Patent Litigation with Endogenous Disputes

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The recent explosion of patenting and patent disputes has sparked a growing literature on the economics of patent litigation. Generally, models in this literature take the existence of a dispute as given. This assumption, however, limits the empirical relevance of these studies.

Disputes would not arise if all technology adopters obtained *ex ante* licenses from patent owners. This suggests that two stories could explain the origin of patent disputes. In one, the technology adopter observes a patented technology, but chooses to imitate, "inventing around" and/or hiding the infringement. In the other, the adopter develops its own technology and is unaware of another firm's putative patent rights. This kind of innocent infringement occurs because patent rights often have uncertain boundaries or questionable validity. In addition, the sheer number of patents facing a typical innovator makes careful assessment quite burdensome. Furthermore, patent claims are often hidden (sometimes strategically) until after firms have sunk technology investments.

These two accounts suggest that a model of disputes should consider: the decisions of patent owners to invent, to patent, and to monitor use of the patented technology by others; and the decisions of potential infringers to monitor extant patents, and develop and adopt new technology. Claude Crampes and Corinne Langinier (2002) endogenize disputes by focusing on a patent owner's monitoring activity and imitative behavior by potential infringers. Our model includes this behavior, but it also includes defendants who "invent around" a patent, and defendants who are unaware of the patented technology. We find that this richer model provides comparative statics that better match empirical evidence on patent litigation.

I. A Model of Patent Disputes

Our model (fully described in our working paper Bessen and Meurer (2006)) embeds a standard model of patent dispute resolution based on Meurer (1989), in a framework with early-stage patent and development investments by a patent owner and a potential defendant. The model has three stages. In stage one, firm 1 chooses an investment, P_1, in patent "refinement." We assume firm 1 has an exogenously given invention, and chooses a level of patent protection that influences the probability (actually a distribution of probabilities) of successfully suing firm 2 for patent infringement. Firm 1 can "refine" its patent protection to improve its probability by obtaining multiple patents, delaying the issuance of some of its patents through continuation practice, crafting multiple claims, investing in high quality claims and disclosures, conducting a careful prior art search, and also by monitoring the activities of firm 2. We assume a constant marginal and average cost of refinement, ρ.

In stage two, firms 1 and 2 simultaneously choose development investments, x_1 and x_2. We assume a constant marginal and average cost of development, δ_i. In stage three, the firms decide whether to dispute infringement and if so, they then decide whether to enter a license agreement or file a lawsuit.

We assume the firms hold symmetric information throughout the game. Between stages two and three, the firms observe the probability α that firm 1 could win an infringement suit against firm 2. At the earlier stages the firms know that α is distributed over [0, 1] according to the distribution function $F(\alpha; P_1, x_2)$. We assume that P_1 and x_2 induce shifts of F that satisfy first order stochastic dominance. It is natural to assume that P_1 and x_2 influence the distribution α. A patent dispute only arises when firm 2 adopts a technology that arguably falls within the scope of at least one of firm 1's patents. Firm 1 can improve its prospect at trial by investing more in patent refinement which shifts the distribution to the right, and firm 2 can affect its prospect at trial through its development investment. Possibly, firm 2 increases its exposure to a lawsuit by increasing it development investment; alternatively, firm 2 might reduce the probability of a successful suit by developing around the claim language in firm 1's patents, or by hiding its infringement. For now, we leave open the possibility that x_2 shifts the distribution either right or left.

In stage three, there are four possible outcomes:

1. Firm 2 observes α and decides to abandon its newly adopted technology ("deterrence"). Firm 1 gets a monopoly payoff $M(x_1)$ and firm 2 gets zero.

2. Firm 2 does not abandon the technology, but firm 1 does not assert its patent ("acquiescence"). The firms get duopoly profits $D_1(x_1)$ and $D_2(x_2)$ respectively.

3. Firm 1 asserts its patents and the firms bargain to a settlement. The payoffs are Nash bargaining solutions, S_1 and S_2. Let $\Sigma(\alpha, x_1, x_2)$ denote the joint profit from settlement, $\Sigma(\alpha, x_1, x_2) = S_1 + S_2$. Development investments could spill-over to raise the joint profit from settlement, but in the basic model we assume they have idiosyncratic value to the investor.

