Allocation of Legal Costs and Patent Litigation:
A Cooperative Game Approach

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Abstract

We compare the bargaining power of the patentee under American and English rules of legal costs allocation. Using the Nash Bargaining Game framework, we show that litigation can be a Pareto efficient outcome. The cooperative game framework allows us to examine how the institutional and market factors influence bargaining powers of plaintiff and defendant under different rules of legal cost allocation, free from assumptions on information and sequence of moves. The American rule renders the patentee more bargaining power when the legal system favors the defendant. An increase in damage reward raises bargaining power of the plaintiff and the settlement rate.

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1 Introduction

The importance of intellectual property (IP) has increased in the decade as technology has made transmission of information wider, cheaper and faster. For many nations, a great proportion of their wealth takes the form of information, knowledge, and intelligence, replacing the traditional forms of land, labor, and capital (Sadananda (1990)). However, compared to other property rights, intellectual property requires far more vigilance by the owner to maintain it and even then the protection is imperfect. [1]

Not surprisingly, IP protection was an important part of the most recent round of GATT (General Agreement on Tax and Tariffs) negotiations, [2] referred to as TRIPS (Trade-Related Aspects of Intellectual Property Rights). An important but an overlooked fact is that there are significant differences in the legal institutions among nations that agree on basically the same patent law. Legal procedures in most countries are not specially designed for patent litigation but formed by cultural, historical, political, and economic factors. It is important to note that the effective strength of patent protection and the bargaining powers of the patentee (plaintiff) and the infringer (defendant) will vary with the legal procedure.

It has long been recognized that different rules of legal cost allocation induce different settlement behaviors (for example, Posner (1973), Shavell

[1] The ex-post probability of the plaintiff (patentee) winning a patent infringement suit was 48% for years 1978 to 1985 (Hylton (1993a)).

[2] The Uruguay Round, initiated in 1986 and finalized in 1994.

(1982), Hause (1989)). Under the American rule, each party pays its own litigation expenses independent of the outcome. The philosophy of the American rule is that justice has its price. One needs to pay for seeking justice. On the other hand, the English rule, also known as the indemnity system, requires the losing party to pay the legal expenses for the prevailing party (Walker (1980), Ch. 20). It indemnifies the righteous side with the litigation cost. One does not need to pay for justice if he is right. Besides the fundamental difference in underlying philosophy of the two rules, the rules are significant in determining the strength of patent protection since they may affect the bargaining power.

We analyze the effect of rules of litigation cost allocation on patent protection using the Nash Bargaining framework. A cooperative game framework is appropriate for our analysis for several reasons. First of all, the Nash equilibrium in the non- cooperative bargaining model is very sensitive to the extensive form specification of the bargaining process. (See Fudenberg and Tirole (1991), Ch. 10) In particular, there is a first-mover advantage for the party which makes an offer first. If both parties were aware of this fact, then both sides would race to make an offer first which we do not observe. This is because both sides are also aware of this fact and take this into account.

Secondly, the equilibrium of the non-cooperative bargaining is also sensitive to informational assumptions. While information asymmetry is natural and significant in certain types of litigation, this is not always the case in patent litigation. In patent litigation, it is not uncommon for the defendant and plaintiff to have worked side by side on the same technology at some stage so that the defendant (the infringer) of a patent infringement suit is one of the inventors of the original patent. Under such circumstances, it is difficult to attribute the critical factor determining the outcome of the suit to informational asymmetry.

On a more theoretical level, the Nash Bargaining Solution is attractive in that it is the limit (either when probability of breakdown goes to zero or when length of time between offers go to zero) of the subgame perfect Nash equilibrium of the Rubinstein Alternating Offers model. (See Osborne and Rubinstein (1990), Ch. 15)

During the 1980's, the number of patent infringement suits rose by 50% and many high profile cases (Polaroid vs. Eastman Kodak, Honeywell vs. Minolta, Hyatt vs. North American Philips) have held out for verdicts instead of settling out of court. Traditional explanations for lack of settlement have resorted to some form of asymmetry. [3] We show that not settling will be the Nash Bargaining Solution as long as the legal costs are not too high relative to profits because the sum of payoffs from a verdict is greater than the sum of payoffs achievable through settlement due to the 'efficiency effect'. [4] The antitrust constraints pose restrictions on the settlement allo-

[3]Most of the existing literature ascribes the failure of settlement to asymmetry of some sort such as asymmetric beliefs in probabilities of winning (Gould (1973), Posner (1973), Shavell (1982), Katz (1988), Hause (1989)), asymmetric degrees of risk aversion (Landes (1971)) or asymmetric information (P'ng (1983), Reinganum (1986), Hylton (1993 b)). Meurer (1989) specifically analyzes a patent infringement suit and also obtains settlement under symmetric beliefs, for the same reason as ours.

