Legal Systems Comparison:
Firms' Strategies in Patent Litigation

Danmo Lin, Du Liu and A. Elizabeth Whalley

Warwick Business School
University of Warwick

Our research questions

Using a dynamic model, we examine:

- How do capital market frictions interact with legal systems in affecting firms' strategies in patent litigation?
  - Motivation: non-troll patent infringement lawsuits vary significantly across countries in terms of litigation and settlement rates.
  - Aoki and Hu (1999) use a game theory model to study the impact of legal cost allocation rule on patent licensing, litigation and R&D decisions, without considerations of capital market frictions.

- How do firms' strategies in patent litigation differ under the English rule ("loser pays") compared to the American rule ("each party pays"), with the consideration of financial constraints?
  - Strategies we investigate include: signing a license agreement before an infringement lawsuit is filed ("ex-ante settlement"), filing an infringement lawsuit, threatening to litigate to force out the alleged infringer, settling during litigation ("ex-post settlement"), unilaterally leaving the lawsuit.

Related literature

- Studies of non-troll patent litigation in economics and finance: e.g., Landes, 1971; P'ng, 1983; Bebchuk, 1984; Reinganum and Wilde, 1986; Meurer, 1989; Lanjouw, 1998; Aoki and Hu, 1999; Schankerman, 2001; Llobet, 2003; Choi and Spier, 2018; Mezzanotti, 2019; Caskurlu, 2019; Lin et al., 2020.

- The effects of financial constraints on real decisions for firms in competition: Bolton and Scharfstein, 1990; Campello et al, 2010; Li, 2011; Hugonnier et al., 2015; Bolton et al., 2019;

- Real options models on dynamic multi-player games: e.g., Lambrecht, 2001; Lambrecht and Perraudin, 2003; Pawlinda and Kort, 2006; Smit and Trigeorgis, 2006; Azevedo and Paxson, 2014; Jeon, 2015; Bustamante, 2015.

Model setup

In a real options model framework:

- Two firms competing in product markets:
  - Incumbent ("I") - patent owner, Challenger ("C") - allegedly infringed.
  - Both earn flow operating profits linear to market demand, i.e., πx_t
    where $x_t \sim$ GBM ($dx_t = \mu x_t dt + \sigma x_t dW_t$), and no other revenues.
  - $\pi = \pi_1$ in I monopoly, $\pi = \pi_2^I$ or $\pi = \pi_2^C$ in duopoly.

- Once litigation starts, the judgement $\sim$ Possion (λ). Both firms incur ongoing cost in litigation. Common knowledge that Prob(I wins) $= p$.

- Firms follow threshold strategies (threshold on x) regarding
  - ex-ante settlement vs. litigate vs. do nothing
  - ex-post settlement vs. leaving the lawsuit unilaterally to save litigation cost (either C exits or I withdraws) vs. waiting for judgement

- Comparison of the US vs UK legal system - focus on cost allocation
  - American rule: each party pays for its own legal costs
  - English rule: the losing party bears all legal costs
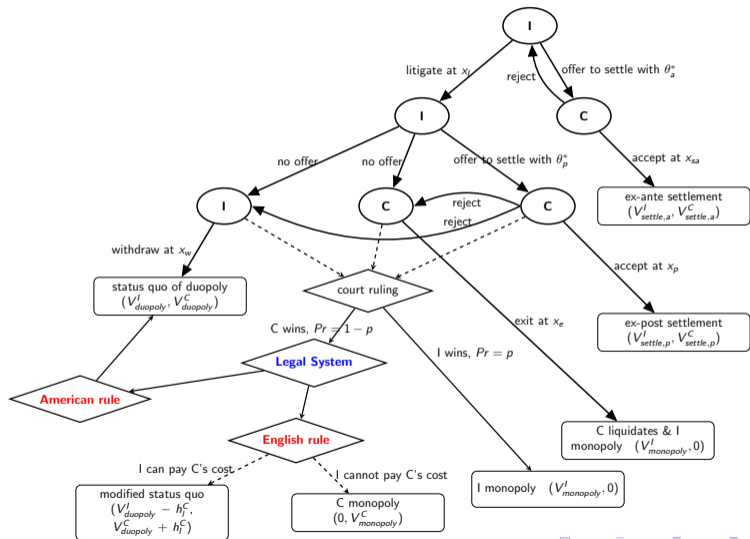
Implications of the English rule