4. If bargaining breaks down, the firms litigate with payoffs $L_1(\alpha, x_1)$ and $L_2(\alpha, x_2)$. Firm 1 may sue because it gains advantages including: (a) a reputation for litigiousness, (b) avoidance of settlement cost, such as dissipation of rents under settlement; and (c) enhanced exclusionary value of a successfully litigated patent.

Naturally, the litigation payoffs depend on the probability that the patentee wins the lawsuit. We also allow the settlement payoffs to depend on this probability, because the rigor of antitrust regulation of patent licenses depends on the strength of the threatened patent suit. At one extreme, simple prosecution of a patent lawsuit can lead to antitrust liability if the suit is baseless. Also, output restrictions negotiated under the cover of sham patent licenses have resulted in antitrust liability. At the other extreme, courts have shown extreme deference to licenses involving strong patents. In particular, we assume that $\partial(L_1 + L_2)/\partial\alpha > \partial \Sigma/\partial\alpha > 0 > \partial L_2/\partial\alpha$, and that M, D_1, and D_2, are independent of α. This condition is required for equilibrium litigation and is consistent with our explanations above.[1]

II. Settlement, Lawsuit, Acquiescence or Deterrence

We find a subgame perfect Nash equilibrium by analyzing backwards through the three-stage game. In general, there are four solution regions as shown in Figure 1. The solution boundaries between these regions are:

1. α_A solves $L_1(\alpha) = D_1$. When $L_1 < D_1$, firm 1 lacks a credible threat of litigation and we assume that antitrust restrictions prohibit settlement, leading to acquiescence.[2]

2. α_L solves $L_1(\alpha) + L_2(\alpha) = \Sigma(\alpha)$. For $\alpha \in [\alpha_A, \alpha_L]$, both parties have a credible threat of suit, and the parties reach a license with $S_1 = (½)(\Sigma + L_1 - L_2)$, and $S_2 = (½)(\Sigma + L_2 - L_1)$. For $\alpha \in (\alpha_L, \alpha_D)$, a lawsuit is filed, firm 1 earns L_1 and firm 2 earns L_2.

3. α_D solves $L_2(\alpha) = 0$. For $\alpha \in [\alpha_D, 1]$, the alleged infringer cannot credibly defend a suit and drops out.

Given our assumptions we have unique solutions such that, $0 < \alpha_A < \alpha_L < \alpha_D < 1$.[3]

Figure 1 also displays the third-stage profit V_i for each firm as a function of the probability of a successful lawsuit α. As might be expected, a stronger patent suit helps firm 1 and hurts firm 2; the profit of firm 1 weakly increases in α, and the profit of firm 2 weakly decreases in α.

