE’s patent portfolio.
Equilibrium analysis with related technologies. Now assume that the technologies of the PEs are related. The NPE first negotiates with firm 1 and then with firm 2 in the predetermined order. We consider the case with reversed roles and the optimal choice of litigation targets in the next section. The NPE’s interaction with firm 1 can end up in three scenarios: They litigate and the NPE wins in court, they litigate and the PE wins, and finally, they do not litigate. Hence, the belief that firm 2 infringes based on the outcome of the NPE’s interaction with firm 1 is given by \( \hat{\theta} \in \{ \theta, \bar{\theta}, \underline{\theta} \} \). The NPE will have a credible threat to litigate against firm 2 if and only if

\[
\hat{\theta} \frac{\pi_2}{2} \geq L
\]  

and the value of the NPE’s patent portfolio with respect to firm 2 is given by

\[
V_2(\hat{\theta}) = \begin{cases} 
\hat{\theta} \frac{\pi_2}{2} & \text{if } L \leq \hat{\theta} \frac{\pi_2}{2}, \\
0 & \text{otherwise.}
\end{cases}
\]

In equilibrium, the NPE and firm 2 never litigate and the extent to which the NPE can extract rents from the PE depends on the threat of litigation, that is, the belief that firm 2 infringes.

Now consider the litigation incentives between the NPE and firm 1. To do so, let \( \Psi_2 \) define the information externality of litigating the first firm in terms of expected profits with the second firm. In the case of winning litigation with the first firm, the probability of infringement of the second firm goes up. On the other hand, upon losing litigation, the probability of the second firm infringing decreases relative to the case where the firms settle. Hence, we get

\[
\Psi_2 = \theta V_2(\bar{\theta}) + (1 - \theta) V_2(\underline{\theta}) - V_2(\theta).
\]

It follows that the NPE has a credible incentive to litigate the first firm if

\[
\theta \frac{\pi_1}{2} - L + \Psi_2 \geq 0.
\]  

If negotiations with the first firm fail, the NPE litigates if the sum of litigation profits with firm 1 and the information externality with firm 2 is positive. The next lemma determines the sign of the information externality.
Lemma 1 If $\frac{\theta_2}{2} < L < \frac{\theta_2}{2}$, the information externality $\Psi_2$ is negative. If $\frac{\theta_2}{2} < L < \overline{\theta_2}/2$, then the information externality $\Psi_2$ is positive. Otherwise, $\Psi_2 = 0$.

Proof:

$$
\Psi_2 = \theta \left\{ \begin{array}{ll}
\overline{\theta_2}/2 & \text{if } L \leq \overline{\theta_2}/2, \\
0 & \text{otherwise}
\end{array} \right\} + (1 - \theta) \left\{ \begin{array}{ll}
\theta_2/2 & \text{if } L \leq \theta_2/2, \\
0 & \text{otherwise}
\end{array} \right\}
- \left\{ \begin{array}{ll}
\theta_2/2 & \text{if } L \leq \theta_2/2, \\
0 & \text{otherwise}
\end{array} \right\} = -(1 - \overline{\theta}) \theta \overline{\theta_2}/2 \text{ if } \overline{\theta_2}/2 < L \leq \theta_2/2, \\
\overline{\theta} \theta_2/2 & \text{if } \theta_2/2 < L \leq \overline{\theta_2}/2, \\
0 & \text{otherwise}.
\right\}
$$

The information externality can be negative or positive as a function of the size of product market profits relative to the cost of litigation. If the profits of the second firm are high relative to the litigation cost, the externality can be negative. If the NPE settles with the first firm, no information is revealed to the second firm and the NPE still has a credible incentive to litigate and extract rents from that firm. By contrast, if the NPE litigates and loses, the expected probability of infringement of the second firm decreases and makes the threat of litigation against firm 2 non-credible. Hence, the presence of the second firm exerts a negative information externality on the NPE as an unsuccessful litigation against firm 1 would eliminate future licensing revenues with firm 2.

If the profits of the second firm are small relative to the litigation cost, the externality can be positive. In the absence of litigation against the first firm, the NPE would not have a credible threat to sue the second firm. However, a positive litigation outcome could increase the perceived probability of infringement such that litigating the second firm would become credible. In this case, the presence of firm 2 has a positive externality on the NPE as a successful litigation could also raise licensing revenues with the other firm.

If condition (2) holds, the NPE has a credible threat to litigate the first firm. Firm 1 and the NPE will settle rather than going to court if their joint profits of settlement exceed
their joint profits from litigation, that is, if

$$\pi_1 + V_2(\theta) \geq \pi_1 - 2L + \theta V_2(\theta) + (1 - \theta)V_2(\theta)$$

or

$$\Psi_2 \leq 2L. \quad (3)$$

The NPE settles with firm 1 if the information externality from litigation does not exceed the total cost of litigation. This holds a priori when the externality is negative or zero. It also holds for a positive externality and \(L \geq \pi_2/2\). The most the NPE can extract with a successful litigation against firm 1, that is, the maximum value of \(\Psi_2\) is \(\theta \pi_2/2\). However, a positive externality requires \(L \geq \pi_2/2\) which means that (3) is always satisfied. Thus, in our model with symmetric information, litigation never takes place. Upon settlement, firms Nash bargain and the NPE receives a total profit of

$$\pi^{NPE} = \frac{1}{2}(\theta \pi_1 + \Psi_2) + V_2(\theta)$$

We can thus characterize the outcome of the benchmark model as follows.

**Proposition 1**  Consider the equilibrium of the benchmark model with exogenously ordered sequential litigation.

(i) The NPE and the first PE never litigate.

(ii) When the information externality is negative, there exist parameter values such that the NPE has no credible litigation threat with respect to the first firm although litigation would be credible if it would deal with this firm in isolation.

(iii) When the information externality is positive, there exist parameter values such that the NPE has a credible threat to litigate against firm 1 although it would not be credible to sue that firm in isolation.

(iv) Compared to the case with unrelated technologies, the NPE may be able to extract higher (lower) total licensing fees when the information externality is positive (negative).

**Proof:** (ii) If \(\theta \pi_2/2 < L \leq \theta \pi_2/2\), then (2) holds if

$$L \leq \frac{\theta}{2}(\pi_1 - (1 - \theta)\pi_2).$$
The RHS is increasing in $\rho$ and takes value $\theta\pi_1/2 \leq \theta\pi_2/2$ at $\rho = 1$. Point (ii) follows.

(iii) If $\theta\pi_2/2 < L \leq \bar{\theta}\pi_2/2$, then (2) holds if

$$L \leq \frac{\theta}{2}(\pi_1 + \bar{\theta}\pi_2).$$

The RHS is increasing in $\rho$ and takes value $\theta(\pi_1 + \pi_2)/2 > \theta\pi_1/2$ at $\rho = 1$. The point follows. 

In equilibrium the NPE never sues the first firm for infringement and no information is revealed in the process. The NPE then interacts with the second firm like in isolation. The informational externality affects the NPE through its effect on the credibility of litigation incentives. In addition, the presence of the informational externality can also change licensing fees via the threat point in negotiations with firm 1.