[4]That is, the sum of duopoly profits is less than the monopoly profit.

cation, and shrink the size of joint profit the two firms can achieve with the settlement. Therefore not-settling can also be a Nash Bargaining solution under symmetric beliefs (Aoki and Hu (1996 a)). This is accomplished by defining the feasible set appropriately so that the disagreement point will be the solution. By definition of Nash Bargaining Solution, the no settlement outcome is Pareto efficient.

We also show that when there is settlement in equilibrium, the payment made by the defendant to the plaintiff is increasing in defendant's legal cost and decreasing in that of the plaintiff. [5] This is consistent with the fact that avoidance of legal cost is the most commonly cited reason for settling out of court by *both* plaintiffs and defendants. Yet previous models in which settlement transfer is endogenous have concluded that the size of transfer does not depend on the legal cost of the defendant (Reinganum and Wilde (1986), Meurer (1989) [6]). The fact that the defendant is just as eager to avoid heavy legal expenses was not reflected in the terms of settlement.

We also extend the basic model to the case where litigation costs are endogenous and determine the perceived probabilities. We find in this general model that the English rule encourages settlement. However the bargaining power of the patent owner depends not only the choice of the rule of allocating legal costs but also the parameters of the perceived probability function.

[5] Cooter and Rubinfeld (1989) has applied the Nash Bargaining Solution to explain terms of settlement in a nuisance suit.

[6] In Meurer's formulation, both parties have identical legal cost. However it is easy to see that the relevant cost is the one born by the plaintiff so that if the costs were different, the transfer is independent of defendant's legal cost.

Generally speaking, the American rule protects the patent right better when both parties think the defendant is more likely to win and the marginal effect of extra litigation cost is greater.

Litigation costs are exogenous and are allocated according to the American rule in the basic model formulated in the next section as a Nash Bargaining Game. The Nash Bargaining Solution is characterized in section 3. We do the same when the costs are allocated according to the English rule in section 4. Endogenous litigation costs are considered for both rules in section 5. We also show that an increase in the magnitude of damage reward raises the bargaining power of the patentee and the settlement rate. Possible extensions are discussed in section 6.

2 The Nash Bargaining Game Model with American Rule

In this section we formulate litigation with settlement as a Nash Bargaining Game (Myerson (1991)). We consider a patent infringement suit when the patentee is seeking an injunction barring further use of the infringing product along with a damage claim.

In the Nash (axiomatic) approach of bargaining, the relative timing of settlement and litigation is irrelevant. The framework covers both cases when settlement is reached after the suit has been filed (but no substantial legal expenditures have been realized) and when litigation is only a threat and the settlement is reached before litigation actually begins. Thus it is possible to interpret the settlement as a licensing agreement obtained to avoid litigation. (For the case when there is discounting and the two cases are differentiated, see Aoki and Hu (1996 b).)

A two-person Nash Bargaining Game (F, v) consists of a set of feasible payoff allocations, F, and a disagreement payoff allocation, v. F is a closed convex subset of $\Re^2$ and $v = (v_1, v_2)$ is a vector in $\Re^2$ and the set

$$FI = F \cap \{(\pi_1, \pi_2) | \pi_1 \geq v_1, \pi_2 \geq v_2\}$$

must be non-empty and bounded. A vector (π_1, π_2) is a payoff allocation where player i gets π_i. The non-emptiness of the set FI implies that there is at least one feasible payoff allocation that guarantees both players a payoff equal to or more than what the player will get if there is disagreement (i.e., feasible and incentive compatible).