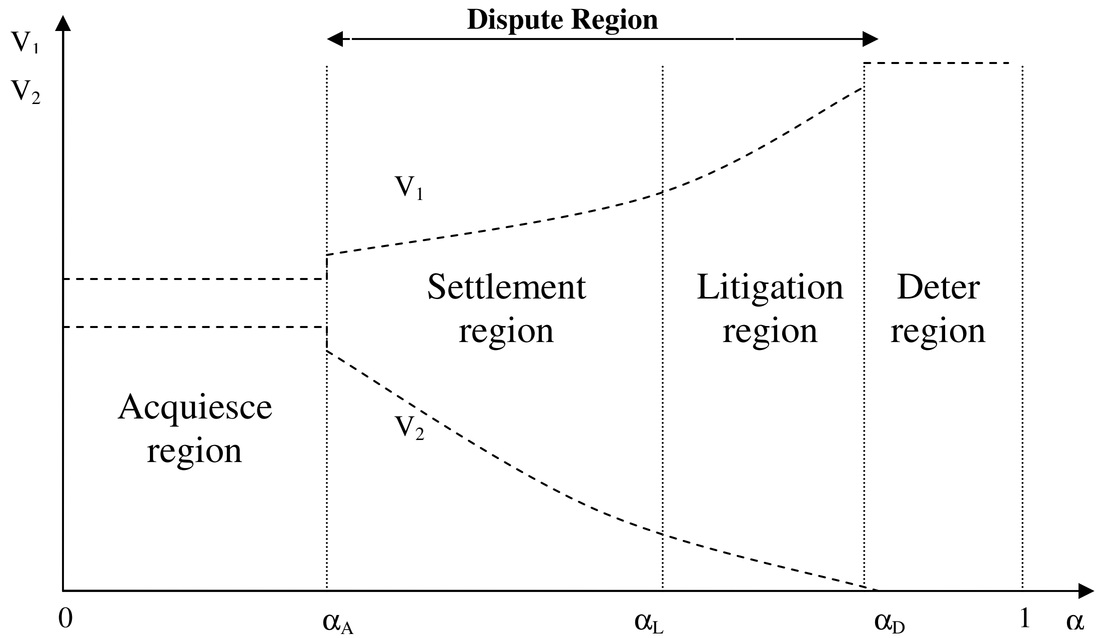

Figure 1.

III. Patent Refinement and Development Investment

At stage one when firm 1 makes patent investments and at stage two when firms 1 and 2 make simultaneous development investments, they believe the strength of a potential patent lawsuit by 1 against 2 has a probability distribution F(α; P_1; x_2). The firms look ahead to stage three using F to calculate the expected payoffs given acquiescence, settlement, litigation or deterrence. The expected profit for each firm is:

$$\pi_1(x_1,x_2,P_1)=\int_0^1 V_1(\alpha;x_1,x_2)dF(\alpha;x_2,P_1)-\delta_1 x_1-\rho P_1 \tag{1}$$
$$\pi_2(x_1,x_2,P_1)=\int_0^1 V_2(\alpha;x_1,x_2)dF(\alpha;x_2,P_1)-\delta_2 x_2$$

Recall $V_i(\alpha)$ denotes the profit to firm i at stage 3, marginal cost of development is denoted δ_i, and marginal cost of patent refinement is denoted ρ. The analysis in our working paper provides conditions on F sufficient to guarantee a unique subgame perfect Nash equilibrium in which x_1 and x_2 are strategic substitutes.

IV. Testable Implications of the Model

Our model of patent disputes generates a variety of comparative static results that we investigate empirically in Bessen and Meurer (2005). Consider two randomly selected firms. What determines the probability that one will file a lawsuit against the other? The probability of litigation is $\lambda = F(\alpha_D; P_1, x_2) - F(\alpha_L; P_1, x_2)$. Referring to Figure 1, this is the portion of the distribution *F* that falls between α_L and α_D. Generally, two sorts of effects will influence this probability: factors that move α_L and α_D, and factors that shift *F*.

Since our empirical investigation, unlike previous empirical studies, controls for the characteristics of both parties in the suits, it suffices to look at direct effects on the probability of litigation. These effects are (letting *f* be the probability density function):

$$\frac{d\lambda}{dP_1} = \frac{\partial}{\partial P_1}[F(\alpha_D; P_1, x_2) - F(\alpha_L; P_1, x_2)], \qquad \frac{d\lambda}{dP_2} = -f(\alpha_L)\frac{\partial \alpha_L}{\partial P_2}$$

$$\text{(2)} \qquad \frac{d\lambda}{dx_1} = -f(\alpha_L)\frac{\partial \alpha_L}{\partial x_1}$$

$$\frac{d\lambda}{dx_2} = f(\alpha_D)\frac{\partial \alpha_D}{\partial x_2} - f(\alpha_L)\frac{\partial \alpha_L}{\partial x_2} + \frac{\partial}{\partial x_2}[F(\alpha_D; P_1, x_2) - F(\alpha_L; P_1, x_2)]$$

These equations provide a framework for thinking about empirical results and the two sorts of influences. Generally, x_1 and x_2 influence α_L and α_D through the effect R&D has on the stakes each firm has at risk in litigation. Consider the effect of the patent holder's R&D, $d\lambda/dx_1$. If the industry is such that additional R&D investment allows firms to earn large additional profits (e.g., patent rents), then R&D investment will lead to greater gains from litigation, shifting α_L to the left (firm 1 would rather sue than settle). All else equal, a patent holder who invests more in R&D in such an industry will be more likely to sue. We find evidence that R&D spending by patent holders in the pharmaceutical and chemical industries—where patent rents are high—increases the probability of suit, but not in other industries, where patent appropriability is not so high. When we control for firm profits (actually, firm market value) to control α_L, this effect becomes insignificant in all industries, consistent with the theoretical model.