The presence of informational externalities can explain different types of troll business models. For instance, consider a case where the NPE would have an incentive to litigate against firm 1 in isolation, that is, $L \leq \pi_1/2$. However, due to the fact that the NPE might lose licensing revenues with firm 2 if it loses litigation with firm 1, the NPE will not enforce its property rights with the first firm and wait for the other, more lucrative target. This equilibrium outcome can explain the behavior of “lottery ticket” patent trolls that aim at and wait for opportunities for a big payout rather than pursuing every licensing opportunity in the presence of a negative informational externality. In contrast, the "bottom feeder" business model of patent trolls can be explained by the presence of a positive informational externality. Consider a case where $L > \pi_i/2$, $i = 1, 2$. In this case, both PEs’ profits are too low relative to the litigation cost to make litigation profitable for the NPE when dealing with them in isolation. However, the possibility of a positive information externality from a successful litigation outcome increases the threat of litigation against firm 1 and allows the NPE to extract some rents in negotiations. Despite the relatively high cost of litigation, information externalities allow the NPE to create a litigation threat and make some profit.

Figure 2 below shows a diagram in the $(L, \rho)$ space that illustrates the credibility of the litigation threat against firm 1 for the symmetric case of $\pi_1 = \pi_2 = \pi$. The grey shaded area depicts all parameter values for which litigation is credible. Area A in the graph refers to point (ii) of the Proposition. As $L \leq \pi/2$, the NPE would have an incentive to litigate against firm 1 in isolation. Nonetheless, it will not enforce its property rights with the first
firm due to the possibility of a negative informational externality in dealing with the other PE. Area B refers to point (iii) of the Proposition. As $L > \pi/2$, both PEs’ profits are too low relative to the litigation cost to make litigation profitable for the NPE when dealing with them in isolation. However, the presence of a positive informational externality allows the NPE to retain litigation credibility and extracts licensing revenues from firm 1.

How does the information externality affect total licensing revenues of the NPE relative to a situation with unrelated technologies? In regions A and C the NPE is worse off whereas in B profits are higher. In region A, due to the negative information externality, the NPE is only able to extract rents from firm 2 whereas it would be able to extract rents from both firms in isolation. In region C, the NPE is able to sell a license to firm 1 but negotiated license fees are lower due to the lower threat point of litigation. Finally, in region B, the NPE would not receive any license income with uncorrelated technologies. However, due to the positive information externality, litigation becomes credible and the NPE can extract rents from firm 1.

Figure 2: Credible litigation threat with information externality

3 Strategic Litigation Target Choice

So far we have assumed that the PEs arrive in a predetermined order. Suppose now that the PEs are both operating in their respective market and the NPE could choose which
firm to target first. Since the order of litigation targets is endogenously determined by the NPE, we now assume that $\pi_1 < \pi_2$ without any loss of generality.

Let $\pi_{ij}^{NPE}$ denote the NPE’s payoff from approaching the PEs in the order of firm $i$ first and firm $j$, where $j \neq i$. Then it can easily be seen that

$$\pi_{ij}^{NPE} = \frac{1}{2} (\theta \pi_i + \Psi_j) I_{[L - \frac{\theta}{2} \pi_i, \infty)}(\Psi_j) + V_j(\theta)$$  \hspace{1cm} (4)$$

where $I$ is an indicator function. Obviously, the NPE will approach PE1 first if and only if $\pi_{12}^{NPE} \geq \pi_{21}^{NPE}$. From the expression in Eq. (4), we immediately have the following result.

**Lemma 2** If $\Psi_1 = \Psi_2 = 0$, the order of target firms is irrelevant. In other words, in the absence of an informational externality, the sequence of approaching target firms does not matter.

**Proof.** If $\Psi_i = 0$, we have $\frac{1}{2} (\theta \pi_i + \Psi_j) I_{[L - \frac{\theta}{2} \pi_i, \infty)}(\Psi_j) = V_i(\theta)$. Thus, when $\Psi_1 = \Psi_2 = 0$, we have $\pi_{12}^{NPE} = \pi_{21}^{NPE} = V_1(\theta) + V_2(\theta)$. ■

In the presence of an informational externality, that is, when at least one of $\Psi_i$, $i = 1, 2$, is non-zero, the optimal target choice depends on the sign and the relative magnitudes of the informational externality. To present our analysis succinctly, let us define the sign function:

$$\text{sgn}(x) = \begin{cases} 
-1 & \text{if } x < 0 \\
0 & \text{if } x = 0 \\
1 & \text{if } x > 0 
\end{cases}$$

Then, the optimal target choice can be summarized as in the following Proposition.

**Proposition 2** The optimal target choice sequence for the NPE depends on the signs and magnitudes of $\Psi_1$ and $\Psi_2$.

(i) If $\text{sgn}(\Psi_1) \neq \text{sgn}(\Psi_2)$, the NPE chooses its target in a way to maximize the positive information externality (or minimize the negative information externality), that is, the first target is firm $i$ if and only if $\text{sgn}(\Psi_i) < \text{sgn}(\Psi_j)$, where $j \neq i$.

(ii) If $\text{sgn}(\Psi_1) = \text{sgn}(\Psi_2) = 1$ or $-1$, the NPE chooses firm 2 (the more profitable firm) as its first target.

**Proof.** See the Appendix. ■
The intuition for Proposition 2 can be explained in the following way. We defined $\Psi_i$ as the informational externality for firm $i$ when litigation takes place against firm $j$. The NPE will choose its first target to maximize the positive informational externality (or minimize the negative informational externality) because the NPE partially internalizes the externality through the Nash bargaining procedure with the first target (if the litigation is credible). For instance, if $\Psi_1 = 0$ and $\Psi_2 > 0$, targeting firm 1 first is the optimal policy because it can create a positive information externality of $\Psi_2$ when litigation takes place, whereas targeting firm 2 first will not generate such an externality. Similarly, if $\Psi_1 < 0$ and $\Psi_2 = 0$, targeting firm 1 has no informational externality whereas targeting firm 2 first generates a negative informational externality for firm 1. Therefore, once again, targeting firm 1 is the optimal policy. As shown in the Appendix, a third possibility that can arise with different signs for $\Psi_1$ and $\Psi_2$ is $\Psi_1 > 0$ and $\Psi_2 < 0$. In this case, targeting firm 2 first is optimal. These results yield statement (i) of the Proposition.

The possibility of both $\Psi_1$ and $\Psi_2$ having the same sign (positive or negative) arises either when the NPE has ex ante credible litigation threats against both firms, or when the NPE has ex ante credible threats against neither firm. In the former case, we have $\Psi_2 < \Psi_1 < 0$ and in the latter case, we have $\Psi_2 > \Psi_1 > 0$ with the assumption of $\pi_1 < \pi_2$. In both cases, the NPE approaches the more profitable firm (PE2) but for different reasons. When the NPE has credible threats ex ante, it is concerned with the loss of litigation credibility for the second target when litigation takes place with the first target. This loss is greater if the more profitable firm is the second target. Thus, to minimize the extent of negative information externality, the NPE targets the more profitable firm (PE2). When the NPE has no credible threats against both firms ex ante, note that the NPE does not have any credible threats against the second target once it settles with the first target. Thus, the only source of revenue is with the first target, the credibility against which is achieved with the presence of another firm. Even though the magnitude of the informational externality is larger when the less profitable firm is the first target, the direct effect of extracting licensing income from the more profitable firm outweighs the indirect effect of the positive informational externality from targeting the less profitable firm.

