Patent Litigation and the Role of Enforcement Insurance *

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August 2011

Abstract

We study the effects of patent enforcement insurance when used by an incumbent patent holder in order to increase its incentives to oppose alleged infringers (entrants). By covering some of the legal costs ex-ante, the incumbent can increase its commitment to litigate and, as a result, deter some potential entrants and, in case of entry, induce a more profitable settlement deal. We identify the circumstances in which it is optimal for the incumbent to undertake patent enforcement insurance, typically with a deductible that either prevents litigation from occurring in equilibrium or trades off the ex post costs of excessive litigation with the aforementioned strategic gains. We assess the impact of patent enforcement insurance on equilibrium outcomes across different legal-cost allocation rules and parameterizations of the model.

JEL Codes: O34, K41.

Keywords: intellectual property, litigation, predation, licensing, patent litigation insurance.

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1 Introduction

The incidence and costs of patent litigation have become notorious in recent years. According to Lanjouw and Schankerman (1998), every thousand patents in the US generate, on average, 10.7 case filings during their life span. In some sectors, such as biotechnology, up to 6% of patents are eventually subject to litigation. The importance of patent litigation is even more salient if we consider its use as a bargaining tool in settlement negotiations. Kesan and Ball (2006) find that about two-thirds of all patent disputes are eventually settled out of court.

For innovative firms, litigation costs are estimated to amount to as much as 25% of their basic R&D expenditures. Hall et al. (2004) reports legal costs in the range from \$500,000 to \$3 million per claim per side. According to Lerner (1995), litigation costs are sufficiently significant to affect firms' decisions to enter a market. He shows that small innovating firms tend to steer away from markets occupied by incumbents with a large patent portfolio. The importance and high costs of patent litigation has impelled the creation of a market for insurance policies that, in exchange for an annual premium, cover part of the costs incurred in patent litigation cases.

In the US, patent litigation insurance is articulated around two types of policies. Policies offering *infringement abatement insurance* (or *patent enforcement insurance*) cover a fraction of the litigation expenses incurred in enforcing the insured patent against infringers, usually a competitor, up to the policy limit.[1] According to Wilder (2001), a typical policy may cover 75% of the enforcement costs up to \$500,000 with annual premiums of \$3,000 to \$4,000.[2] Policies offering *infringement liability insurance* (or *defensive insurance*) protect the insured from allegations of having infringed on someone else's patent. For instance, a defensive

[1] Litigation expenses under coverage typically include most legal and non-legal costs necessary to prove infringement and rebut any counterclaim of invalidity (for instance, the fees and travel costs of expert witnesses).

[2] Anecdotal evidence suggests a substantial expansion of the coverage (up to two million dollars) in recent years; see `http://www.insurancejournal.com/news/national/2007/03/29/78216.htm`.

policy may establish an annual premium of between $20,000 and $50,000 for one million dollars in coverage, with a deductible ranging from 15% to 25%. Industry descriptions of these insurance policies as well as some consulting reports on the topic argue that patent litigation insurance is particularly valuable for small firms.

Systematic statistical information or empirical evidence on patent litigation insurance do not exist. Casual observations confirm that a patent insurance market certainly exists in various countries but suggest that its size remains relatively small, even in the US, possibly due to the nascent nature of this line of business, the small and disperse set of providers, and the incidence of asymmetric information problems.[3] Taking these imperfections into account and with the goal of fostering innovation by small firms, the European Commission has entertained in recent years the possibility of implementing a compulsory patent insurance scheme (see CJA Consultants (2006)).

In this paper we focus on the rationale for and determinants of the usage of patent enforcement insurance. We consider an incumbent patent holder that faces the possible entry of a competitor with a product that may infringe an existing patent. After entry and with the prospect of possible litigation into account, firms negotiate a settlement deal. In case a settlement is not reached, the patent holder can either desist and accommodate the entrant in the market or else go to court. In that case legal costs are incurred and firms wait for the uncertain outcome of a court ruling on the dispute—which will either restore the incumbent's monopoly or allow the competition between the two firms in the market.

In that setup we consider the possibility that the patent holder purchases patent enforcement insurance before entry occurs, i.e. before knowing whether its patent will be infringed or not. In exchange for an initial premium, the insurance policy covers all its legal costs except a fraction set as a deductible. We show that without insurance the patent holder

[3] Gørtz and Konnerup (2001) reports the availability of patent insurance policies in, among other countries, Australia, France, New Zealand, Sweden, and the UK.

is exposed to *patent predation*: entry or patent infringement in situations where, given the probability that the court rules in favor of the patent holder, entry would not occur if the threat of litigation were credible. This happens because the entrant anticipates that the incumbent's net gains from litigation are lower than those from settling (or simply accommodating the entrant), particularly when legal costs are high. We show that taking patent enforcement insurance can break this predatory logic. That is, by guaranteeing the coverage of some of the legal costs ex-ante, the incumbent can increase its commitment to litigate, deter some entrants, and obtain larger expected profits from settlement.

We show that if insurance is fairly priced (i.e. in the absence of frictions in the insurance market), it is always in the interest of the incumbent to contract some protection. However, even in these circumstances, it is not generally optimal to choose full coverage of the litigation costs since there is a trade-off between strengthening the incumbent's commitment to litigate and, possibly, inducing ex post *excessive* litigation (that is, litigation when the expected gains to the incumbent are lower than the legal costs incurred by the incumbent and the insurer altogether). In some occasions, the optimal deductible induces excessive litigation, particularly when the patent holder is very likely to prevail in court, but these costs are compensated by the lower entry or the better terms of settlement induced in anticipation of the incumbent's greater inclination to go to court.

The deductible that characterizes the optimal insurance contract decreases with legal costs and increases with the bargaining power of the patent holder. The logic for the first effect is that lowering the deductible (partially) compensates for the incumbents' lowered incentive to litigate when legal costs are higher. The second effect is due to the fact that the incumbent's bargaining power and the coverage provided by the insurance policy are substitutes in diminishing the entrant's prospect of a favorable settlement deal after entry.

An increase in the incumbent's monopoly profits has an ambiguous effect on the optimal deductible because two opposite forces concur. On the one hand, these profits increase the incumbent's ex post willingness to litigate, making enforcement insurance less necessary as a commitment device. On the other hand, greater monopoly profits make entry deterrence more appealing. We show that, under a US-type rule for the allocation of legal costs to the litigating parties (that is, when each party pays its own cost), the relationship between the stand-alone excess profit and the resulting deductible can have an inverse-U shape, so that the first effect dominates when profits are low and the second when profits are large. In contrast, under a UK-type cost allocation rule (that is, when the loser pays all costs) and for the same parametrization of the model, the first effect always dominates.

When asymmetric information or market power introduces imperfections that add an excess cost to the actuarially-fair insurance premium, the prediction of universal interest in contracting insurance no longer holds. Our comparison between the expected profits obtained by the patent holder with and without insurance in these circumstances identify that insurance will be more likely to be used by incumbents with low to medium monopoly profits, very high (or perhaps also very low) litigation costs, and low bargaining power—intuitively, by incumbents with weaker incentives to litigate or facing entrants with a greater temptation to predate.

The literature on patent litigation has developed substantially in recent years. A large strand has focused on the determinants of patent settlement. A classical example is Meurer (1989) that, in a context where there is private information regarding the validity of the patent, characterizes the compensations and licensing agreements that arise from settlement negotiations.[4] Aoki and Hu (1999) stress the importance of the uncertainty about the outcome of the legal process for the emergence of licensing in equilibrium and study the ex ante

[4] In the literature the patent holder is typically assumed to make take-it-or-leave-it offers. In our paper, we consider generalized Nash bargaining, which allows us to analyze the effects of changes in bargaining power and embeds, as a polar case, the situation in which the incumbent has all the bargaining power.

effects on firms' incentives to innovate. Crampes and Langinier (2002) study the incentives for patent holders to find out whether their patents have been infringed and the ensuing settlement and litigation.

We contribute to this literature by considering the effects of patent enforcement insurance.[5] Following the classical contributions of Bebchuk (1984) and Reinganum and Wilde (1986), the emergence of litigation in equilibrium in most of the existing papers is the result of private information regarding the probability that each side prevails in court. To keep things simple, we abstract from informational asymmetries between the patent holder and the infringer and we model settlement as an efficient bargaining process. Yet, we predict the emergence of litigation in equilibrium when a court ruling in favor of the incumbent is able to restore its monopoly position and lead to industry profits that cannot be replicated by a private agreement regulating the coexistence between the incumbent and the entrant in the market—e.g. because competition, the threat of it, or the legal impediments and costs of enforcing a market-sharing agreement dissipate some of the monopoly profits away.[6] The implication from the analysis below is that, when the patent is sufficiently valuable or strong, no feasible settlement can dissuade the incumbent from going to court.

As some of the referred papers, we analyze how different rules of legal-cost allocation affect the incentives to settle and litigate.[7] The various possibilities are exemplified by the

[5]In a recent paper, Buzzacchi and Scellato (2008) analyze of the effects of patent enforcement insurance on innovation incentives. Their analysis abstracts from the characterization of the optimal deductible, the comparison between cost allocation rules, the decision to take insurance in the presence of frictions in the insurance market, and several other issues that we discuss.

[6]Maurer and Scotchmer (2006) argue that agreements implying a reversion to monopoly would most likely raise antitrust concerns. However, recent *reverse payment settlements* in the pharmaceutical industry seem to provide a counterexample (Holman, 2007). In our flexible formalization below, a parameter measures the profits reached under market coexistence agreements, covering the whole spectrum of possibilities and allowing us to qualify the main predictions accordingly.

[7]Cost allocation rules were first considered in general analyses of litigation, including Shavell (1982), Bebchuk (1984), and Reinganum and Wilde (1986). The findings in the literature are rather mixed and the conclusions, as in our paper, are typically contingent on the relative importance of each party's probability of victory and the legal costs. For example, in Meurer (1989), the UK rule benefits the incumbent if it holds a strong (valid) patent, but the US rule dominates in terms of expected profits.

US and the UK cost allocation rules. We show that most results are qualitatively identical under both rules, even though they differ in the amount of litigation induced in equilibrium and in the size of the gains due to the insurance (both typically higher under the US rule). Our findings also suggest that the benefits of patent litigation insurance are greater in the US system, especially when monopoly profits are relatively small and litigation costs are large. Interestingly, in this later case, the introduction of insurance reverses the comparison between the US and the UK rule in terms of the incumbent's expected net profits, which become uniformly larger under the US rule.

The rest of the paper is organized as follows. Section 2 introduces the model. Section 3 characterizes the equilibrium for a given insurance contract. Section 4 discusses the optimal determination of the deductible and shows that, in a frictionless insurance market, undertaking some insurance is always desirable to the incumbent. Sections 5 and 6 describe equilibrium outcomes for several parametrizations of the model under the US and UK cost allocation rules, respectively. Section 7 concludes. All proofs are relegated to Appendix A. Appendix B describes the equilibrium in the absence of patent enforcement insurance.