We assume that firm 1 is the patentee (plaintiff) and firm 2 is the infringer (defendant). We define S to be the set of all possible profit pairs that the two firms may achieve together. A settlement will allow them to achieve one of these points. Given the antitrust restrictions, the most they can realize are duopoly profits. Thus

$$S = \{(\pi_1, \pi_2) | \pi_1 + \pi_2 \leq 2\pi_d, \pi_i \geq 0, i = 1, 2\}.$$

It is possible for the payoffs to be negative. One or both firms making a loss in the litigation and negotiation process is not ruled out *a priori*. If there were no antitrust considerations, the maximum the two firms can achieve together would be the monopoly profit, π_m, instead of $2\pi_d$.

Payoff that each firm gets in the absence of negotiation is the expected payoff of a verdict. We assume that firm i believes the patentee (the plaintiff) will win with probability θ_i. Thus firm 1 thinks itself will win with probability θ_1 while firm 2 thinks itself will win with probability $1-\theta_2$. In the basic model, we assume the perceived probabilities are exogenous. If firm 1, the patent owner, wins then firm 1 will be the monopolist with a damage reward (D) and firm 2 exits the market and pays the damage reward. If firm 2 wins, each firm will get the duopoly profit. The disagreement point is defined by the expected payoffs from litigation,

$$v_1 = \theta_1(\pi_m + D) + (1-\theta_1)\pi_d - \ell_1, \qquad v_2 = -\theta_2 D + (1-\theta_2)\pi_d - \ell_2,$$

where ℓ_i is the legal cost of firm i.

The disagreement point may be an element of the set S (case 1) or not (case 2). Case 1 occurs when the legal costs (ℓ_i's) are large or if the perceived probability of plaintiff victory (θ_i's) are sufficiently small (specifically, $\ell_1 + \ell_2 \geq \theta_1\pi_m - (\theta_1+\theta_2)\pi_d + (\theta_1-\theta_2)D$, see Figure 1). On the other hand, if the legal costs are small or if the firms believe that the probability of plaintiff victory is large ($\ell_1 + \ell_2 < \theta_1\pi_m - (\theta_1+\theta_2)\pi_d + (\theta_1-\theta_2)D$, see Figure 2), it will be case 2. Case 2 occurs because the monopoly profit is possible only by litigation.

Now we define the feasible set F by

$$F = convex\ hull(S \cup \{(v_1, v_2)\}).$$

When the disagreement point is an element of set S (case (1), Figure 1), the definition reduces to $F = S$ and

$$FI = \{(\pi_1, \pi_2) | \pi_1 + \pi_2 \leq 2\pi_d, \pi_1 \geq v_1, \pi_2 \geq v_2\}.$$

If the disagreement point lies outside the set S (case 2), then F corresponds to the shaded area in Figure 2. The set $FI = \{(v_1, v_2))\}$ is non-empty and bounded. [7]

3 The Nash Bargaining Solution under the American Rule

The Nash Bargaining Solution (NSB) is the only payoff allocation that satisfies the following five conditions: (i) strong efficiency, (ii) independence of irrelevant alternatives, (ii) symmetry, (iv) individual rationality, and (v) scale invariance.[8] We denote the NBS payoff allocations by $(\pi_1^{NBS}, \pi_2^{NBS})$. We

[7] Had we defined $F = S$, then the set FI would be empty when the disagreement point is not an element of S. See Aoki and Hu (1996 a) for details.

[8] Condition (i) guarantees that NBS is Pareto efficient. Condition (ii) requires that eliminating feasible points (except the disagreement point) that are not part of the solution

obtain the following characterization of the NBS of our Bargaining Game.

Proposition 1 *The Nash Bargaining Solution of the Nash Bargaining Game with American rule of cost allocation is the following:*

Case 1: *When* $\ell_1 + \ell_2 \geq \theta_1\pi_m - (\theta_1 + \theta_2)\pi_d + (\theta_1 - \theta_2)D$*, a settlement is reached and the payoffs are,*

$$\pi_1^{NBS} = \pi_d + \{\theta_1\pi_m + (\theta_1 + \theta_2)(\pi_d + D) - \ell_1 + \ell_2\}/2,$$
$$\pi_2^{NBS} = \pi_d - \{\theta_1\pi_m + (\theta_1 + \theta_2)(\pi_d + D) - \ell_1 + \ell_2\}/2.$$