The filled gray shaded area in Figure 3 gives all parameter values for which targeting

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$^8$With the assumption of $\pi_1 < \pi_2$, it can easily be shown that the following three cases do not arise: (i) $\Psi_1 = 0$ and $\Psi_2 < 0$, (ii) $\Psi_1 < 0$ and $\Psi_2 > 0$, and (iii) $\Psi_1 > 0$ and $\Psi_2 = 0$. 

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the more profitable firm 2 first strictly dominates. Targeting the less profitable PE 1 first tends to yield higher profits if technologies’ correlation is intermediate and the litigation cost rather high.

Figure 3: Strategic Targeting of PEs

4 Litigation and Licensing with Downstream Competition

Suppose that the two PEs are competitors in the product market. Let $\pi^d$ denote the duopoly profits each PE is making when they both either own a license for the NPE’s technology or are not found infringing or are not challenged by the NPE. If exactly one firm gets a license or exactly one firm is not infringing, then this firm earns monopoly profits $\pi^m > 2\pi^d$. Negotiations are again sequential; the NPE first bargains with firm 1 and then with firm 2.

Consider the bargaining with the second firm. Suppose firm 1 is active in the product market, either because it bought a license or it did not infringe on the patent. The updated belief that firm 2 is infringing is $\hat{\theta}$, and the NPE gets

$$V^d(\hat{\theta}) = \begin{cases} \hat{\theta}\pi^d/2 & \text{if } L \leq \hat{\theta}\pi^d/2, \\ 0 & \text{otherwise} \end{cases}$$
If the first firm was found infringing and did not obtain a license, the NPE gets

\[
V^m(\hat{\theta}) = \begin{cases} 
\hat{\theta} \pi^m / 2 & \text{if } L \leq \hat{\theta} \pi^m / 2, \\
0 & \text{otherwise}.
\end{cases}
\]

Now consider negotiations with the first firm. Suppose the NPE decides to litigate for infringement and wins the court case. In this case the NPE can either license the technology or exclude firm 1 from the market. Licensing will occur if the joint profits of the NPE and firm 1 exceed the profits the NPE can make when excluding the PE, that is,

\[
\pi^d + V^d(\hat{\theta}) \geq V^m(\hat{\theta}).
\] (5)

This condition is satisfied if \( \hat{\theta} \) is sufficiently small and the duopoly profits are relatively high.

Lemma 3 Suppose the first firm has been found infringing on the NPE’s patent. If product market competition is weak and the updated probability of infringement of the second firm is low, the NPE sells a license to the first firm. Otherwise, the NPE excludes the first firm and negotiates a license fee with the second firm only.

Proof: Consider \( L \leq \hat{\theta} \pi^d / 2 \). Condition (5) holds if and only if

\[
\pi^d \geq \frac{\bar{\theta} \pi^m}{2 + \bar{\theta} \pi^m}.
\]

Let \( \Gamma_1 \) be the set of all parameter values \((L, \pi^d)\) that satisfy these two conditions. Consider \( \hat{\theta} \pi^d / 2 < L \leq \hat{\theta} \pi^m / 2 \). Condition (5) holds if and only if

\[
\pi^d \geq \frac{\hat{\theta} \pi^m}{2 \pi^m}.
\]

Let \( \Gamma_2 \) be the set of all parameter values \((L, \pi^d)\) that satisfy the conditions for licensing.

When licensing dominates exclusion, the NPE and firm 1 Nash bargain over the split of
their joint profits. Hence, the NPE’s profits from a successful litigation outcome is

$$\tilde{V}(\theta) = \frac{\pi^d}{2} + \begin{cases} 
\hat{\theta}(\pi^d + \pi^m)/4 & \text{if } (L, \pi^d) \in \Gamma_1, \\
\hat{\theta}(\pi^m)/4 & \text{if } (L, \pi^d) \in \Gamma_2, \\
\hat{\theta}(\pi^m - \pi^d)/2 & \text{otherwise}. 
\end{cases}$$

Thus, the NPE’s individual threat of litigation against firm 1 is credible if

$$\theta \tilde{V}(\theta) + (1 - \theta)V^d(\theta) - L \geq V^d(\theta). \quad (6)$$

Similarly, litigation arises in equilibrium if the joint profits from licensing for NPE and firm 1 are less than the profits from litigation, that is

$$V^d(\theta) \leq (1 - \theta)V^d(\theta) - 2L + \theta \begin{cases} 
V^d(\theta) & \text{if } (L, \pi^d) \in \Gamma_1, \\
0 & \text{if } (L, \pi^d) \in \Gamma_2, \\
\hat{\theta} \pi^m/2 - \pi^d & \text{otherwise}. 
\end{cases} \quad (7)$$

To isolate the effect of product market competition on licensing, let us first consider the case with unrelated technologies, that is, without informational externality.

**Proposition 3** Suppose firm 1 and 2 are product market competitors using unrelated technologies.

(i) If product market competition is strong and the litigation cost sufficiently low, the NPE litigates against the first PE and, if successful, sells a license to the second firm.

(ii) There exist parameter values such that the NPE has a credible litigation threat with respect to the first firm although litigation would not be credible if it would face two firms with profits $\pi^d$ operating in different product markets.

**Proof:** With unrelated technologies ($\rho = 0$) we have $\theta = \underline{\theta} = \bar{\theta}$. Consider condition (7). Upon inspection, if $(L, \pi^d) \in \Gamma_1$ or if $(L, \pi^d) \in \Gamma_2$, the condition cannot be satisfied. In the third case successful litigation leads to exclusion of firm 1. If, additionally, $L \leq \theta \pi^d/2$, the litigation condition holds if

$$L \leq \frac{\theta}{4}(\theta \pi^m - (2 + \theta)\pi^d).$$

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In contrast, if $\theta \pi^d / 2 < L \leq \theta \pi^m / 2$, condition (7) is satisfied if

$$L \leq \frac{\theta}{4}(\theta \pi^m - 2\pi^d).$$

This gives point (i). The credibility constraint (6) can be rewritten as

$$\frac{\theta \pi^d}{2} - L + \theta \begin{cases} 
\theta(\pi^m - \pi^d)/4 & \text{if } (L, \pi^d) \in \Gamma_1, \\
\theta(\pi^m)/4 & \text{if } (L, \pi^d) \in \Gamma_2, \\
(\theta \pi^m - (1 + \theta)\pi^d)/2 & \text{if } (L, \pi^d) \notin (\Gamma_1 \cup \Gamma_2) \text{ and } L \leq \theta \pi^d/2, \\
(\theta \pi^m - \pi^d)/2 & \text{otherwise}
\end{cases} \geq 0.$$ 

It is easy to check that the bracketed term is always positive and point (ii) follows. ■

The results of Proposition 3 are summarized in the following figure. In regions A and B the NPE litigates against firm 1. If successful, firm 1 is excluded and the NPE only sells a license to firm 2. If firm 1 is not found infringing, the NPE still has a credible litigation threat with firm 2 in region A but not in B. In regions C and D, the NPE sells licenses to both PEs. In regions E and F, the NPE can extract fees from the first firm but not from the second. In both parameter regimes the NPE is able to make strictly positive profits when it could not extract any rents facing two firms with profits $\pi^d$ operating in different product markets. In these cases, product market competition between the PEs helps the NPE. In region E, the NPE has a credible threat to exclude one of the PE firms if the court finds infringement. In region F, this threat is not credible as the NPE and firm 1 would settle and license if the court finds infringement. However, the NPE is able to use potential exclusion as a threat point in bargaining and extract more rents.