2 The Model

Consider an industry where an incumbent i that sells a patented product faces the risk of entry of a rival j with a competing product. All agents are risk neutral. If firm j enters and firm i accommodates, competition pushes them into sharing the market equally and obtaining profits that are normalized to 1 each. If no entry occurs, profits are $1 + \pi$ for the incumbent and zero for the rival, where $\pi > 1$ represents the increase in the incumbent's profits due to its monopoly position.

2.1 Possibility of litigation

When entry occurs, the incumbent may try to enforce its patent by suing the rival for infringement. The uncertainty about the outcome of the dispute, if finally resolved in court, is captured by the probability $p \in [0,1]$ that the court rules in favor of the incumbent, restoring its monopoly position. Intuitively, this probability measures the strength of the incumbent's case relative to the rival's, that is, the chances of preserving the validity of the patent and demonstrating the existence of infringement.

We assume that there is some initial uncertainty about the strenght of the patent and capture it by assuming that p is ex ante a random variable with density function $f(p)$, cumulative distribution function $F(p)$, and full support on the interval $[0,1]$. The realization of p is observed by the rival and the incumbent right before the former decides on entry, but it is assumed to remain unverifiable throughout the entire process.[8]

Litigation entails identical costs $c > 0$ to each of the parties.[9] However, at the end of the legal process these litigation costs are reallocated according to the rule set by the law. In this respect, we consider two polar cost allocation rules (and their convex combinations). At one extreme, each party pays its own cost as under the *US rule*; at the other extreme, the loser pays all the legal costs, as under the *UK rule*.[10] To make the presentation compact, we formulate the legal costs for the incumbent and the entrant as

$$c_i = \alpha c + (1-\alpha)(1-p)2c \tag{1}$$

[8]The results are unchanged if p is observed by the rival before deciding on entry, and by the incumbent if and only if the rival enters.

[9]For simplicity we assume that c is incurred if and only if the case is finally resolved in court. Bebchuk (1996) shows that if c is divisible and can be partly paid at an earlier stage this could have strategic value to the litigant. The insurance arrangements that we examine below play a similar role.

[10]Our representation of the US and UK rules constitutes a stylized description of what has been extensively discussed by others (see, for instance, Bebchuk and Chang (1996)). In the modeling of the US rule, we abstract from the treatment of the so-called *frivolous* or *nuisance* lawsuits: lawsuits without merit in which US courts allocate the legal cost to the suing party (as under the UK rule). See Rosenberg and Shavell (1985) for a study of nuisance suits.

and

$$c_j = \alpha c + (1-\alpha)p2c, \tag{2}$$

where the parameter $\alpha \in [0,1]$ can be understood as either the probability of having the costs allocated as in the US system or the description of an intermediate allocation system. We assume that $c < 1$ so that, under the US system (α=1) and even if litigation is anticipated, the rival's expected net profits from entering, $1 - p - c$, are positive when the incumbent's probability of winning, p, is sufficiently small.

2.2 Possibility of settlement

Importantly, after entry and before the incumbent makes a final choice between accommodation or litigation, the two firms can reach a settlement agreement regarding the terms of their relationship in the market. In this case, the incumbent renounces to go to court and the incumbent and the entrant get net final payoffs of $a + s(p)$ and $a - s(p)$, respectively, where $a \in [1, (1+\pi)/2]$ is a parameter representing the per-firm profits when the market is shared under the agreed terms (e.g via a licensing agreement) and $s(p)$ is the *settlement payment* that the entrant makes to the incumbent. The established interval for a is intended to capture the whole range of possibilities from competition as in the duopoly situation reached in case of accommodation (where $a = 1$ implies total industry profits of 2) to the effective restoration of monopoly (where $a = (1+\pi)/2$ implies total industry profits of $1 + \pi > 2$). [11]

We assume that the terms of settlement are determined according to a Generalized Nash Bargaining solution that leaves each party with its disagreement payoff plus a fraction of the surplus from avoiding litigation (if positive). Such a fraction, which represents bargaining power, is assumed to be $\beta \in [0,1]$ for the incumbent and $1-\beta$ for the rival. The surplus

[11] Additional to antitrust concerns, attaining monopoly profits in the situation in which the two firms operate in the market may be difficult due to the standard incentives to deviate from collusion. The distance of a from $(1+\pi)/2$ may be interpreted as a proxy for the loss in expected profits due to the difficulties of enforcing perfect collusion.

from settlement as an alternative to litigation amounts to the saved legal costs minus the loss in expected industry profits associated with renouncing to the possibility that courts restore the incumbent's monopoly position.[12]

2.3 Possibility of insurance

Prior to the realization of p and the entry of the competitor, the incumbent is allowed to contract patent enforcement insurance with some available insurer. According to this arrangement, the insurer commits to pay a fraction $1-x$ of future litigation costs in exchange of an initial premium P. The remaining fraction of the costs x is a deductible or copayment decided when contracting the policy in order to maximize the incumbent's expected profits net of insurance and litigation costs.[13]

To capture frictions in the market for patent enforcement insurance, we assume that the premium P might differ from the actuarialy fair price of the insurance policy by some amount $\mu \geq 0$. In this context, $\mu = 0$ represents the situation in which the insurance market is frictionless, while $\mu > 0$ captures extra charges due to the lack of competition or the presence of adverse selection in the market for insurance.[14]

[12] Such loss is given by the difference between the expected total industry profits in case of litigation, $2 + p(\pi - 1)$, and the total industry profits under settlement, $2a$. This loss is positive for $a = 1$ and negative for $a = (1 + \pi)/2$, so in general the sign and size of the surplus from settlement depends on p and a. When settlement prevents accommodation, the surplus is simply $2(a - 1)$, which is unambiguously non-negative.

[13] We have assumed that p is not verifiable which, realistically, precludes the deductible to be made contingent on p.

[14] Adverse selection in insurance markets was first modeled by Rothschild and Stiglitz (1976). In general a single insurance contract may attract insurance takers of different unobservable risk types. Making the contract profitable on expectation to the insurer implies cross-subsidization of the riskier types by the less risky types that undertake the contract. A typical implication is that the best types drop out of the market, reducing the average quality of the pool of insurance takers and increasing the price P at which the insurer can make profits from the offered policy. For the average candidate insurance taker the net effect is equivalent to the presence of an excess cost $\mu > 0$ as the one that we capture here in reduced form.

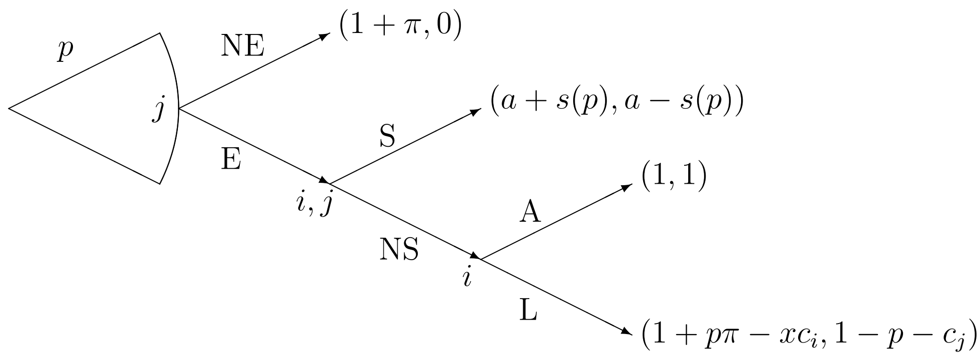


Figure 1: Structure of the Game.

2.4 The game tree

Figure 1 summarizes the timing of the events and the structure of the game between the incumbent and its rival. Prior to the realization of p, the incumbent can seek patent enforcement insurance from a competitive insurer. After this insurance is contracted, p is realized and the rival decides whether to enter (E) or not (NE). If entry occurs, both firms engage in a settlement negotiation that, if successful, leads both firms to produce under a settlement agreement (S). If no settlement agreement is reached (NS), the incumbent can decide either to simply accommodate the entrant (A) or to litigate against it (L).

3 Determination of the Equilibrium

The game described in the previous section can be naturally solved using backwards induction, which is what we do next.

3.1 Accommodation vs litigation

We start with the last decision node in Figure 1, where, if the out-of-court settlement fails, the incumbent must decide whether to accommodate or to litigate the rival. It is immediate from comparing the (expected) payoffs under each alternative that the incumbent will prefer to accommodate when its patent is not sufficiently strong (that is, for small p). Specifically, there is a critical value

$$p_A \equiv \frac{(2-\alpha)xc}{\pi + 2(1-\alpha)xc} < 1, \tag{3}$$

such that accommodation will occur for $p \leq p_A$ and litigation for $p > p_A$.

3.2 Settlement

Turning to the node in which the incumbent and the rival bargain on settlement, it is now clear that for $p \leq p_A$ both parties expect accommodation if they fail to agree. Thus, the settlement compensation $s(p)$ will only be acceptable to the incumbent if $a + s(p) \geq 1$ and to the rival if $a - s(p) \geq 1$. Under our assumptions, the surplus from settlement under the expectation (or threat) of accommodation in case of disagreement is $2(a-1) \geq 0$. So we can assume, without loss of generality, that settlement will always occur for $p \leq p_A$. The Generalized Nash Bargaining Solution in this case can be found by solving $a + s(p) = 1 + \beta 2(a-1)$, which implies $s(p) = (2\beta - 1)(a-1)$.[15]

For $p > p_A$, both parties expect litigation if they fail to agree. Thus, the settlement compensation $s(p)$ will only be acceptable to the incumbent if

$$a + s(p) \geq 1 + p\pi - xc_i,$$

and to the rival if

$$a - s(p) \geq 1 - p - c_j.$$

Combining these inequalities, and using (1) and (2), we obtain the condition

$$(a-1) + p + \alpha c + (1-\alpha)2pc \geq s(p) \geq p\pi - \alpha xc - (1-\alpha)(1-p)2xc - (a-1). \tag{4}$$

[15]In the limit case with $a = 1$, settlement involves $s(p) = 0$ and is equivalent, in all relevant respects, to accommodation.

The existence of a mutually acceptable compensation $s(p)$ requires that the range delimited above is non-empty or, equivalently, that the surplus from settlement is non-negative:

$$g(p) \equiv 2(a-1) + \alpha(1+x)c + (1-\alpha)2xc - p[\pi - 1 - 2(1-\alpha)(1-x)c] \geq 0. \qquad (5)$$

The first term in this expression is identical to the surplus from settlement that arises when the disagreement point entails accommodation, and its associated with the emergence of duopoly competition both under accommodation and when the incumbent litigates but does not win. The next two terms represent the savings in litigation costs that would accrue if p were zero. The third term groups all the terms proportional to p and reflects the unrealized gains (net of the relevant litigation costs) associated with renouncing to litigate (and hence missing the opportunity of restoring the incumbent's monopoly position). If those unrealized gains are not positive, $\pi \leq 1 + 2(1-\alpha)(1-x)c$, then the settlement surplus is positive for all p. Otherwise, it will be positive for low values of p but may be negative for large values of p. The expression for the surplus suggests that settlement tends to generate value relative to litigation when the gains from agreeing to share the market (rather then competing straightforwardly) $a-1$ are large, when the stand-alone monopoly profits π of the incumbent are relatively low, and when its probability of winning the case p is relatively small.