Shifts in the distribution *F* provide another margin of influence. We assume that the probability distribution is massed to the left, at low values of α. This assumption is motivated by the observation that technologies are diverse and that most pairs of randomly chosen firms will have very different technologies, unlikely to infringe each other's patents. In the empirical paper we construct a measure of technological distance and find support for this assumption.

This means that if, say, P_1 shifts the distribution to the right, then this will increase the probability of litigation—more mass will fall between α_L and α_D.[4] Since greater patent refinement—more patents, better quality patents, better monitoring, etc.—should shift *F* to the right, this is exactly the relationship we should expect, and we do, indeed, find that firms with larger portfolios are more likely to sue, all else equal.

Similarly, firm 2's R&D spending, x_2, may also shift the distribution, but this effect could be positive or negative. If firm 2 uses development investment mainly to "invent around" patents or aid piracy, then probability mass is shifted to the left out of the litigation interval—with this sort of infringement avoidance, firm 2 would be less likely to be found to infringe. Alternatively, if increasing firm 2's development investment exposes it to greater risk of inadvertent infringement, then probability mass is shifted to the right into the litigation interval. When we include firm profits (market value) in the regression to control for α_L and α_D, we find a strong positive effect of firm 2's R&D on the probability of litigation. This suggests that most defendants are inadvertent infringers rather than pirates or firms attempting to cheat by inventing around.[5]

The distribution of trial outcome probabilities is affected not only by the endogenous patenting and development choices of the firms, but also by a variety of exogenous factors of interest to us. This framework can also be used to think about policy changes. For example, relaxed antitrust rules increase the attractiveness of settlement, shifting α_L to the right, while reduced litigation cost and larger rents increase the attractiveness of litigation, moving it left. Similarly, legal changes that expand the scope of patent rights or make patent boundaries less clear would shift the distribution *F* to the right.

V. Conclusion: Vague Property Rights, Patent Disputes, and Patent Lawsuits

In an ideal (though not necessarily optimal) patent system in which validity and scope are clear, potential patent lawsuits would result in either a certain win or a certain loss for the patent owner. Then there would not be any patent disputes or lawsuits filed.[6] Innovative firms would seek an ex ante license or avoid adopting patented technology. And patent owning firms would have no incentive to make strategic investments in patent refinement. The distribution of *F* would be bi-modal, falling entirely within the acquiescence and deterrence regions.

In contrast, in our model the vagueness of patent rights leaves firms unsure about the strength of a potential patent lawsuit. In equilibrium, there are patent disputes, i.e., ex post settlement and litigation, when the realization of α falls into the interval $[\alpha_A, \alpha_D)$, and there are (observable) lawsuits filed when α falls into the interval (α_F, α_D).

Our model provides a framework for analyzing patent law changes affecting the certainty of patent rights. In the early 1980s, all patent appeals were consolidated in the newly created Federal Circuit. One goal of this change was to increase the clarity of patent rights. In the mid 1990s, patent claim construction was moved from juries to judges; again, one goal of this change was to increase the clarity of patent rights.

Clearly, if these reforms succeeded, then we should observe a reduction in lawsuits. More subtly, the model also provides a framework for predicting the effect of these reforms on the profit, development investment, and patenting behavior of innovative firms. We plan to investigate these effects in future work, and we hope to learn whether patent vagueness is a substantial impediment to innovative activities.

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End Notes

*Research on Innovation and Boston University School of Law, and Boston University School of Law, respectively. JEL Codes: K41, O31, O34.

[1] We refer the reader to our working paper Bessen and Meurer (2006) for other assumptions about the third stage payoffs.

[2] Shapiro (2003) discusses settlement of lawsuits involving weak patents.

[3] The proofs of this and all other results are contained in the working paper.

[4] This inference actually requires a slightly stronger assumption: that the probability density, *f*, monotonically decreases. Given the evidence that the probability mass is concentrated at low values of α, this would seem to be a parsimonious assumption for a large sample of diverse firms.

[5] In addition, we find that most defendants spend heavily on R&D—they are not simple copyists. Also, a substantial portion of lawsuits occur between firms that are in completely different industries and are technologically distant, again suggesting inadvertent or unavoidable infringement.

[6] Ignoring private information and other causes of litigation.