Compared to the American rule, the English rule ("loser pays", interchangeable with *the UK rule*) has two implications:

1. If C wins, I $\xrightarrow{\text{£ (C's litigation cost)}}$ C; if I wins, no transfer due to C's financial constraint. $\Rightarrow$ *The English rule makes litigation more expensive for I.*

2. If C wins, I may liquidate b/c of its own financial constraints, if so, C becomes the new monopolist. *Losing the lawsuit becomes more detrimental to I under the English rule.* 2 possibilities with English rule:
   - Case 1. "I remains a going-concern" (always true under American rule)
   - Case 2. "I may liquidate" (only relevant under English rule)

Remark: both implications suggest that the English rule *favours C against I* when firms' financial constraints are taken into consideration.

Proposition

In Case 1 ("I remains a going-concern"), the value functions during litigation follow

$$V_s^I(x) = B_s^I x^{\alpha_1} - H_I^I + \frac{\pi_2^I x}{r-\mu} + \delta p(\pi_1^I - \pi_2^I)x, \tag{1}$$

$$V_s^C(x) = B_s^C x^{\alpha_1} - H_I^C + (\frac{1}{r-\mu} - p\delta)\pi_2^C x, \tag{2}$$

where $\delta = \frac{\lambda}{(r-\mu)(r+\lambda-\mu)}$, $\alpha_1 = \frac{1}{2} - \frac{\mu}{\sigma^2} - \sqrt{(\frac{1}{2} - \frac{\mu}{\sigma^2})^2 + \frac{2(r+\lambda)}{\sigma^2}}$. $H_I^I = h_I^I + \frac{\mathbb{1}_{UK} \cdot h_I^C(1-p)\lambda}{r+\lambda}$, $H_I^C = h_I^C - \frac{\mathbb{1}_{UK} \cdot h_I^C(1-p)\lambda}{r+\lambda}$ are the expected discounted expenditure on litigation with $h_I^C = \frac{c_I^I}{r+\lambda}$ and $h_I^I = \frac{c_I^C}{r+\lambda}$. B_s^I and B_s^C are two arbitrary constants to be determined depending on firms' strategies. The subscripts $s \in \{w, e, p\}$, and they represent "I withdraws", "E exits", "ex-post settlement").

Firm values during litigation - Case 2

Proposition

In Case 2 (i.e., "I may liquidate"), the firm values during litigation follow:

$$v_s^I = \begin{cases} a^I x^{\alpha_2} + b_s^I x^{\alpha_1} - h_I^I + \frac{\pi_2^I x}{r-\mu+\lambda} + p\delta\pi_1^I x, & \text{if } x_s < x < \bar{x} \\ B_s^I x^{\alpha_1} - H_I^I + \frac{\pi_2^I x}{r-\mu} + \delta p(\pi_1^I - \pi_2^I)x. & \text{if } x \geq \bar{x} \end{cases} \quad (3)$$

$$v_s^C = \begin{cases} a^C x^{\alpha_2} + b_s^C x^{\alpha_1} - h_I^C + \frac{\pi_2^C x}{r-\mu+\lambda} + \pi_1^C(1-p)\delta x, & \text{if } x_s < x < \bar{x} \\ B_s^C x^{\alpha_1} - H_I^C + (\frac{1}{r-\mu} - p\delta)\pi_2^C x. & \text{if } x \geq \bar{x} \end{cases} \quad (4)$$

where $\bar{x} = \frac{\mathbb{1}_{UK} \cdot h_I^C(r-\mu)}{\pi_2^I}$ is I's liquidation threshold, $\alpha_{1,2} = \frac{1}{2} - \frac{\mu}{\sigma^2} \pm \sqrt{(\frac{1}{2} - \frac{\mu}{\sigma^2})^2 + \frac{2(r+\lambda)}{\sigma^2}}$. The arbitrary constants a^I, a^C, b_s^I, B_s^I, b_s^C, B_s^C depend on firms' strategies. The subscripts $s \in \{w, e, p\}$, representing "I withdraws", "E exits", "ex-post settlement").