The following lemma completes and summarizes the discussion on whether accommodation, settlement, or litigation occur after entry.[16]

Lemma 1. *For $p \in [0, p_A]$, settlement emerges in the expectation that, otherwise, entry would be* accommodated *and competition would arise. If $\pi \leq 1 + 2c - \alpha(1-x)c$, entry is also followed by* settlement *(under the expectation that disagreement would lead to litigation) for*

[16]In case of indifference, we use an innocuous tie-breaking rule: we assume that accommodation prevails over settlement, and settlement over litigation.

all $p \in (p_A, 1]$. *Otherwise, there is a critical value*

$$p_S \equiv \frac{2(a-1) + \alpha c + (2-\alpha)xc}{\pi - 1 - 2(1-\alpha)(1-x)c} > p_A, \tag{6}$$

such that entry is followed by settlement *(under the expectation that disagreement would lead to litigation) for* $p \in (p_A, \min\{1, p_S\}]$ *and, if* $p_S < 1$, *by* litigation *for* $p \in (p_S, 1]$.

This lemma confirms the intuition that the incumbent's reaction to entry depends crucially on the relative merit of its case in court, represented by p, as well as the monopoly rents π, the surplus from settlement vis-a-vis accommodation $2(a-1)$, and the allocation of litigation costs. Other things equal, a higher probability of winning the trial, p, makes the incumbent more likely to have litigation as a disagreement or threat point in the settlement negotiations, and more likely to end up going to court. Increasing the monopoly rents π (as well as decreasing the litigation costs c) reduces p_A and p_S, leading to the same qualitative effects. Increasing the market-sharing profit a does not change p_A but increases p_S, hence expanding the range of values of p for which settlement arises. In contrast, the signs of the variations induced by changes in the deductible x and the cost-allocation parameter α are less clear. The threshold p_A is increasing in x, but varies ambiguously with α, while p_S varies ambiguously with both x and α.[17]

In the following lemma we characterize the compensation to the incumbent, $s(p)$, that results from applying the Generalized Nash Bargaining solution to the negotiations on settlement:

Lemma 2. *For* $p \in [0, p_A]$, *the settlement payment is* $s(p) = s_A \equiv (2\beta - 1)(a-1)$, *which is increasing in* β, *increasing in* a *for* $\beta > 1/2$ *and decreasing in* a *for* $\beta < 1/2$. *For* $p \in$

[17] The ambiguities regarding the effects of changing α are partly due to the fact that the ordering of each party's expected litigation costs across legal systems varies with p. For example, for the incumbent, litigating is strictly more expensive under the US cost allocation rule than under the UK rule if and only if $p > 1/2$. Additionally, under the UK rule, the effect of the deductible x interacts with p and further complicates the evaluation of whether settlement generates a positive surplus or not (vis-a-vis litigation).

$(p_A, \min\{1, p_S\}]$, *the settlement payment is given by*

$$s(p) = s_A + \beta\{\alpha c + [1 + 2(1-\alpha)c]p\} - (1-\beta)\{(2-\alpha)xc - p[\pi + 2(1-\alpha)xc]\}, \qquad (7)$$

which is increasing in p, π, *and* β, *decreasing in* x, *increasing in* a *for* $\beta > 1/2$, *and decreasing in* a *for* $\beta < 1/2$.

Notice that, as it is generally the case under efficient bargaining, the allocation of bargaining power does not affect the region where settlement arises, but changes the allocation of the settlement surplus across agents in the obvious direction: the settlement compensation $s(p)$ is increasing in the incumbent's bargaining power β. When the disagreement leads to accommodation, the only other parameter that affects $s(p)$ is the market-sharing profit a. When disagreement leads to litigation, $s(p)$ is also increasing in the strength of the incumbent's case p and the monopoly profit π, and decreasing in the deductible x, reflecting the various factors that reinforce the incumbent's willingness to defend its patent in court. Changes in the litigation cost parameters α and c affect both parties in a more complicated manner, producing ambiguous impacts on $s(p)$ on the range $p \in (p_A, \min\{1, p_S\}]$.

Although we have assumed that in the case of settlement firms receive identical gross payoffs (a each, gross of $s(p)$), the results would be unchanged for any other distribution of the total payoff $2a$. Only the settlement payment $s(p)$ would vary across different initial allocations.[18] An interesting extreme variation with respect to our symmetric division of $2a$ arises if the gross payoffs in case of settlement are $2a$ for the incumbent and 0 for the entrant. This might represent the situation in which settlement implies a reversion to monopoly in which the incumbent makes gross profits of $2a \leq 1+\pi$ and the entrant makes zero profits.[19] In this case, the bargaining process would end up giving $2a+\hat{s}(p)$ to the incumbent and $-\hat{s}(p)$ to

[18] This property is a natural consequence of the Nash Bargaining rule, that allocates to each party its threat-point payoff (independent of a) plus a fraction of the surplus from the negotiation (which just depends on the total profits $2a$).

[19] We would expect that $2a < 1 + \pi$ because of costs, for example, associated with enforcing the no-competition agreement.

the entrant, with $\hat{s}(p) = s(p) - a$ and $s(p)$ fixed as in (7). This variation could produce reverse payment settlements similar to those observed in the pharmaceutical industry: situations in which the patent holder compensates a generic drug firm producer for staying out of the market.

3.3 Entry

In the entry stage, anticipating whether the incumbent's reaction will lead to settlement under the threat of accommodation, settlement under the threat of litigation or straight litigation, the rival decides to enter if its expected net profits from doing so are strictly positive.[20] If the entrant expects settlement under the threat of accommodation, entering is clearly optimal since the accommodation threat point guarantees a profit of at least 1 (and staying out yields zero). When settlement under the threat of litigation is anticipated, the entrant's expected net profits are $a - s(p)$, with $s(p)$ given by (7). These profits are positive if and only if

$$p < p_{ES} \equiv \frac{1 + 2(1-\beta)(a-1) - \beta\alpha c + (1-\beta)(2-\alpha)xc}{\beta[1 + 2(1-\alpha)c] + (1-\beta)[\pi + 2(1-\alpha)xc]}, \tag{8}$$

where p_{ES} is increasing in x and a, and decreasing in π and β.[21] If litigation is expected, entry will occur if

$$p < p_{EL} \equiv \frac{1 - \alpha c}{1 + 2(1-\alpha)c} < 1. \tag{9}$$

The final configuration of the equilibrium outcomes over the possible values of p depends on the relative position of some of the thresholds obtained so far. The next lemma establishes the ordering of p_S, p_{ES} and p_{EL}. Remember that $p_A \leq p_S$.

Lemma 3. *If* $x \leq \widehat{x} \equiv \frac{\pi(1-\alpha c) - (2a-1)[1+2(1-\alpha)c]}{\alpha c + 4(1-\alpha)c^2}$, *then* $p_S \leq p_{ES} \leq p_{EL}$. *Otherwise,* $p_{EL} < p_{ES} < p_S$.

[20] As an innocuous tie-breaking rule, we assume that in case of indifference between entering or not, the rival stays out of the market.

[21] Since this threshold satisfies $s(p_{ES}) = a$, the results referred to x, π, and β follow immediately from Lemma 2 .

Litigation in this model requires $p > p_S$ so that, conditional on entry, no settlement occurs, and simultaneously $p < p_{EL}$ so that the rival wants to enter in spite of anticipating litigation. Hence litigation occurs for $p \in (p_S, p_{EL}]$, provided that this interval is not empty. Lemma 3 essentially says that the litigation interval is not empty if the fractional deductible x is set below some critical value $\widehat{x}$.[22] In this case, the premium charged to the incumbent for its patent enforcement insurance policy is

$$P = \int_{p_S}^{p_{EL}} (1-x)c_i \, f(p)dp + \mu, \tag{10}$$

where the first term is the expected value of the part of the legal costs that the insurer pays and $\mu \geq 0$ captures the extra costs due to imperfections in the insurance market. For $x > \widehat{x}$, litigation does not occur in equilibrium and the insurance premium is just $P = \mu$.

Rather than developing a complex taxonomy of the equilibria that can emerge for every possible value of x, including some that will never be optimal to choose), we start the next section showing that the optimal deductible x^* either is zero (if π is small) or belongs to the interval $[0, \widehat{x}]$ (if π is sufficiently large). Using this result, the characterization of the set of relevant equilibrium configurations is notably simpler.

Finally, the situation in which the incumbent does not take any insurance can be formally represented as one with $x = 1$ and $\mu = 0$ (so that, using (10), we have $P = 0$). The characterization of the set of relevant equilibrium configurations in this case is relegated to Appendix B.

4 Optimal Insurance Coverage

The first proposition in this section refers to the value of the deductible x^* that will prevail if the incumbent decides to undertake patent enforcement insurance. The bounds on x^* estab-

[22] Note that $\widehat{x}$ might be lower than zero in which case no feasible deductible can produce a non-empty litigation interval.

lished in the proposition are key to simplifying the taxonomy of equilibrium configurations.

Proposition 1. *If* $\pi \leq \widehat{\pi} \equiv (2a-1)\frac{1+2(1-\alpha)c}{1-\alpha c}$*, the optimal deductible* x^* *is zero. Otherwise, we have* $x^* \in [0, \min\{1, \widehat{x}\}]$*.*

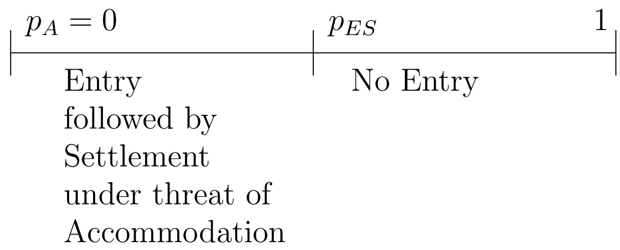
This result reflects the incumbent's interest in making an aggressive use of patent enforcement insurance either to improve its bargaining position vis-a-vis the entrant when entry occurs or, even better, to just dissuade it from entering. In fact, in case of having $\widehat{x} < 1$, setting a deductible in the range $(\widehat{x}, 1]$ would produce *patent predation*: for $p \in (p_{EL}, p_{ES}]$ the entrant would enter due to the expectation that the incumbent, in case of disagreement about settlement, would not litigate. Provided that the incumbent takes some insurance, its optimal preemptive response to this predatory entry is to fully eliminate it by setting $x^* \leq \widehat{x}$ if $\widehat{x} > 0$ or, otherwise, to minimize it by setting $x^* = 0$. The intuition for this is that with $x \geq \widehat{x}$ litigation does not occur in equilibrium, so lowering the deductible x has no impact on the cost of taking insurance, P, while it has advantages in all other dimensions: reduces predatory entry and improves the incumbent's bargaining position and, hence, its compensation, whenever settlement occurs.