Product market competition exerts a positive effect on the credibility of litigation for the NPE. For $\rho > 0$, this effect interacts with the informational externalities discussed above. An interesting result occurs when the technologies are perfectly related.

**Proposition 4** Suppose firm 1 and 2 are product market competitors. When the technologies are perfectly related, the NPE has a credible litigation threat with the first firm if $L \leq \theta \pi^m / 2$. 

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Figure 4: Exclusion and litigation incentives when PEs are product market competitors

**Proof:** For $\rho = 1$, we have $\bar{\theta} = 0$ and $\tilde{\phi} = 1$. Condition (6) becomes

$$
\frac{\theta \pi^d}{2} - L + \begin{cases} 
\theta (\pi^m - 2\pi^d)/2 & \text{if } L \leq \theta \pi^d/2, \\
\theta (\pi^m - \pi^d)/2 & \text{if } \theta \pi^d/2 < L \leq \theta \pi^m/2.
\end{cases} \geq 0
$$

which always holds.■

5 Cost Shifting and Litigation Incentives of NPEs

In the US the default rule for patent litigation is that each party bears its own attorneys’ fees. In patent cases under 35 U.S.C. §285, attorneys’ fees are only shifted in exceptional cases, which have been very rare. The Congress is currently considering different pieces of legislation that all aim to reduce NPE patent litigation by adopting “loser-pays” fee shifting, also called the British rule of legal fee allocation. The idea is that if NPEs have to face the possibility of paying the target firm’s attorneys’ fees, they would not initiate litigation unless the case has sufficient merit. In this section, we analyze whether the British rule of legal fee allocation reduces the NPE’s incentives to litigate and the profitability of their business model relative to the American rule.

Consider our above model under the British rule. Facing the second firm, the NPE only
pays attorneys’ fees in the case that he loses but then he also has to cover the defendant’s fees. Hence, for a given belief $\hat{\theta}$, the NPE has an incentive to litigate if and only if

$$\frac{\hat{\theta} \pi_2}{2} - (1 - \hat{\theta})2L \geq 0 \quad \text{or} \quad L \leq L(\hat{\theta}) = \frac{\hat{\theta}}{1 - \hat{\theta}} \frac{\Pi_2}{4}. \quad (8)$$

Consider the effect of the fee shifting rule on litigation incentives with respect to the second firm. The NPE has a lower incentive to litigate with the British rule if, and only if, the ex post infringement probability of firm 2 is less than 1/2. Hence, the effect of the cost shifting rule depends on the initial merit of the case $\theta$ and the technological closeness of the target firms in question. For instance, if the NPE wins litigation against firm 1 and technologies are perfectly related, then the NPE is sure to win against the second firm and not to pay any litigation costs. Hence, its litigation threat against the second firm is always credible. Similarly, if the NPE loses the litigation case, it would never litigate against the second firm if the technologies are perfectly correlated. More generally, we can compare litigation incentives against the second firm under the British and American rule as follows.

**Lemma 4** Assume $\theta \leq 1/2$. If the NPE loses the first litigation or does not litigate, then the threat of litigation against the second firm is lower under the British rule. If the NPE wins and the technologies are sufficiently close, the threat of litigation is higher under the British rule.

If the NPE has a credible threat, Nash bargaining ensues and the value of the NPE’s patent portfolio with respect to firm 2 is given by

$$V^B(\hat{\theta}) = \begin{cases} \frac{\hat{\theta} \pi_2}{2} + 2L(\hat{\theta} - 1/2) & \text{if } L \leq L(\hat{\theta}), \\ 0 & \text{otherwise.} \end{cases}$$

Let us analyze the decision to litigate against the first firm. The NPE initiates infringement litigation if

$$\frac{\hat{\theta} \pi_2}{2} - (1 - \hat{\theta})2L + \Psi^B \geq 0 \quad (9)$$

where the information externality is defined as

$$\Psi^B = \theta V^B(\bar{\theta}) + (1 - \theta)V^B(\bar{\theta}) - V^B(\theta).$$
Proposition 5 If $\rho \geq 1/2$ and technologies are closely related, then the NPE has weakly more credibility to litigate and weakly higher profits under the British litigation cost allocation compared to the American rule. For lower values of $\rho$, the incentives to litigate might be weaker or stronger under the British rule.

Under the British rule, the information externality is non-negative for any $\rho \geq 1/2$. This guarantees that litigation is credible for any $L \leq L(\theta)$. Furthermore, consider situations in which litigation against firm 2 is only credible if the NPE wins against firm 1 under both the American and British rules. In this case, the British rule allows for a stronger information externality as winning against the first firm very likely involves that the NPE wins against firm 2 and pays no litigation cost. This in turn increases the NPE’s outside option and credibility vis-a-vis the first firm.

6 Extensions

6.1 Infinite Horizon and Weak Patents

In this section we extend our benchmark model into two directions. We consider a set-up with more than two PEs and we introduce the possibility that patents might be weak. We achieve the former by considering an infinite horizon model with discrete periods. In each period one PE is entering and potentially infringing on the NPE’s patent. For simplicity, assume that the technologies of all PEs are perfectly correlated. The firms’ discount factor is $0 \leq \delta < 1$. We also entertain the assumption that patent right are probabilistic, that is, if challenged, there is a chance that the patent is invalidated. Let $\alpha$ denote the strength of the NPE’s patent, which is the probability that the patent could be invalidated. In the presence of weak patents, we assume that the PE counters the infringement suit of the NPE by challenging the validity of the patent. Assume that there is no additional cost in doing this.\footnote{We can easily accommodate the possibility of an increase in litigation costs. Our results remain qualitatively the same as long as the PE has an incentive to counter-sue in equilibrium.} In what follows we first characterize the equilibrium of the game with an infinite horizon and and weak patents. We then analyze the effect of probabilistic patents on the incentives to litigate and show that the NPE might be better off with weak patents.