Firm values before litigation

Proposition

If the Incumbent were to withdraw first during litigation, firm values before litigation follow

$$(V_{bl}^I(x), V_{bl}^C(x)) = (\frac{\pi_2^I x}{r - \mu} + A_{bl}^I x^{\beta_1}, \frac{\pi_2^C x}{r - \mu} + A_{bl}^C x^{\beta_1})$$

If the Challenger were to exit first during litigation, firm values before litigation follow

$$(V_{bl}^I(x), V_{bl}^C(x)) = (\frac{\pi_2^I x}{r - \mu} + A_{bl}^I x^{\beta_1} + B_{bl}^I x^{\beta_2}, \frac{\pi_2^C x}{r - \mu} + A_{bl}^C x^{\beta_1} + B_{bl}^C x^{\beta_2})$$

where $\beta_{1,2} = \frac{1}{2} - \frac{\mu}{\sigma^2} \pm \sqrt{(\frac{1}{2} - \frac{\mu}{\sigma^2})^2 + \frac{2r}{\sigma^2}}$ ($\beta_1 > 0$). The arbitrary constants A_{bl}^i, B_{bl}^i, a_{bl}^i, b_{bl}^i are determined by whether firms settle ex-ante or enter litigation, and depend on Case 1 ("I remains a going-concern") vs Case 2 ("I may liquidate").

Result 1: royalty rate in ex-post settlement

The form of settlement: If settles, C $\xrightarrow{\text{a flow payment of } \Theta_p \pi_2^C \, dt}$ I.

$$\text{royalty rate: } \Theta_p^* = p\delta(r-\mu)\Big(1 - \frac{1}{\frac{\alpha_1}{\alpha_1-1}+\frac{1}{\Gamma}}\Big) + \frac{p\delta(r-\mu)}{\Phi}\Big(\frac{1}{\frac{\alpha_1}{\alpha_1-1}+\frac{1}{\Gamma}}\Big)$$

"relative cost saving": $\Gamma = \frac{H_I^C - c_p^C}{H_I^I - c_p^I}$. $\Gamma \uparrow \Rightarrow$ high litigation cost for C relative to I

"gain-to-loss ratio": $\Phi = \frac{\pi_2^C}{\pi_1 - \pi_2^I}$. $\Phi \downarrow \Rightarrow$ total(market size) shrinks more due to infringement

Result

Ceteris paribus, the royalty rate in an ex-post settlement is higher under the American rule than under the English rule (i.e., $\Theta_{p,UK}^* < \Theta_{p,US}^*$).

Result 2: Delay vs accelerate litigation

Result

Litigation thresholds are more sensitive to the gain-to-loss ratio Φ under the English rule than under the American rule. For small/big Φ, litigation thresholds are lower/higher under the English rule than under the American rule.
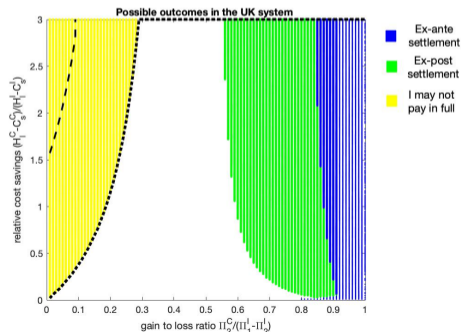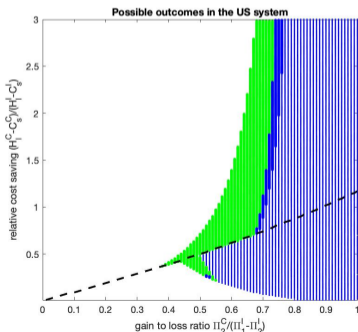
- Interpretation: When infringement reduces total market size to a greater/lesser extent, the English rule accelerates/delays litigation compared to the American rule.