The top diagram of Figure 2 shows the configuration obtained for $\pi \leq \widehat{\pi}$ (which implies $\widehat{x} \leq 0$). In this case full insurance ($x^* = 0$) does not prevent entry (followed by settlement under the threat of accommodation) for the lowest values of p, but minimizes the length of the range where that occurs (as p_{ES} is increasing in x). The expected net profits of the incumbent in this scenario are

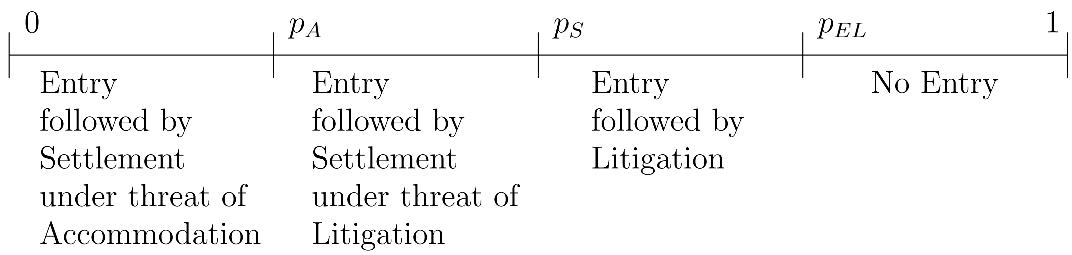
$$V = \int_0^{p_{ES}} [a + s(p)]f(p)dp + [1 - F(p_{ES})](1+\pi) - \mu, \tag{11}$$

with p_{ES} evaluated at $x = 0$. The last term reflects the cost of taking insurance, $P = \mu$, when litigation does not occur in equilibrium.

When $\pi > \widehat{\pi}$ (which implies $\widehat{x} > 0$), the optimal deductible belongs to the interval



A. Case with $\pi \leq \widehat{\pi}$



B. Case with $\pi > \widehat{\pi}$ and $x^* < \widehat{x}$

Figure 2: Equilibrium outcomes as a function of p. The top and bottom diagrams correspond to the cases without and with litigation in equilibrium, respectively.

$[0, \min\{1, \widehat{x}\}]$. In fact, if $x < \min\{1, \widehat{x}\}$, then the configuration of equilibrium is like in the bottom diagram of Figure 2, which involves litigation for $p \in [p_S, p_{EL}]$. The lower part of this range includes realizations of p where, without insurance, litigation would not occur since the overall expected profits from litigating (inclusive of the part of the litigation costs paid by the insurer) are lower than the profits from settlement. For those realizations of p, the outcome in the presence of insurance implies some loss of surplus, but this loss is offset by the gains from either a larger settlement compensation or a lower entry threshold, for even lower realizations of p. The optimal deductible will indeed be chosen so as to maximize the expected net gain. The expression for the incumbent's profits becomes:

$$\begin{aligned} V &= [1+2\beta(a-1)]F(p_A) + \int_{p_A}^{p_S} [a+s(p)]f(p)dp + \int_{p_S}^{p_{EL}} (1+p\pi - xc_i)f(p)dp \\ &\quad +[1-F(p_{EL})](1+\pi) - P, \end{aligned} \tag{12}$$

where the initial insurance premium P captures the part of the litigation costs paid ex ante. Using (10) to substitute for P and rearranging terms, we obtain

$$\begin{aligned} V &= 1+2\beta(a-1)F(p_A) + \int_{p_A}^{p_S} [(a-1)+s(p)]f(p)dp + \int_{p_S}^{p_{EL}} (p\pi - c_i)f(p)dp \\ &\quad +[1-F(p_{EL})]\pi - \mu, \end{aligned} \tag{13}$$

where p_A, p_S, and $s(p)$ are all functions of x, as specified on previous pages.

Proposition 1 already identifies $\widehat{x} < 1$ as a sufficient condition for some patent enforcement insurance coverage to be optimal (i.e., $x^* < 1$). Additionally, it is possible to verify that, when $\widehat{x} > 0$, the derivative of V (as defined in (13)) with respect to x is strictly negative at $x = 1$, which implies that, conditional on taking insurance, the optimal deductible x^* must be strictly lower than one. This also implies that, if the excess cost μ due to imperfections in the insurance market is zero, then the incumbent will strictly benefit from the use of some patent enforcement insurance.

Proposition 2. *For $\mu = 0$, it is always beneficial to the incumbent to contract some amount of patent enforcement insurance, i.e., to set $x^* < 1$.*

Further characterization of the optimal deductible when insurance is taken, as well as the comparison between taking insurance and not taking insurance when $\mu > 0$, requires specifying a probability distribution for p and proceeding numerically. For concreteness, in the remaining of the paper we study the case in which p is uniformly distributed over the interval $[0, 1]$. Under this assumption, we can analytically solve for the optimal deductible under the US cost allocation rule ($\alpha = 1$).

5 Outcomes under the US Cost Allocation Rule

Our stylized description of the US cost allocation rule corresponds to $\alpha = 1$, which means that each party pays its own litigation costs. To analyze the optimal deductible and the associated equilibrium outcomes in greater detail, we consider the example in which the incumbent's probability of winning the case in court is uniformly distributed over the interval $[0, 1]$.[23]

Proposition 3. *When p is uniformly distributed on the interval $[0,1]$, the optimal deductible under the US cost allocation rule ($\alpha = 1$) is $x^* = 0$ if $\beta < \bar{\beta} = \frac{2(a-1)(2a-1)}{2(a-1)(2a-1)+c(1-c)}$. Otherwise, it is*

$$x^* = \begin{cases} 0 & \text{if } \pi \leq \frac{2a-1}{1-c}, \\ \frac{\pi(1-c)-(2a-1)}{c} & \text{if } \pi \in \left(\frac{2a-1}{1-c}, \overline{\pi}\right], \\ \frac{\beta\pi - 2(a-1)(1-\beta)\frac{\pi^2}{c}}{\pi^2+\pi-\beta} & \text{if } \pi \in \left(\overline{\pi}, \frac{\beta c}{2(a-1)(1-\beta)}\right) \\ 0 & \text{if } \pi \geq \frac{\beta c}{2(a-1)(1-\beta)}, \end{cases} \tag{14}$$

where the threshold $\overline{\pi} > 1/(1-c)$ is increasing in c and β.

This result is based on Proposition 1 and the first order conditions for a maximum that emerge after particularizing (11) and (13) to the case with $\alpha = 1$, $f(p) = 1$, and $F(p) = p$. For sufficiently low π (relative to a and c), we have $\pi \leq \widehat{\pi}$ and, thus, $x^* = 0$, as established in Proposition 1. As argued before, the optimal deductible is zero when litigation does not arise in equilibrium since reducing the deductible strengthens the bargaining position of the incumbent at no cost. For the subsequent range of values of π (a range that moves upwards with c and lengthens with β), the optimal deductible equals the minimal deductible that prevents litigation from happening in equilibrium, $\widehat{x}$. This outcome reflects a corner solution to the trade-off between strengthening the bargaining position of the incumbent (by lowering

[23]When the distribution of p is uniform, the optimal deductible has a closed form solution. Considering the whole interval $[0, 1]$ as its support is a just a convenient form of avoiding additional parameters and a cumbersome discussion of corner situations.

x) and inducing inefficient litigation (if x goes below $\widehat{x}$). For even larger values of π, the optimal deductible is lower than $\widehat{x}$, solving the first order condition for reaching an interior maximum in (13). In this case, x^* is such that the marginal gain from strengthening the bargaining position of the incumbent (which preempts entry at the p_{EL} margin and raises the compensation received by the incumbent in the interval $(p_A, p_S]$) is equal to the marginal cost of the additional litigation induced at the p_S margin. Finally, since x^* decreases with π in this range, it may reach its lower bound of zero, producing the last case described in (14).

For illustration purposes (and to facilitate the comparison with the results for the UK system, that must be numerically solved), the solid lines in Figure 3 show how x^* moves with each of the parameters of the model around a baseline scenario with $\pi = 2.3$, $c = 0.4$, $\beta = 0.5$, and $a = 1$. The effects captured by the solid lines in the four panels of Figure 3 can be better understood by referring to the corresponding panels of Figure 4, which display, for the same value of the parameters, the critical values of p that delimit the regions where the various equilibrium outcomes arise. Specifically, the range of realizations of p for which litigation occurs is contained between the lines corresponding to p_S and p_{EL}. The areas at the top of each panel identify the no-entry range. The large area in the lower part of each panel corresponds to settlement under the threat of litigation, while the tiny area that appears at the very bottom of each panel corresponds to settlement under the threat of accommodation.[24]

Let us briefly comment on the effects of moving each of the parameters π, c, β, and γ. According to Figure 3, increasing the monopoly profits π has a non-monotonic impact on the optimal deductible x^*. This non-monotonicity is associated with the shift from the corner solution that arises for $\pi \in (\frac{1}{1-c}, \overline{\pi}]$ (that prevents litigation from occurring in equilibrium)

[24] This last area is small due partly to the presence of patent litigation insurance and partly to the illustrated parameterization, which makes litigation relatively attractive vis-à-vis accommodation. Specifically, in the baseline parametrization we have $x = x^* = 0.16$. Without insurance ($x = 1$) the region in which settlement occurs under the threat of accommodation would be about six times its size under the optimal deductible.

to the interior solution that arises for $\pi > \overline{\pi}$ (which produces litigation for some realizations of p, see Figure 4). In the first range, x^* must increase with π to prevent the incumbent from opting for litigation when the rise in π makes it more tempting. In the second range, the incumbent's net profits from litigating are actually positive for the highest realizations in which $p \in (p_S, p_{EL})$, and the fall in x^* as π increases reflects the optimality of inducing an increasingly aggressive litigation strategy.

Figure 3 does not identify non-monotonic effects on x^* for the other parameters, although there are regions where some effects are null or lower than in other, generally depending on whether litigation occurs or not in equilibrium, or whether the corner solution $x^* = 0$ applies. The most remarkable effects associated with changing the cost of litigation c appear in Figure 4. Quite intuitively, increasing c reduces the occurrence of litigation, eventually all the way down to zero. Simultaneously, it dramatically increases the no-entry range, showing how c increases the preemptive effect of the threat of litigation on the decision of the entrant.

In contrast with other parameters, the parameter that represents the bargaining power of the incumbent β does not affect the size of the no-entry region and has relatively small effects on the size of the other regions. Yet it has a clear positive effect on the optimal deductible x^*. This evidences, quite intuitively, that bargaining power and the strenghtening of the incumbent's bargaining position coming from patent litigation insurance are substitutes.