First consider a the sustainability of a rent extraction strategy without litigation for the NPE. Suppose for the moment that the NPE has a credible threat to litigate. The value of
settling with the PEs without litigation is recursively given by

\[ v(\alpha, \theta) = \frac{1}{2} \left[ \pi + \delta v(\alpha, \theta) \right] + \frac{1}{2} \left[ \alpha \theta \left( \frac{\pi}{2} + \delta v(1, 1) \right) - L \right] - \frac{1}{2} \left[ \pi - \alpha \theta \frac{\pi}{2} - L \right] \]

where \( v(1, 1) = \pi/[2(1 - \delta)] \) is the discounted profit from a valid patent when all PEs are infringing. Let us check under which condition this settlement strategy is sustainable. The NPE has a credible incentive to litigate if

\[ \alpha \theta \frac{\pi}{2} - L + \alpha \theta \delta v(1, 1)) \geq \delta v(\alpha, \theta) \]

or

\[ L \leq \frac{\alpha \theta \pi}{2}. \]  

(10)

If the NPE can sustain the credibility of settlement without litigation in the future, the information externality is zero, \( \alpha \theta \delta v(1, 1)) = \delta v(\alpha, \theta) \). This is similar to the benchmark model where, for low values of the litigation cost, the NPE’s incentive to litigate with perfectly correlated is the same as if he faced each PE in isolation. Overall, the value of the NPE without litigation is given by

\[ V(\alpha, \theta) = \begin{cases} v(\alpha, \theta) = \alpha \theta \pi/[2(1 - \delta)] & \text{if } L \leq \alpha \theta \pi/2, \\ 0 & \text{otherwise.} \end{cases} \]

Now consider the incentives to litigate if condition (10) is not satisfied. The NPE has a credible threat to litigate if

\[ \alpha \theta \frac{\pi}{2} - L + \alpha \theta \delta v(1, 1)) \geq 0 \]

or

\[ L \leq \frac{\alpha \theta \pi}{2(1 - \delta)}. \]  

(11)

In this case the informational externality of litigation is strictly positive as the NPE is unable to extract any profits when firms are uncertain about the validity and the possibility of infringement. This makes current litigation relatively more profitable and increases the credibility of the NPE’s litigation incentives.

Finally, consider the condition under which litigation maximises the joint profits of the
NPE and the current PE. Litigation is optimal if

\[ \pi + \alpha \theta \delta \nu(1, 1) - 2L \geq \pi + \delta V(\alpha, \theta). \]

This holds if either condition (10) holds or

\[ L \leq \frac{\delta \alpha \theta \pi}{4(1 - \delta)}. \]  

(12)

Comparing the above incentive constraints yields our first result.

**Proposition 6** Suppose PEs arrive over an infinite horizon. If the cost of litigation is small and condition (10) holds, the NPE settles with all PEs. For higher cost of litigation, litigation arises in equilibrium if the discount factor is sufficiently high. For intermediate values of \( \delta \), settlement without litigation occurs.

If the cost of litigation is low and condition (10) holds, there is no information externality. The NPE has the same incentive to litigate as if he faced each PE in isolation. In this case, litigation never arises as the parties try to avoid the cost of litigation. For higher values of \( L \), there is a positive information externality of value \( \alpha \theta \delta \nu(1, 1) \). This value increases as the PEs arrive more frequently and \( \delta \) goes up. As the discount factor approaches one, current profits and litigation cost are negligible and litigation is optimal from the point of view of the NPE and the PE-NPE pair jointly. Moreover, the NPE always has a stronger incentive to litigate compared to the PE-NPE pair jointly as the NPE ignores the cost he imposes on the PE. It follows that for high discount factors, litigation occurs in equilibrium, while for intermediate values the NPE has a credible threat of litigation and he settles with all PEs. These results are illustrated below in a L-\( \delta \) diagram where the black lines correspond to the incentive constraints with an ironclad patent.

Let us turn to the effect of weak patents on the incentives to litigate and the profits of the NPE. We compare a situation where the patent is iron-clad with a situation where the strength of the patent is \( \alpha < 1 \). Figure 4 illustrates this comparison. The gray lines correspond to the constraints with a weak patent. As the patent becomes weaker all three conditions above become harder to satisfy. This directly implies that there situation where the PE-NPE would have litigated with a valid patent whereas, with a weak patent, the NPE has an incentive to litigate but settles with all PEs (region A). However, there is also

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a second effect. A weak patent reduces the sustainability of future license extraction if there is no litigation. This creates a positive information externality and increases the incentives to litigate in the current period. Hence, in region B, a weak patent induces litigation where the NPE and PE would have settled with an ironclad patent. The weak patent also has the effect to reduce the NPE’s credible threat of litigation in region C.

![Figure 5: Litigation incentives with an ironclad (black lines) and a weak patent (gray lines).](image)

What is the effect of weak patents on the NPE’s profits? It is easy to check that if a weak patent induces litigation (region B), the NPE is always worse off. Now consider the case where a weak patent induces settlement. In this regime the NPE prefers a stream of settlement profits with a weak patent over litigation profits with an ironclad patent if and only if

\[ v(\alpha, \theta) \geq \frac{\theta \pi}{2} - L + \theta \frac{\delta}{1 - \delta} \frac{\pi}{2} \]

or

\[ L \geq \frac{(1 - \alpha)\theta\pi}{2(1 - \delta)}. \]

It remains to check whether this condition is satisfied in region A. This allows us to establish our second result.

**Proposition 7** Weak patents may lead to more or less litigation in equilibrium relative to ironclad patents. If the patent is not too weak and it reduces litigation, then the NPE makes higher profits than with an ironclad patent.
**Proof:** There exist parameter values such that condition (13) and (12) for an ironclad patents hold if the RHS of (12) is larger than the RHS of (13) which is satisfied for

\[
\frac{[\delta - 2(1 - \alpha)]\theta \pi}{4(1 - \delta)} \geq 0.
\]

Thus, if \( \alpha > 1/2 \), such values always exist. Condition (12) for an ironclad patent implies (11) for a weak patent if the RHS of (11) is larger than the RHS of (12) or

\[
\frac{[2\alpha - \delta]\theta \pi}{4(1 - \delta)} \geq 0
\]

Check that for \( \alpha > 1/2 \) this condition is always satisfied. This establishes the second part of the proposition.

6.2 Endogenous Litigation Effort

We have assumed that the probability that the patent holder prevails in litigation is exogenously given by the relationship between patent claims and the technologies of the PEs. The probability of winning in the court may also depend on the litigation efforts by both parties. We show that when litigation efforts are considered, a positive information externality can arise and increase the credibility of the NPE. This effect is similar to the front-loading of legal efforts identified by Che and Yi (1993) when the court decision has the precedential effect. However, we also demonstrate that the endogenous cost of the court case provides a disincentive to litigate when the merit of the case is small and the discount factor is intermediate.

To illustrate the idea, consider a set-up with an infinite horizon and discrete periods. In each period one PE enters. The technologies of the PEs are perfectly correlated. The discount factor is \( \delta \), which can be interpreted as the average waiting time for the next PE. To focus on the effects from endogenous litigation effort, suppose the fixed cost of litigation is zero, that is, \( L = 0 \). However, we assume that there are discretionary legal expenses that each party can spend to influence the court outcome. Let \( e_N \) and \( e_P \) be variable legal expenses incurred by the NPE and a PE, respectively. We consider a Tullock type contest to model the strategic litigation effort of the parties. In this contest, the effectiveness of legal expenses depends on the initial strength of the infringement case. This could, for example, reflect the fact that producing convincing evidence is harder, the worse the case.
is stuck against a party. Hence, assume that the expected probability of the NPE winning the court case is given by
\[ p(e_N, e_P) = \frac{\theta e_N}{\theta e_N + (1 - \theta)e_P}. \]

Suppose a new PE enters and there has not been any litigation so far and the parties go to court. The PE chooses the litigation effort that maximizes his current period profit,
\[ \max_{e_P} \pi - p(e_N, e_P)\frac{\pi}{2} - e_P. \]

which yields as first-order condition
\[ \frac{\theta(1 - \theta)e_N}{(\theta e_N + (1 - \theta)e_P)^2} = 1. \]