- Intuition: the English rule reduces I's value of starting a litigation through (1) increasing I's effective litigation cost directly as a result of C's financial constraints and (2) increasing I's loss in case of losing the lawsuit due to I's own financial constraints. These effects make I less willing to wait (to litigate) when Φ is low. A larger Φ relaxes financial constraints for both firms, more so under the English rule than under the American rule, leading to more sensitive litigation decision by I under the English rule.

Result 3: settlement likelihood with respect to Φ and Γ

Result

Same under the two legal systems:

- *Settlement is only likely to occur if the gain-to-loss ratio is high enough.*
- *When one firm is particularly financially constrained, then settlement is less likely.*
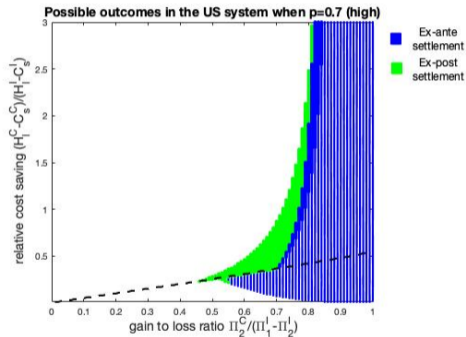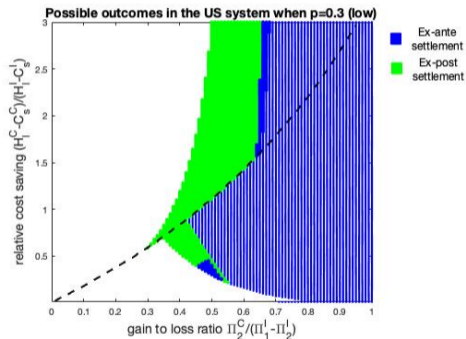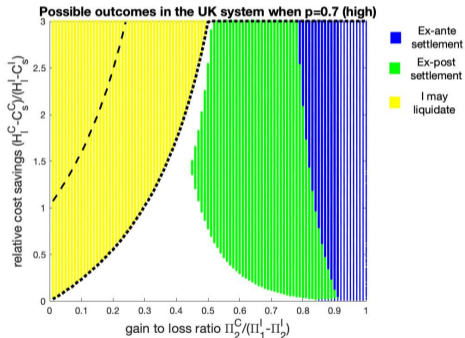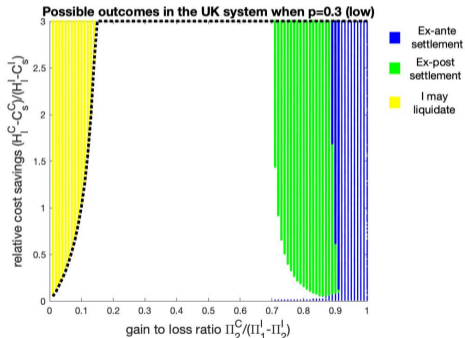
Result

*The effects of the probability of I winning (p) on settlement likelihood are **opposite** in the two legal systems: it increases/decreases the settlement likelihood under the American/English rule.*