Finally, increasing the market-sharing profit a increases the size of the joint profits $2a$ that the incumbent and the entrant can make through settlement, approaching them to the level $1+\pi$ that the incumbent would make as a monopolist. For a constant deductible x, the effect of larger a on settlement payoffs would make us expect more entry, less litigation, and more settlement. Indeed, this is what Figure 4 shows to happen, in spite of the fact that, as reflected in Figure 3, the optimal deductible x^* is reduced (until it quickly reaches its lower bound of zero) so as to partly compensate the entry-inducing effect of the expectation of larger settlement payoffs.

To conclude this section, we look at the equilibrium expected profits of the incumbent under the optimal patent enforcement policy, and compare them with their value in the absence of insurance, that is, for $x = 1$ (see Appendix B for the characterization of equilibrium without insurance). As previous figures in this section, Figure 5 contains four panels that show the effects of moving the parameters π, c, β, and a, each at a time. The expected profits of the incumbent with insurance are computed for $\mu = 0$, that is, for the situation in which the insurance market is frictionless where taking insurance strictly dominates not taking it, as already anticipated in Proposition 2.

In Figure 5, the equilibrium expected profits with insurance are monotonically increasing in π, β, and a, which are all parameters naturally related with the value that the incumbent can extract from its position in the market under various circumstances. The effect of c is, in contrast, non-monotonic: profits initially decrease with c before becoming clearly increasing in it. This reflects the fact that when litigation occurs (as it happens with large frequency when c is low, see Figure 4) the incumbent pays its part of the expected litigation costs (directly ex post or in the premium paid for its patent enforcement insurance contract), but as c increases the actual incidence of litigation declines and the entry-preemption effect of a larger c (reinforced by the presence of insurance and its declining deductible) dominates.

The importance of insurance in the described effects is clear when comparing the solid and dashed lines in Figure 5, especially in the panels reporting the effects of moving c and a. Without insurance, a larger c does not necessarily protect the incumbent against entry. In fact, for sufficiently large values of c, patent predation becomes prevalent and the incumbent's expected profits fall with c. In the case of the market sharing profits a, the absence of insurance also implies that increasing them does not necessarily benefit the incumbent: the negative effects of the entry produced by the weaker threat of litigation (and the entrant's prospect of a favorable settlement) are not compensated by a reinforcement of the bargaining position of the uninsured incumbent, whose profits may fall with a, as it happens over the lowest range of values of a in Figure 5.

The previously commented substitutability between patent enforcement insurance and bargaining power is confirmed by the slope of the curves shown in the panel reporting the effect of moving β. Larger bargaining power has a stronger positive impact on the incumbent' expected profits without insurance since, when insurance is taken, the weakness of bargaining power is compensated by setting a lower optimal deductible x^*.

Finally, it is worth commenting on the drivers of the decision to take insurance in the case the market for patent enforcement insurance is subject to frictions. If market power or asymmetric information imply $\mu > 0$, then the currently depicted solid lines should simply be shifted down by the amount μ, and otherwise the discussion of the optimal deductible would be unchanged. Of course, by the same token as $\mu = 0$ makes the use of insurance overall dominant, a sufficiently large value of μ might fully eliminate the net advantages of taking insurance over the whole spectrum of parameters. For intermediate values of μ, the predictions that emerge from Figure 5 are more qualified: insurance will tend to preserve its positive net value (and/or be comparatively more valuable) for low values of π, very high (and perhaps very low) values of c, low values of β, and high values of a.

6 Outcomes under the UK Cost Allocation Rule

Under our general formulation, the UK cost allocation rule, whereby the costs of litigation are shifted to the party that loses the case, corresponds to the situation with $\alpha = 0$. In this case, the optimal deductible x^*, whenever it falls in the interior of the interval $[0, \widehat{x}]$, does not have a closed-form solution. So this section fully relies on obtaining numerical solutions for the parameterizations already explored in the various figures of Section 5 under the US rule ($\alpha = 1$). Qualitatively, the optimal deductible, the configuration of equilibrium, and the net gains from taking patent enforcement insurance behave very similarly under both cost allocation rules, which makes detailed explanations for what is observed under the UK rule somewhat redundant. Some details (especially at the quantitative level) are, of course, different and deserve some comment.

The dashed lines in Figure 3 represent the optimal deductible x^* under the UK rule, which is typically, but not always, larger than under the US rule. Like under the US rule, when positive, x^* is non-increasing in the litigation costs c and the market-sharing profits a, and increasing in the incumbent's bargaining power β, while it becomes zero when the monopoly profits π are small, c is large, and a is large. The main qualitative difference refers to the dependence of x^* with respect to π since the lack of monotonicity observed under the US rule does not appear under the UK rule. This probably reflects differences in the relative value to the incumbent of preventing the excess litigation that occurs for some realizations of p. As most of those realizations involve $p < 0.5$ in our simulations, the UK rule (that assigns the litigation costs to the loser) implies higher expected costs from excess litigation for the incumbent than the US rule, pushing for a deductible that keeps increasing with π so as to moderate the insured incumbent's tendency to litigate.

As depicted in Figure 6, the equilibrium outcomes under the UK rule look again qualitatively very similar to those obtained under the US rule, but the size of some regions differs. The intuition that some effects are due to the larger expected litigation costs that the patent holder would incur if litigation were to occur for $p < 0.5$ gets reinforced by the comparison Figure 6 with Figure 4. The UK rule induces larger areas of settlement under the prospect of accommodation (below the p_A line) and smaller areas of litigation (between the p_S and the p_{EL} lines). Notice also that, under both rules, large parts of the litigation regions involve $p < 0.5$.

Figure 7 shows the incumbent's equilibrium expected net profits with and without insurance under the UK rule. As before the profits with insurance are calculated for $\mu = 0$ and the impact of insurance market frictions can be simply analyzed by vertically shifting down, in parallel, the solid line representing the profits with insurance. All comments made in light of Figure 5 apply also under the UK cost allocation rule. Quantitatively, however, the comparison between figures 5 and 7 implies that, under most of the parameterizations shown in them, the incremental value of insurance and the overall expected profits of the insured incumbent are larger under the US rule than under the UK rule, while the comparison between both rules in the absence of insurance is less clear cut. Interestingly, there are circumstances (e.g., for high litigation costs) where the presence of patent enforcement insurance changes the ranking between the rules in terms of the incumbent's expected net profits. This suggests that some of the normative implications found in the existing literature on patent litigation (that abstracted from the possibility of insurance) might not be robust to the introduction of insurance.

All in all, the comparison of figures 5 and 7 suggests that for a similar level of imperfections in the patent enforcement insurance market ($\mu > 0$), the use of insurance would tend to be more prevalent in jurisdictions operating under the US rule. This prediction, as well as those derived from other comparative statics results commented throughout the last two sections might constitute the basis for future empirical research on patent litigation and the potential value of patent enforcement insurance.

7 Concluding Remarks

This paper has studied the effects of patent enforcement insurance in a situation where the patent holder faces the risk of infringement by a competitor. The main insight of the paper is that insurance has commitment value for the incumbent. Allowing for policies that incorporate a fractional deductible, we have shown that the deductible optimally set by the insurer and the patent holder when contracting on insurance is always lower than 100% but typically strictly positive, in order to limit excessive litigation. A properly chosen deductible makes credible the threat to litigate alleged infringers, even when the incumbent's chances in court are small. This strategy reduces entry and, when entry occurs, allows the incumbent to enlarge its compensation in the out-of-court settlement of the dispute. The downside, however, is that insurance can produce litigation in instances where, otherwise, it would not occur. Hence the optimal deductible trades off the costs of excessive litigation with the strategic advantages in terms of entry preemption and reinforcement of the incumbent's bargaining position in settlement negotiations.

We have compared the outcomes of the model under the US cost allocation rule (with no cost shifting) and the UK rule (with cost shifting to the loser). Although qualitatively the results are similar under both rules, in the parameterizations that we have explored, and conditional on the use of insurance, litigation tends to occur more frequently under the US rule, but the incumbent's expected net profits (and the contribution of insurance to them) tend to be also higher under the US rule. Interestingly, there are circumstances (e.g., for high litigation costs) where the introduction of patent enforcement insurance alters the ranking between the rules in terms of the patent holder's expected net profits.

Our analysis of the impact of insurance market frictions (e.g. due to market power or asymmetric information) suggests that the use of patent enforcement insurance will tend to be more prevalent, if at all, among patent holders with low bargaining power, as well as in markets or sectors characterized by relatively low monopoly profits, very high (and perhaps very low) litigation costs, and relatively good opportunities to reach profitable market sharing arrangements between patent holders and their rivals.

As the bulk of the literature on patent litigation, we have abstracted from firm risk-aversion. A priory, the implications of including it in the model are ambiguous. Risk-aversion on the side of the entrant will tend to reduce the threat of entry and, contingent on entry, the prevalence of litigation. Both effects make patent litigation insurance less appealing. Risk-aversion on the side of the incumbent, however, will tend to reduce the strength of its threat to litigate an entrant, and thus, to facilitate the emergence of competition. This effect together with the standard advantages of insurance as a way to reduce payoff variability makes patent litigation insurance more appealing. Thus, we should expect that introducing risk aversion in the preferences of both parties will produce generally ambiguous results on the use of patent litigation insurance, together with the less ambiguous prediction of a lower prevalence of litigation.

Future research should pay attention to the empirics of patent litigation insurance and test the validity of the predictions of our analysis. We will just elaborate on three predictions associated with comparative statics results already discussed in the body of the paper. First, insurance should be more valuable for patents involving smaller monopoly profits as well as for patents that, because of the nature of their technologies or the legal environment, are exposed to larger litigation costs. Second, if firms with larger portfolios of patents enjoy more bargaining power (say, because of their larger incentive to build a reputation as tough bargainers or their greater financial strength), then enforcement insurance should be more valuable to small firms, whose policies will tend to feature smaller deductibles. Third, after controlling for endogenous selection, that is, conditional on other factors that explain the tendency to litigate (e.g., the strength of the infringed patent), enforcement insurance should lead to more litigation. Unfortunately, the incipient nature of the enforcement insurance market and, to the best of our knowledge, the lack of data describing the use of insurance by the potentially insurable patent holders as well as the ex post performance of the insured ones, makes testing the validity of our predictions unfeasible at this time.