The NPE solves the following maximization problem
\[ \max_{e_N} p(e_N, e_P)(\frac{\pi}{2} + \delta V(1)) - e_N \]

where \( V(1) = \pi/[2(1 - \delta)] \) is the continuation value with legally ascertained infringement. The optimal effort level of the NPE follows from
\[ \frac{\theta(1 - \theta)e_P}{(1 - \delta)(\theta e_N + (1 - \theta)e_P)^2} = 1. \]

It is easy to verify that there exists an equilibrium in which both parties exert strictly positive amounts of effort. The corresponding Nash equilibrium effort levels are given by
\[ e_N^* = \frac{\theta(1 - \theta)}{[1 - \delta(1 - \theta)]^2} \frac{\pi}{2} \quad \text{and} \quad e_P^* = (1 - \delta)e_N^*. \]

The equilibrium effort level is non-monotonic in the merit of the case. Both parties exert less effort if \( \theta \) is either small or large. The effort level is highest for more ambiguous cases where \( \theta \) is intermediate. Furthermore, the NPE spends more as the discount factor increases. The PE’s expenditures first increase and then decrease as \( \delta \) increases. Finally, the NPE exerts more effort for any strictly positive discount factor. This implies that the equilibrium
winning probability is always larger than the prior \( \theta \),

\[
p^* = \frac{\theta}{1 - \delta(1 - \theta)} > \theta.
\]

Let \( V(\theta) \) denote the stream of discounted payments for the NPE in the absence of litigation when the NPE Nash bargains with a credible threat of litigation in place. This value is recursively defined as

\[
V(\theta) = \frac{1}{2}(\pi + \delta V(\theta)) + \frac{1}{2}[p^*(\frac{\pi}{2} + \delta V(1)) - e_N^*] - \frac{1}{2}[\pi - p^*\frac{\pi}{2} - e_P^*]
\]

which yields

\[
V(\theta) = p^* \frac{\pi/2}{1 - \delta} - \frac{e_N^* - e_P^*}{2 - \delta}.
\]

In order to analyze the NPE’s incentive to litigate, consider the following lemma.

**Lemma 5** The NPE’s expected future profits are higher with litigation, that is, \( p^*V(1) \geq V(\theta) \).

When the parties exert effort in court, the winning probability of the NPE is endogenous. This introduces an additional effect. Litigation in the presence of future entrants raises the NPE’s incentive to invest and increases his winning probability above the ex ante merit of the case \( \theta \).

Now consider the individual incentive constraint for litigation for the NPE. Litigation is credible if the current and future expected gains from litigation outweigh the future profits from bargaining when the merit of the infringement case is uncertain,

\[
p^*\frac{\pi}{2} - e_N^* + \delta[p^*V(1) - V(\theta)] \geq 0.
\]

As shown above the expected future profits with litigation are always higher. However, in order to obtain this stream of future income from infringing PEs, the NPE has to invest in litigation effort. The expected current profit of this investment is negative if the initial merit of the case \( \theta \) is sufficiently small. In fact, this condition is satisfied if and only if

\[
\theta \geq \frac{2\delta(1 - \delta)}{2(1 - \delta^2) + \delta}.
\]
The next proposition gives the main result of this analysis.

**Proposition 8** With endogenous litigation effort, the NPE has no credible threat of litigation if the merit of the case is low and the discount factor is intermediate. As the discount factor approaches 0 or 1, the NPE always has an incentive to litigate. Litigation never occurs in equilibrium.

With unrelated technologies and in the absence of a fixed cost of litigation, the NPE always has a credible threat to litigate against individual PEs. The same is true for the case where the NPE is not considering future entrants when making its current litigation decision, that is, for $\delta = 0$. At the other extreme, as the discount factor approaches 1, all that matters are future profits independent of the current investment in litigation effort.

### 6.3 Asymmetric Infringement Probabilities across Firms

So far we have assumed that all PEs have the same probability of infringement of NPE’s patent portfolios and the inference process from one firm’s litigation outcome for other firms’ infringement probability was symmetric even though we allowed PEs’ profits to be different. In this section, we consider the case where PEs can have different infringement probabilities and the inference process can differ depending on which firm is litigated first. To address this issue, we consider the case where the set of technologies used by one PE is a subset of the other PE’s. For instance, we can imagine that one PE’s product has strictly more features than the other PE’s or incorporates more sophisticated technologies. To focus on this issue, we assume that both PEs’ profit is the same, i.e., $\pi_1 = \pi_2 = \pi$. Without any loss of generality, assume that PE2’s product has more features. Let $k(\in [0, 1])$ parametrize the proportion of technologies used by PE1 compared to PE2. This is reflected by differences in infringement probabilities. More specifically, we assume that firm 1’s infringement probability is given by $k\theta$ whereas PE2’s infringement probability is given by $\theta$. This implies that the updating process from litigation outcomes is different depending on the identity of the defendant firm. For instance, if firm 1 is litigated and found to infringe on the NPE’s patents, this is a sure signal that firm 2 also infringes on the NPE’s patents because firm 2’s set of technologies used is a superset of firm 1’s, while firm 2’s infringement does not necessarily mean that firm 1 also infringed. Likewise, if firm 2 is found not to have infringed on NPE’s patent, this is a sure sign that firm 1 has not infringed, either, while
the converse is not necessarily true. The application of Bayes’ rule implies the following inference process

\[ \Pr(Both \text{ Firms Infringe}) = k\theta \]
\[ \Pr(PE_1 \text{ Infringe and } PE_2 \text{ Not Infringe}) = 0 \]
\[ \Pr(PE_1 \text{ Not Infringe and } PE_1 \text{ Infringe}) = (1 - k)\theta \]
\[ \Pr(No \text{ Firm Infringes}) = (1 - \theta) \]  
(14)

and it follows

\[ \Pr(PE_1 \text{ Infringe}|PE_2 \text{ Infringe}) = \frac{\Pr(Both \text{ Infringe})}{\Pr(PE_2 \text{ Infringe})} = k(> k\theta) \]
\[ \Pr(PE_1 \text{ Infringe}|PE_2 \text{ Not Infringe}) = \frac{\Pr(PE_1 \text{ Infringe} \text{ but not } PE_2)}{\Pr(PE_2 \text{ Not Infringe})} = 0(< k\theta) \]
\[ \Pr(PE_2 \text{ Infringe}|PE_1 \text{ Infringe}) = \frac{\Pr(Both \text{ Firms Infringe})}{\Pr(PE_1 \text{ Infringe})} = 1(> \theta) \]
\[ \Pr(PE_2 \text{ Infringe}|PE_1 \text{ Not Infringe}) = \frac{\Pr(PE_2 \text{ Infringe} \text{ but not } PE_1)}{\Pr(PE_1 \text{ Not Infringe})} = \frac{(1 - k)\theta}{1 - k\theta}(< \theta) \]

[To be written]

6.4 Patent Portfolio Acquisition

Our analysis so far has assumed that a non-practicing entity has a patent portfolio of certain strength. We now analyze the NPE’s incentives to acquire patent portfolio vis-a-vis PEs’. Suppose that a patent portfolio of strength \( \alpha > 0 \) has been put up for sale. We ask which type of entities is more likely to acquire the patent portfolio. To illustrate the implications of litigation externalities for patent portfolio acquisition incentives, we consider the simplest setting of one NPE and two PEs bidding for the available patent packet. To simplify the analysis, we analyze a setting in which all parties have no existing patent portfolios.\(^\text{10}\) As a benchmark case, we first establish that all firms have the same willingness to pay for the patent portfolio in the absence of any litigation externalities.