Implication: If the patent approval process becomes more stringent, so it is more likely for a patent to be ruled valid in court, or if the probability of infringement ruling becomes higher, then the likelihood that the two firms settle decreases under the American rule, but increases under the English rule.
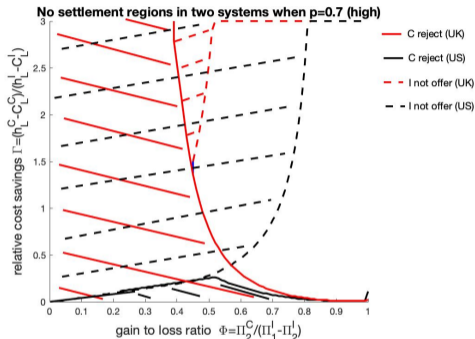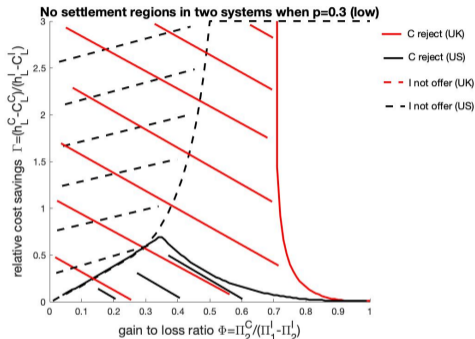
Result 4 - 1: $\dfrac{\partial \text{US(settlement likelihood)}}{\partial p} < 0$

Result 4 - 2: $\dfrac{\partial \text{UK(settlement likelihood)}}{\partial p} > 0$

Intuition for the result

Under both rules: $p \uparrow \Rightarrow$ Area(settlement offer rejected by C)$\downarrow$ Area(I refuses to offer settlement)$\uparrow$.
Because I Withdrawal area is larger under English rule than under American rule, therefore as p $\uparrow$

- English rule: C's rejection matters more for no-settlement $\Rightarrow$ settlement likelihood $\uparrow$
- American rule: I's refusal matters more for no-settlement $\Rightarrow$ settlement likelihood $\downarrow$

Result 5: product market volatility ↑⇒ settlement ↓

Result

Product market volatility σ reduces settlement likelihood. The effect of σ is more significant under the English rule than under the American rule.
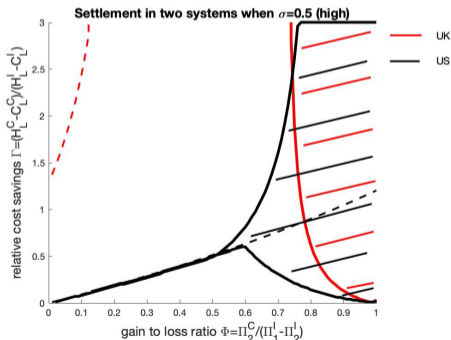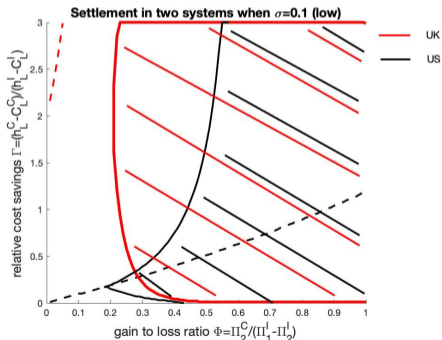
Model extension - Infringement and Innovation decisions

Going further back to C's infringement decision and I's innovation decision,

- Finding in a simple setting: the Incumbent has less innovation incentives under the English rule, compared with the American rule.

- Intuition: The English rule shifts the impact of financial constraints on patent litigation towards the Incumbent, reducing Incumbent 's value of innovation.

Testable implications

1. Litigation rates
   - The litigation rate is higher/lower under the English rule than the American rule if the infringing products are substitutes/compliments to I's.
2. Settlement rates
   - Under the American rule, policies which increase the winning probability of the plaintiff in a patent infringement lawsuit reduce settlement likelihood. It is opposite under the English rule.
3. Settlement terms
   - Everything else equal, the royalty rate in an ex-post settlement is lower under the English rule than under the American rule.

Main contribution

- Take a first theory step towards understanding how legal systems affect corporate innovation (Examples of empirical work on this topic include Caskurlu, 2019 and Mezzanotti, 2020) .
- Provide theory evidence that a legal system affects the strength of competitive advantage resulting from financial constraints

Thank you!

[Please send your comments/suggestions to the authors.]