Appendix

A Proofs

Proof of Lemma 1: The case with $p \in [0, p_A]$ has been fully discussed in the main text. In the case with $p > p_A$, the patent holder and the incumbent will agree on settlement if the surplus $g(p)$ defined in (5) is positive. Clearly, if $\pi \leq 1 + 2c - \alpha(1-x)c$, we have $g(p) \geq 0$ for all p, and settlement occurs up to $p = 1$. Otherwise, there exists a critical value $p_S < 1$ such that $g(p_S) = 0$ and $g(p) \geq 0$ for all $p \leq p_S$. By inspection of the corresponding expressions, it is immediate that $p_S > p_A$.■

Proof of Lemma 2: The case with $p \in [0, p_A]$ has been fully discussed in the main text. In the case with $p > p_A$, disagreement would lead to litigation, so Nash Bargaining will produce a settlement payment $s(p)$ such that the incumbent's final payoff equals its disagreement payoff plus a proportion β of the bargaining surplus, i.e. $a + s(p) = (1 + p\pi - xc_i) + \beta g(p)$. This yields the expression for $s(p)$ in equation (7). The comparative statics of $s(p)$ with respect to π, p, a, and x is immediate. Regarding β, notice that

$$\frac{\partial s}{\partial \beta} = 2(a-1) + \alpha c + (2-\alpha)xc - p\left[\pi - 1 - 2(1-\alpha)(1-x)c\right]. \tag{15}$$

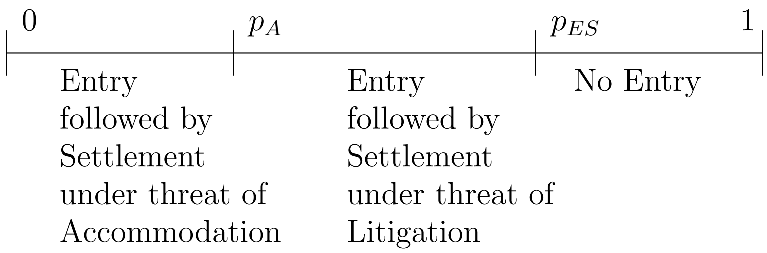
If $\pi < 1 + 2(1-\alpha)(1-x)c$, the expression in brackets is negative and, thus, we clearly have $\partial s/\partial\beta > 0$ for all p. Otherwise, (15) is decreasing in p, so it is sufficient to notice that, at the upper limit of the settlement range, when $p = p_S$, we have $\partial s/\partial\beta = 0$.■

Proof of Lemma 3: Simple manipulation of p_S, p_{ES}, and p_{EL}, defined in (6), (8), and (9), respectively, yields the result that the inequalities $p_S \leq p_{ES}$ and $p_{ES} \leq p_{EL}$ are both satisfied if and only if $x \leq \widehat{x}$. So the result follows.■

Proof of Proposition 1: Notice first that $\widehat{x} \leq 0$ if and only if $\pi \leq \widehat{\pi}$. Thus the discussion can be divided in two cases, depending on the value of π.

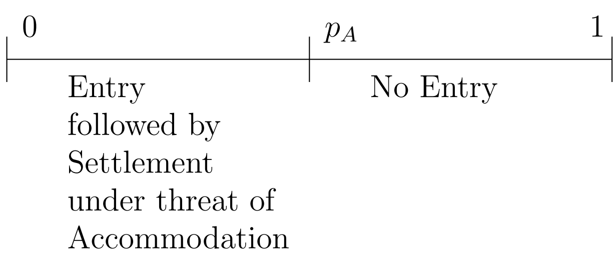
1. Case with $\pi \leq \widehat{\pi}$. We have $\widehat{x} \leq 0$. Then for all relevant x, we have $x \geq \widehat{x}$ and, hence, by Lemma 2, $p_{EL} \leq p_{ES} \leq p_S$, where the inequalities are strict except if $x = \widehat{x} = 0$. In principle, depending on the relative positions of p_A and p_{ES}, two possible subcases may emerge.

(a) Subcase $p_A < p_{ES}$. The relevant thresholds would be ordered as indicated in the following diagram, giving raise to three different types of outcomes over the range of possible realizations of p:



However, with this configuration, reducing x would decrease both p_A and p_{ES}, reducing the region where entry is followed by settlement in expectation of accommodation, increasing the settlement compensation to the incumbent, and decreasing overall entry. This change would not trigger litigation and would thus keep $P = \mu$.

(b) Subcase $p_{ES} \leq p_A$. Here we would have:



However, reducing x would decrease p_A, reducing entry without triggering litigation (and hence keeping $P = \mu$).

Previous arguments imply that only $x^* = 0$ can be optimal, since any other policy could be improved by reducing x. Setting $x = 0$ implies $p_A = 0 < p_{ES}$.

2. Case with $\pi > \widehat{\pi}$. We have $\widehat{x} > 0$. By the same arguments used in points 1(a) and 1(b) above, any arrangement involving $x > \widehat{x}$ (if at all relevant, since only $x \leq 1$ makes sense) could be improved by reducing x. Thus we must have that x^* belongs to the non-empty interval $[0, \min\{1, \widehat{x}\}]$.■

Proof of Proposition 2: Given Proposition 1, we only need to show that, in the case with $\widehat{x} \geq 1$ and conditional on undertaking insurance, it is optimal for the incumbent to set $x^* < 1$. With $\widehat{x} \geq 1$, the equilibrium configuration must be as in the top panel of Figure 2 under any x, included the optimal x^*. The derivative of (13) with respect to x is:

$$\frac{\partial V}{\partial x} = \int_{p_A}^{p_S} \frac{\partial s}{\partial x} f(p)dp - \frac{\partial p_A}{\partial x} s(p_A) f(p_A) - \frac{\partial p_S}{\partial x} \left[p\pi - c_i - s(p_S) \right] f(p_S).$$

For a general value of x, the sign of this expression is ambiguous. Whereas the first two terms are negative, the sign of the last one depends (among other things) on the value of x. However, for $x = 1$, this last term becomes zero and hence we unambiguously have $\partial V/\partial x < 0$, which implies that $x = 1$ cannot be optimal and, hence, x^* must be lower than 1. Obviously for $\mu = 0$ these arguments also imply that undertaking some insurance ($x = x^* < 1$) dominates not taking insurance at all (which is formally equivalent to having $x = 1$ and $\mu = 0$).■

Proof of Proposition 3: By Proposition 1, we can focus the discussion on the case with $\pi > \widehat{\pi} = \frac{2a-1}{1-c}$, where $x^* \in [0, \widehat{x}]$ and $\widehat{x} = \frac{\pi(1-c)-(2a-1)}{c} > 0$; otherwise $x^* = 0$. In this case, x^* must maximize (13) within the referred range. After replacing $f(p) = 1$ and $F(p_{EL}) = p_{EL}$ in (13), we obtain a quadratic and strictly concave function of x that reaches an unconstrained maximum at $x' = \frac{\beta\pi - 2(a-1)(1-\beta)\frac{\pi^2}{c}}{\pi - \beta + \pi^2}$. This value is non-negative for $\pi \leq \pi' = \frac{\beta c}{2(a-1)(1-\beta)}$ and satisfies $\partial x'/\partial a < 0$ and $\frac{\partial^2 x'}{\partial a \partial \pi} < 0$. Moreover, if $\pi' < \widehat{\pi}$, which occurs if $\beta > \bar{\beta} = \frac{2(a-1)(2a-1)}{2(a-1)(2a-1)+c(1-c)}$, Proposition 1 directly implies $x^* = 0$.

Turning to the complementary case with $\pi' \geq \widehat{\pi}$, which occurs if $\beta \leq \bar{\beta}$, it is clear that if $x' > \widehat{x}$ then $x^* = \widehat{x}$. Otherwise we have $x^* = x'$ if $\pi < \pi'$ and $x^* = 0$ if $\pi \geq \pi'$. To finish the proof, we will show that there is a unique critical value $\overline{\pi}$ such that $x' < \widehat{x}$ if and only if $\pi > \overline{\pi}$. To see this notice that with $\pi = \widehat{\pi} = \frac{1}{1-c}$ we have $\widehat{x} = 0 < x'$. Furthermore, at $\pi = \pi'$ we have $x' = 0 < \widehat{x}$ and

$$\frac{\partial \widehat{x}}{\partial \pi} = \frac{1-c}{c} > 0 > \frac{\beta}{1 - \frac{\beta}{\pi} + \pi^2} \frac{\beta - \pi^2}{\pi^2} = \left.\frac{\partial x'}{\partial \pi}\right|_{a=1} > \frac{\partial x'}{\partial \pi},$$

since $\frac{\partial^2 x'}{\partial a \partial \pi} < 0$ and $\pi > \frac{1}{1-c} > 1 > \sqrt{\beta} > \beta$. Then, by continuity, there exists a unique value $\overline{\pi}$ for which $x' = \widehat{x}$. The comparative statics of $\overline{\pi}$ follows immediately from the fact that x' is increasing in β and c, whereas $\widehat{x}$ is decreasing in c and independent of β.■

B Equilibrium in the Absence of Insurance

When the incumbent lacks insurance, the structure of the game remains unchanged. The relevant thresholds and the settlement compensation $s(p)$ that correspond to this case can be obtained from (3) and (6)-(9) by setting $x = 1$. In this case we have $p_A < p_S$ and using Lemma 3, one can obtain the following result.

Lemma 4. *In the absence of insurance ($x = 1$), there exist two critical values, $\pi_L \equiv \frac{\alpha c+4(1-\alpha)c^2}{1-\alpha c}$ and $\pi_H \equiv \frac{(2a-1)+[4a(1-\alpha)+3\alpha-2]c+4(1-\alpha)c^2}{1-\alpha c}$, such that the configuration of equilibrium is as follows:*

1. *If $\pi \leq \pi_L$, then $p_{EL} \leq p_A < p_{ES} < p_S$ or $p_{EL} < p_{ES} \leq p_A < p_S$. Entry occurs for $p \leq p_S$, and is followed by settlement under the threat of accommodation for $p \in [0, p_A]$ and by settlement under the threat of litigation for $p \in (p_A, p_S]$.*

2. *If $\pi \in (\pi_L, \pi_H]$, then $p_A < p_{EL} < p_{ES} < p_S$. Entry occurs for $p \leq p_{ES}$, and it is followed by settlement under the threat of accommodation for $p \in [0, p_A]$ and by settlement under the threat of litigation for $p \in (p_A, p_{ES}]$.*

3. *If $\pi > \pi_H$, then $p_A < p_S < p_{ES} < p_{EL}$. Entry occurs for $p \leq p_{EL}$, and it is followed by settlement under the threat of accommodation for $p \in [0, p_A]$, by settlement under the threat of litigation for $p \in (p_A, p_{ES}]$, and by litigation for $p \in (p_{ES}, p_{EL}]$.*

Proof. The threshold π_L is obtained as the value of π for which $p_A = p_{EL}$ with $x = 1$. The threshold π_H is obtained as the value of π for which $\widehat{x} = 1$, according to the definition of $\widehat{x}$ in Lemma 3. The equilibrium outcomes associated with each region are obtained using arguments similar to those in the rest of the paper. We omit further details for brevity.■

Using the previous lemma, it is immediate to check that the incumbent's expected net profits in the absence of insurance are

$$\overline{V} = \begin{cases} [1+2\beta(a-1)]F(p_A) + \int_{p_A}^{p_S}[a+s(p)]f(p)dp + [1-F(p_S)](1+\pi), & \text{if } \pi < \pi_L, \\ [1+2\beta(a-1)]F(p_A) + \int_{p_A}^{p_{ES}}[a+s(p)]f(p)dp + [1-F(p_{ES})](1+\pi), & \text{if } \pi \in [\pi_L, \pi_H], \\ [1+2\beta(a-1)]F(p_A) + \int_{p_A}^{p_S}[a+s(p)]f(p)dp \\ \quad + \int_{p_S}^{p_{EL}}(1+p\pi-c_i)f(p)dp + [1-F(p_{ES})](1+\pi), & \text{if } \pi > \pi_H, \end{cases}$$

where $s(p)$ is given by (7) evaluated at $x = 1$. The dashed lines in Figures 5 and 7 are generated using this expression for $\alpha = 1$ and $\alpha = 0$, respectively.