**Lemma 6** If there are no litigation externalities (i.e., \( \rho = 0 \)), all firms bidding for the patent portfolio have the same willingness to pay.

\(^\text{10}\) We can easily extend the analysis of the game to a setting in which firms have existing patent portfolios. See Choi and Gerlach (2014) for more details of such an analysis.
The intuition for this result is simple. The acquisition incentives for the NPE are determined by the amount of licensing revenues it can extract from the two PEs. Let $R_1$ and $R_2$ be the amount of revenues the NPE can extract from each firm with the acquisition of the patent portfolio. Then, the NPE’s maximum willingness to pay is $(R_1+R_2)$. For PE1, its payoff from the acquisition of the patent portfolio is $R_2$, which is the licensing income it can generate from PE2. If PE1 does not acquire the patent portfolio, its payoff will be $-R_1$. As a result, PE1’s maximum willingness to pay for the patent portfolio is the same as the NPE’s and given by $(R_1+R_2)$. The same logic applies to PE2.

However, if we allow for the possibility of litigation externalities, we show that there are cases in which the NPE will have strictly higher incentives to acquire patent portfolios than any PEs due to the free rider problem between PEs. To see this, consider the following scenario.

It turns out that which type of firms has more incentives to acquire the patent portfolio depends on the sign of information externality. We summarize the findings in the following proposition.

**Proposition 9** The patent portfolio acquisition incentives for the NPE vis-a-vis the PEs depend on the sign of the information externality. If there is a positive option value of an earlier litigation, the NPE has (weakly) higher incentives to acquire the patent, whereas PEs have higher incentives if the option value is negative.

**Proof.** See the Appendix. ■

### 7 Concluding Remarks

We have developed a model of patent trolls to understand NPEs’ business models and litigation tactics used to maximize their licensing revenues. We have considered a setting in which the technologies covered by NPEs’ patent portfolios can be potentially infringed by multiple PEs who use related technologies. The main driver of our analysis was implications

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11Here the assumption that PE2 does not have any existing patent portfolio it can use against PE1 as a countermeasure is important. If there is any existing patent portfolio for PE2, the licensing income PE1 can generate will depend on the relative patent portfolio strength and can be different from what the NPE can extract from PE2.
of information that can be revealed in litigation for future licensing negotiations with other potential infringers. If the credibility of litigation threats is not an issue, such potential information externality is in expectation neutral and licensing bargaining with each potential infringer is not affected by the presence of other infringers and can be analyzed in isolation. However, if the outcome of current litigation affects the credibility of future litigation threat, information externality is created and a rich set of predictions can be derived depending on the signs and magnitudes of such information externality.

7.1 Appendix

Proof of Lemma 1.

Proof of Proposition 2. To prove part (i), we consider three possible cases with the assumption of $\pi_1 < \pi_2$.

Case 1: $\theta \frac{\pi_2}{2} < L$

In this case, litigation threat is not credible against both firms in isolation. In this case, $\Psi_i$ cannot be negative. Thus, the only possibility that can arise for $sgn(\Psi_1) \neq sgn(\Psi_2)$ is $sgn(\Psi_1) = 0$ and $sgn(\Psi_2) = 1$, that is, $\bar{\theta} \frac{\pi_1}{2} \leq L < \bar{\theta} \frac{\pi_2}{2}$. In such a case, successful litigation against firm 2 does not make ex post litigation threat credible against firm 1. In such a case, the information value from litigation against firm 2 is irrelevant. Therefore, the NPE cannot extract any surplus from PEs if it approaches firm 2 first. Now suppose that the NPE approaches PE1 as the litigation target. In this case if $\theta [\frac{\pi_1}{2} + \bar{\theta} \frac{\pi_2}{2}] > L$, the NPE’s threat is credible. If the NPE and PE1 settles out of court, no information about the probability of PE2’s infringement is revealed. As a result, the NPE does not have any credible threat against PE2. Thus, the joint surplus for the NPE and PE1 without litigation is given by

$$\Pi_{NPE-PE2} = \pi_1$$

The expected payoffs from litigation for the NPE and PE2 are given by:

$$\Pi_L^{NPE} = \theta \left[ \frac{\pi_1}{2} + \bar{\theta} \frac{\pi_2}{2} \right] - L$$

$$\Pi_L^{PE1} = (1 - \frac{\theta}{2}) \pi_1 - L$$

It can easily be shown that the joint surplus is higher with settlement between the NPE
and PE1 because $\Pi_{NPE-PE1}^{NPE} - (\Pi_{L}^{NPE} + \Pi_{L}^{PE1}) = 2L - \bar{\theta}\frac{\pi_2}{\theta} \geq 2L - \theta \frac{\pi_2}{\theta} > 0$. The first (weak) inequality comes from the fact that $\bar{\theta} \leq 1$, and the second inequality comes from our assumption that the ex ante litigation threat is non-credible for both firms, i.e., $\theta \frac{\pi_2}{\theta} < L$.

The gains from settlement, $2L - \bar{\theta}\frac{\pi_2}{\theta}$, are equally shared if we assume Nash bargaining between the NPE and PE1. Thus, approaching firm 1 with a litigation threat is a (weakly) dominant strategy for the NPE when $\text{sgn}(\Psi_1) = 0 < \text{sgn}(\Psi_2) = 1$.

**Case 2: $\theta \frac{\pi_1}{\theta} > L$**

In this case, litigation threat is credible against both firms in isolation. In this case, $\Psi_i$ cannot be positive. Thus, the only possibility that can arise for $\text{sgn}(\Psi_1) \neq \text{sgn}(\Psi_2)$ is $\text{sgn}(\Psi_1) < 0$ and $\text{sgn}(\Psi_2) = 0$, that is, $\theta \frac{\pi_1}{\theta} < L \leq \theta \frac{\pi_2}{\theta}$. In such a case, if the NPE litigates against firm 2 first and loses the case, it does not have any credible litigation threat against firm 1. This implies that when the NPE litigates against firm 2 first, it has something to lose on expected terms compared to the case where litigation does not reveal any information for future litigation outcome (i.e., $\rho = 0$) because its threat becomes non-credible when it loses. This issue does not arise when the NPE litigates against firm 1 first. This suggests that the NPE prefers to approach firm 2 first. To be more precise, when the NPE approaches firm 1 first, the joint surplus for the NPE and PE1 without litigation is given by

$$\Pi_{NPE-PE1} = \pi_1 + \theta \frac{\pi_2}{\theta}$$

The expected payoffs from litigation for the NPE and PE1 are given by:

$$\Pi_{L}^{NPE} = \theta \left[ \frac{\pi_1}{\theta} + \theta \frac{\pi_2}{\theta} \right] + (1 - \theta) \left[ \theta \frac{\pi_2}{\theta} \right] - L = \theta \left[ \frac{\pi_1}{\theta} + \frac{\pi_2}{\theta} \right] - L$$

$$\Pi_{L}^{PE1} = (1 - \theta)\pi_1 - L$$

It can easily be shown that the joint surplus is higher with settlement between the NPE and PE1 because $\Pi_{NPE-PE1}^{NPE} - (\Pi_{L}^{NPE} + \Pi_{L}^{PE1}) = 2L > 0$. By settling, each party can save litigation costs of $L$. Note that when the NPE approaches PE1, no information externality can be generated with litigation. As a result, the NPE receives the same payoff as in the case of $\rho = 0$, that is, $\pi_{12}^{NPE} = \theta \left[ \frac{\pi_1}{\theta} + \frac{\pi_2}{\theta} \right]$.