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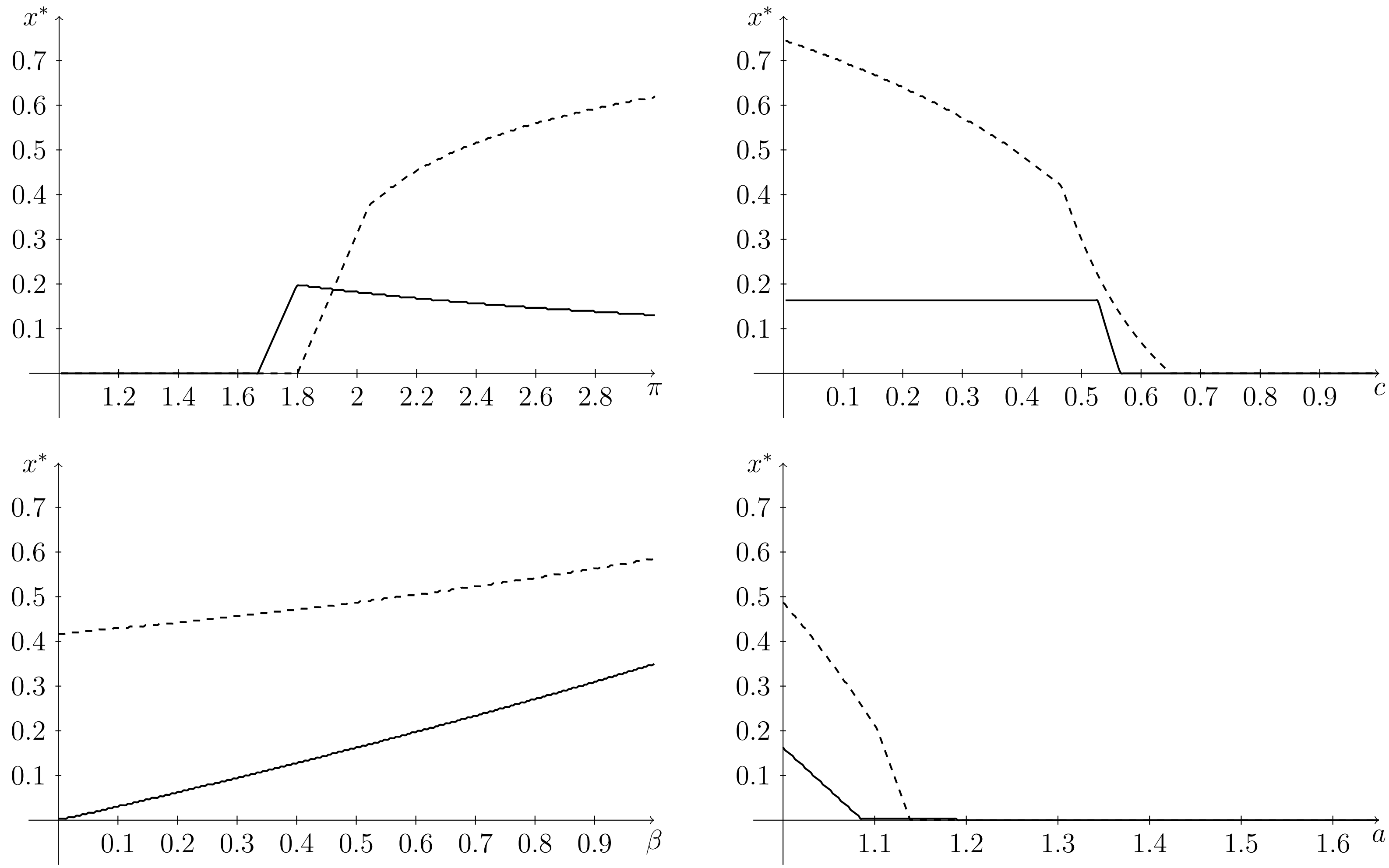

Figure 3: Optimal deductible under each cost allocation rule. The solid (dashed) line represents the optimal fractional deductible under the US (UK) rule. Parameter values are as in the baseline scenario described in the main text (i.e. $\pi = 2.3$, $c = 0.4$, $\beta = 0.5$, $a = 1$, and $\mu = 0$) except for the varying parameter that appears on the horizontal axis in each panel.

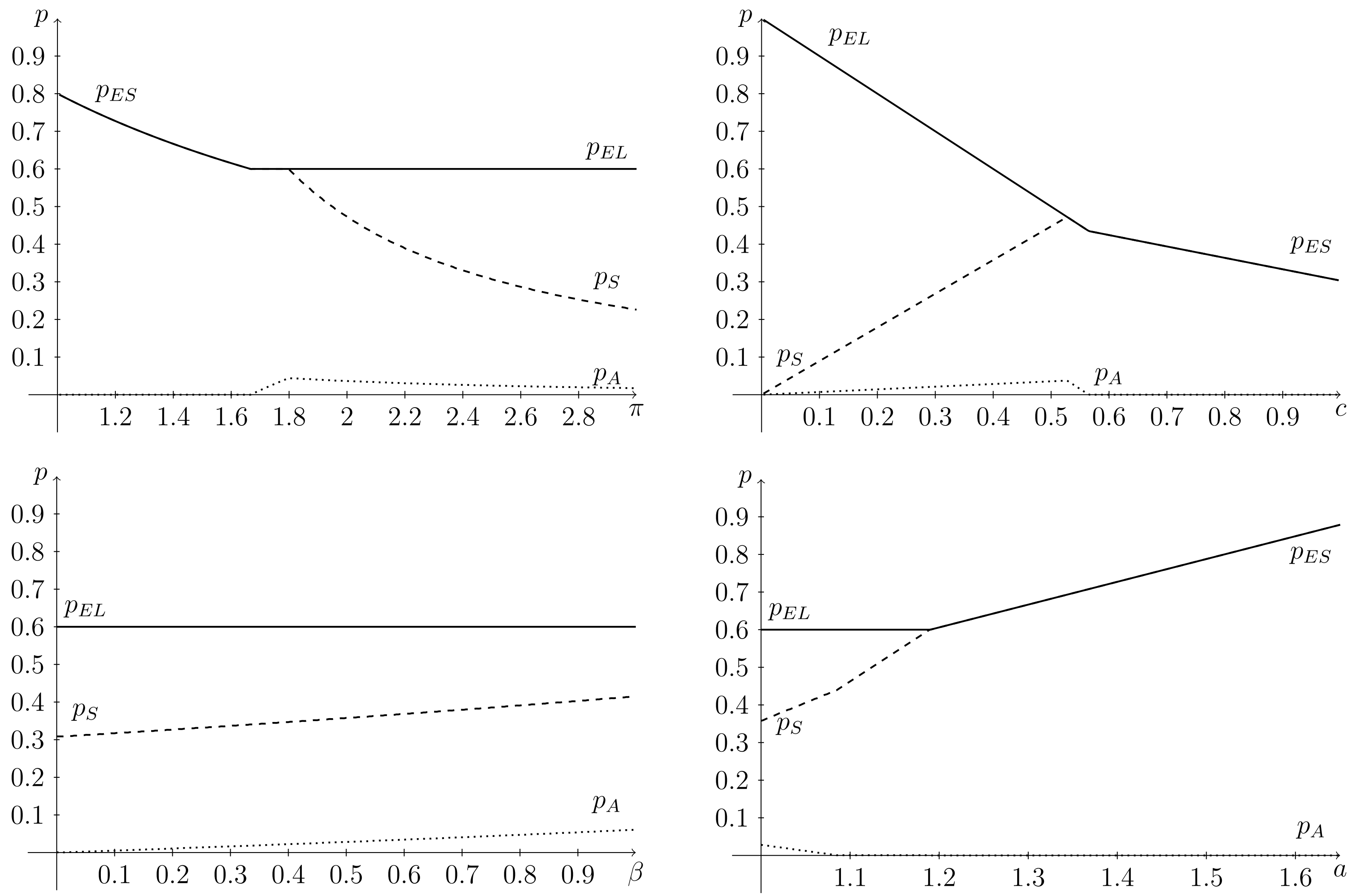

Figure 4: Equilibrium outcomes under the US cost allocation rule. The critical values of p displayed delimit the regions for the various equilibrium outcomes: accommodation (below p_A), settlement (between p_A and p_S), litigation (between p_S and p_{EL}), and no entry (above p_{EL} or p_{ES}). Parameters and the underlying deductible are set as in Figure 3 (US rule).

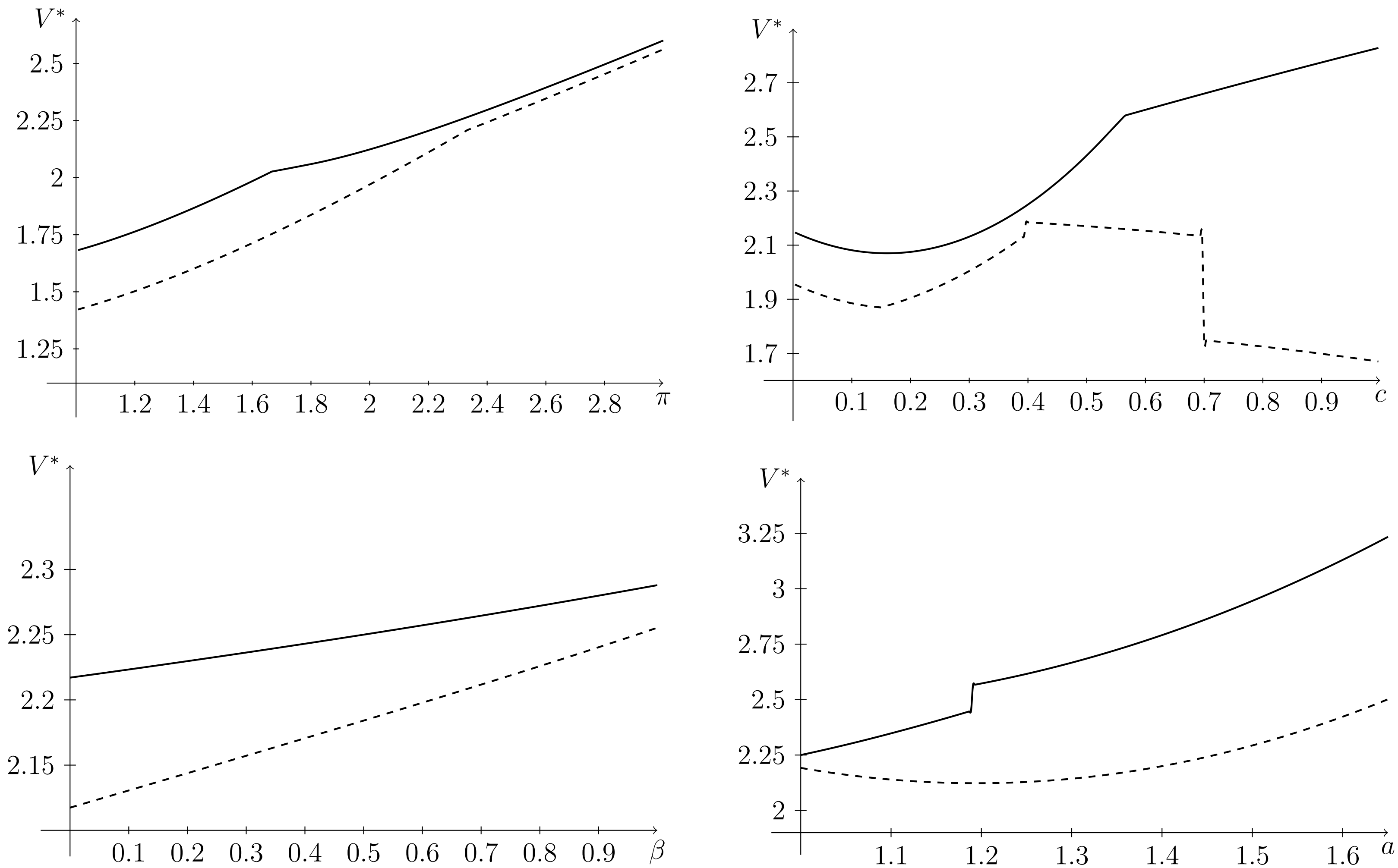

Figure 5: Expected profits of the patent holder with an without insurance (US rule). The solid (dashed) line represents profits with (without) insurance. Parameter values are as in the baseline scenario described in the main text (i.e. $\pi = 2.3$, $c = 0.4$, $\beta = 0.5$, $a = 1$, and $\mu = 0$) except for the varying parameter that appears on the horizontal axis in each panel.

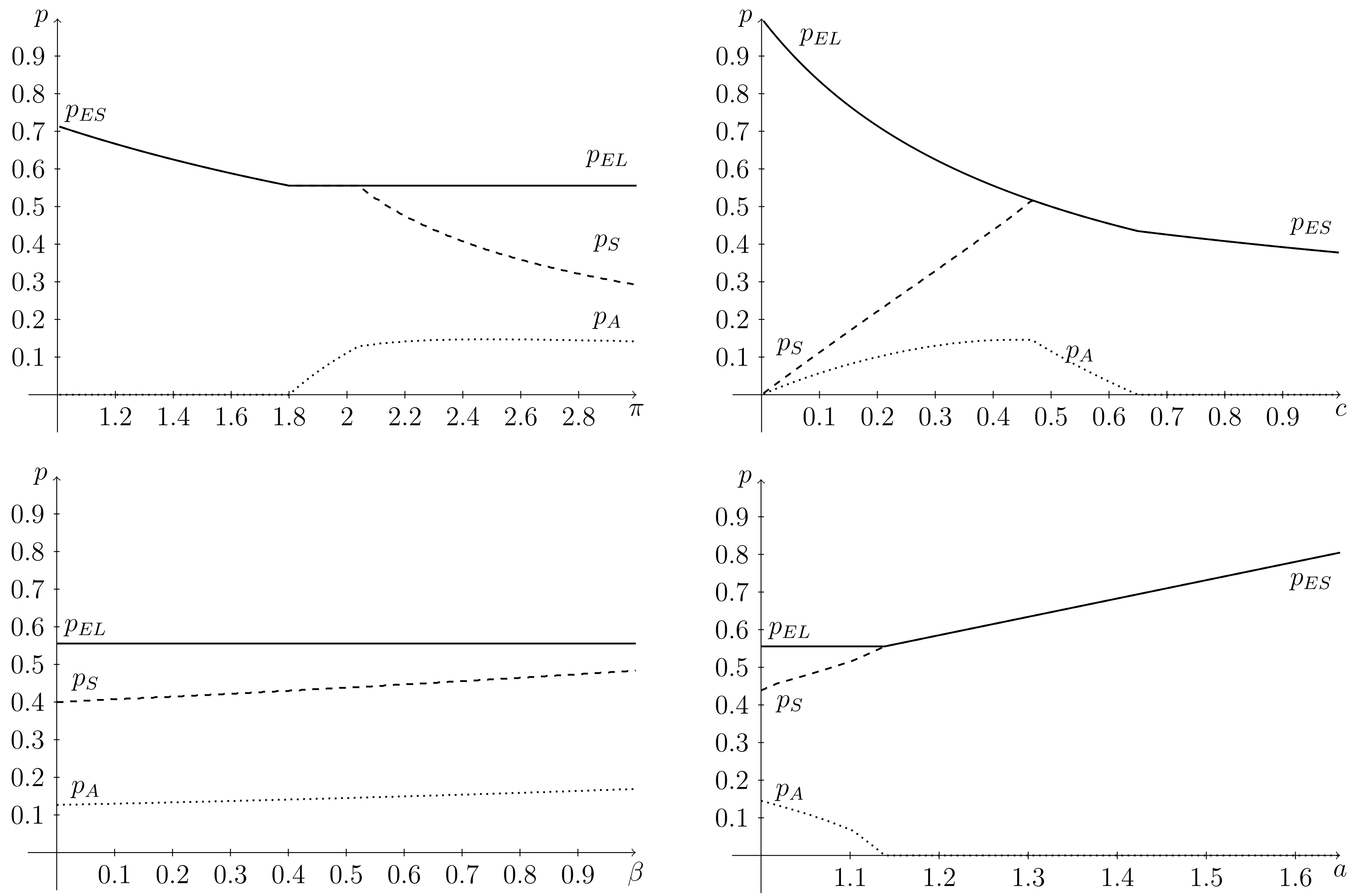

Figure 6: Equilibrium outcomes under the UK cost allocation rule. To allow for direct comparison of the outcomes, this figure has the same structure, scale, and underlying parameter values as Figure 4, but the legal costs are allocated as under the UK rule discussed in Section 6. The underlying deductible is optimally set at the value depicted in Figure 3 (UK rule).

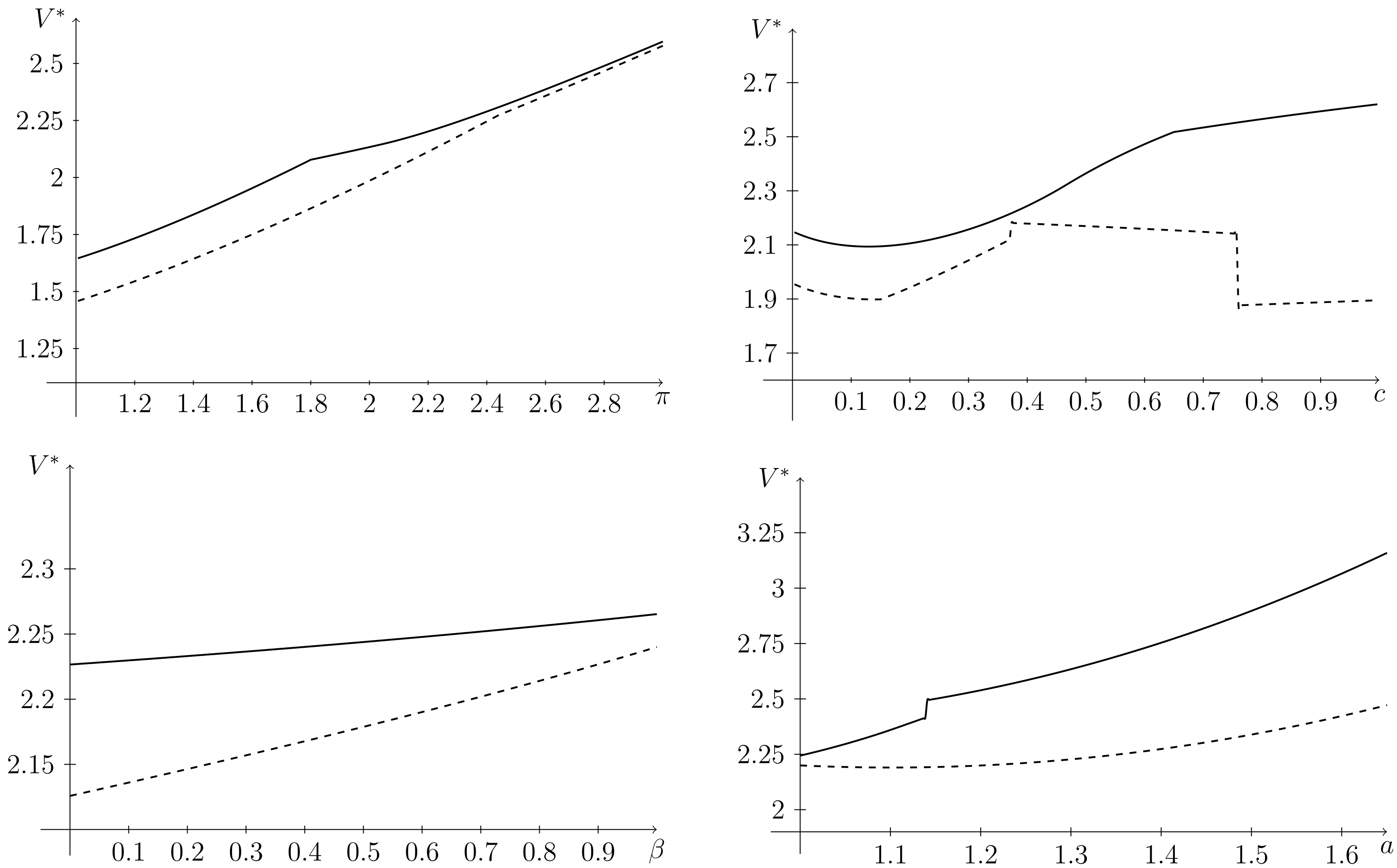

Figure 7: Expected profits of the patent holder with an without insurance (UK rule). The solid (dashed) line represents profits with (without) insurance. Parameter values are as in the baseline scenario described in the main text (i.e. $\pi = 2.3$, $c = 0.4$, $\beta = 0.5$, $a = 1$, and $\mu = 0$) except for the varying parameter that appears on the horizontal axis in each panel.