Now suppose that the NPE approaches firm 2 first. The joint surplus for the NPE and
PE2 without litigation is given by

\[ \Pi^{NPE-PE_2} = \pi_2 + \theta \frac{\pi_1}{2} \]

The expected payoffs from litigation for the NPE and PE2 are given by:

\[
\begin{align*}
\Pi_L^{NPE} &= \theta \left[ \frac{\pi_2}{2} + \frac{\pi_1}{2} \right] - L \\
\Pi_L^{PE_2} &= (1 - \frac{\theta}{2})\pi_2 - L
\end{align*}
\]

The joint surplus is higher with settlement between the NPE and PE2 because \( \Pi^{NPE-PE_2} - (\Pi_L^{NPE} + \Pi_L^{PE_1}) = \theta(1 - \theta)\frac{\pi_2}{2} + 2L > 0 \). Nash bargaining between the NPE and PE2 yields the payoff for the NPE as \( \pi_2^{NPE} = \theta \left[ \frac{\pi_1}{2} + \frac{\pi_2}{2} \right] - (1 - \theta)\frac{\pi_1}{4}(\pi_2^{NPE}) \). Thus, approaching firm 2 first is the optimal strategy for the NPE.

**Case 3:** \( \frac{\pi_1}{2} < L < \frac{\pi_2}{2} \)

In this case, the ex ante litigation threat is credible only for firm 2. In this case, \( sgn(\Psi_1) \) can be either 0 or 1, whereas \( sgn(\Psi_2) \) can be either 0 or \(-1\). By proceeding as before, we can easily verify that the NPE prefers to approach firm 2 first when \( sgn(\Psi_1) > sgn(\Psi_2) \).

All cases taken together, we can conclude that when \( sgn(\Psi_1) \neq sgn(\Psi_2) \), the NPE chooses firm \( i \) as the first target if and only if \( sgn(\Psi_i) < sgn(\Psi_j) \).

To prove part (ii), we need to consider two cases:

**Case 1:** \( sgn(\Psi_1) = sgn(\Psi_2) = -1 \)

This case arises when \( \frac{\pi_2}{2} < L < \frac{\pi_1}{2} \). In this case, NPE has ex ante litigation credibility against both firms. However, unsuccessful litigation against any PE induces the NPE to lose its litigation credibility against the remaining PE. Suppose that the NPE approaches PE \( i \) first. The expected payoffs from litigation for the NPE and PE\( i \) are given by:

\[
\begin{align*}
\Pi_L^{NPE} &= \theta \left[ \frac{\pi_i}{2} + \frac{\pi_j}{2} \right] - L \\
\Pi_L^{PE_i} &= (1 - \frac{\theta}{2})\pi_i - L
\end{align*}
\]

If the NPE and PE settle out of court, there will be no information revelation, and thus the NPE retains its litigation threat against firm \( j \). Thus, it can subsequently approach
firm $j$ and extract $\theta \pi_j$. Thus, the joint surplus for the NPE and PE$i$ without litigation is given by

$$\Pi_{NPE-PEi} = \pi_i + \theta \pi_j$$

With Nash bargaining between the NPE and PE$i$, the extra surplus from avoiding litigation, $\Pi_{NPE-PEi} - (\Pi_L^{NPE} + \Pi_{PEi}^{NPE}) = 2L + [1 - \bar{\theta}]\theta \pi_j$, can be shared equally between the two parties. Notice that there are two components in the extra surplus from avoiding litigation. The first is legal cost savings for both parties, which is given by $2L$. In addition, there is another term, $[1 - \bar{\theta}]\theta \pi_j$, which can be interpreted as beneficial effects of suppressing potentially adverse information for the NPE. To see this, notice that $\bar{\theta} \hat{\theta} + (1 - \theta)\hat{\theta} = \theta$ by the martingale property. This implies that $[1 - \bar{\theta}]\theta = (1 - \theta)\hat{\theta}$. Thus, $[1 - \bar{\theta}]\theta \pi_j = (1 - \theta)\hat{\theta} \pi_j$ is the expected profit the NPE can extract from firm $j$ in the event it loses litigation against $i$ if it retained the credibility of litigation against $i$. However, when $\theta \pi_j < L$, the NPE loses its credibility when it loses against firm $i$ while it retains credibility in the absence of prior litigation. Thus, each party’s payoff can be written as:

$$\Pi_{ij}^{NPE} = \theta \left[ \frac{\pi_i}{2} + \frac{\pi_j}{2} \right] + (1 - \theta)\hat{\theta} \frac{\pi_j}{4}$$
$$= \theta \left[ \frac{\pi_1}{2} + \frac{\pi_2}{2} \right] - (1 - \theta)\hat{\theta} \frac{\pi_j}{4}$$
$$\Pi_{PEi} = (1 - \theta)\frac{\pi_i}{2} + (1 - \theta)\hat{\theta} \frac{\pi_j}{4}$$

The expression for $\Pi_{ij}^{NPE}$ reveals that it is optimal to approach firm 2 first because $\Pi_{21}^{NPE} > \Pi_{12}^{NPE}$ and the NPE’s payoff is less than the case of no informational externalities when litigation threats are ex ante credible, that is, $\Pi_{21}^{NPE} < \theta \left[ \frac{\pi_1}{2} + \frac{\pi_2}{2} \right]$. In contrast, firm 1’s payoff is higher due to litigation externalities because it can capture half of the benefits of suppressing information with a settlement. Firm 2’s payoff stays the same as the no information externality case.

**Case 2:** $sgn(\Psi_1) = sgn(\Psi_2) = 1$

This case arises when $\theta \pi_j < L < \bar{\theta} \pi_j$. In this case, the NPE has ex ante litigation credibility against neither firm. However, once the NPE is successful against any PE, it gains litigation credibility against the remaining PE. By proceeding as in the previous case, we can derive the NPE’s expected payoff from approaching firm $i$ first (then firm $j$) as
\[
\pi_{ij}^{NPE} = \frac{1}{2}(\theta \pi_i + \Psi_j) I_{[L_2^{-\frac{\Psi_j}{\pi_i}}, \infty)}(\Psi_j)
\]

Since \( \theta \pi_2 + \Psi_1 = \theta(\pi_2 + \frac{\pi_2}{2}) > \theta(\pi_1 + \frac{\pi_2}{2}) = \theta \pi_1 + \Psi_2 \) and \( I_{[L_2^{-\frac{\Psi_2}{2}}, \infty)}(\Psi_1) \geq I_{[L_2^{-\frac{\Psi_1}{2}}, \infty)}(\Psi_2) \), we have \( \pi_{21}^{NPE} > \pi_{12}^{NPE} \). Thus, in both cases where \( sgn(\Psi_1) = sgn(\Psi_2) = 1 \) or \(-1\), approaching firm 2 (the more profitable firm) first is the optimal sequence for the NPE.
References