Case 2: *When* $\ell_1 + \ell_2 < \theta_1\pi_m - (\theta_1 + \theta_2)\pi_d + (\theta_1 - \theta_2)D$*, litigation results and the payoffs are,*

$$\pi_1^{NBS} = v_1 = \theta_1(\pi_m + D) + (1 - \theta_1)\pi_d - \ell_1,$$
$$\pi_2^{NBS} = v_2 = -\theta_2 D + (1 - \theta_2)\pi_d - \ell_2.$$

If the litigation costs are low enough or probabilities of a victory are large enough, firms do not settle. This is because monopoly profit is only achievable with litigation. Each firm's payoff from settlement decreases with its own litigation and increases with rival litigation.

will not change the solution. If the players are symmetric ($v_1 = v_2$), then the symmetry of NBS guarantees the same payoff to each player. Individual rationality requires that the Nash Bargaining Solution should make each player at least as well off as with the disagreement point. Scale covariance implies that the solution is independent of any risk-neutral utility specification. (See Meyerson (1990) for details.) The scale covariance condition is required because the bargaining set is characterized in the Euclidean space.

Proof: When the disagreement point is not in the set S (Case 2), then the solution is simple since $FI = F \cap \{(\pi_1, \pi_2) | \pi_1 \geq v_1, \pi_2 \geq v_2\} = \{(v_1, v_2)\}$. The NBS is the disagreement point, i.e., $\pi_1^{NBS} = v_1$ and $\pi_2^{NBS} = v_2$.

For Case 1, we show in the Appendix using the standard characterization theorem (Meyerson (1990)),

$$\pi_i^{NBS} = v_i + \frac{1}{2}\{2\pi_d - (v_1 + v_2)\}, \quad i = 1, 2.$$

The two players equally split the surplus they achieve by a settlement.□

By definition, NBS is Pareto optimal. Lack of settlement in our model is not an inefficient outcome as result of strategic behavior or imperfect information as in non-cooperative game formulations. The Nash Bargaining Game describes a negotiation process where all relevant information is revealed. Particularly important is that both parties know each others' beliefs about winning. It is assumed that the negotiation process is such that all feasible payoff allocations are considered.

The settlement payoffs can be rewritten as

$$\pi_1^{NBS} = \pi_d + T, \quad \pi_2^{NBS} = \pi_d - T,$$

where $T = \{\theta_1 \pi_m + (\theta_2 - \theta_1)\pi_d + (\theta_1 + \theta_2)D - \ell_1 + \ell_2\}/2$. T is the transfer payment from the infringer to the patentee. T is positive if the plaintiff's expected payoff of a litigation is no less than duopoly profit ($v_1 \geq \pi_d$). Thus we have the following.

Proposition 2 *The settlement transfer payment from defendant to plaintiff (T) is strictly increasing in perceived probability of plaintiff victory (θ_1, θ_2), the defendant litigation cost (ℓ_2), and damage award (D). The transfer is strictly decreasing in plaintiff litigation cost (ℓ_1).*

The defendant is willing to pay more when its legal cost is high while it takes advantage of higher plaintiff legal costs. If either party believes a victory by the plaintiff to be more likely, the transfer payment increases. If the defendant believes (and the plaintiff is convinced that the defendant believes so) that it is very likely that it will lose (θ_2 large), it is willing to pay more to avoid litigation. If the plaintiff believes (and the defendant is convinced that the plaintiff believes so) the likelihood of own win is very high (θ_1 large), it enhances its bargaining power. A rise in damage award (D) also increases the patentee's bargaining power.

It is important here that we understand the significance of a *belief* or perceived probability in a bargaining game where there is no informational asymmetry. A player having a particular belief means that the player has credibly convinced the other player that it has such a belief. In order for the plaintiff to extract a higher transfer payment, it is not sufficient that it just announces that it has believes that it can win with high probability. The plaintiff must convince the defendant that it truly believes that the probability is high.

4 Comparison with the English Rule

The Nash Bargaining Game of litigation and settlement with the English rule of litigation cost allocation is identical to the model with the American rule presented in section 2 except for the disagreement point. Thus the settlement set S is the same. The disagreement point is now

$$\begin{aligned} v_1' &= \theta_1(\pi_m + D) + (1-\theta_1)(\pi_d - \ell_1 - \ell_2), \\ v_2' &= \theta_2(-\ell_1 - \ell_2 - D) + (1-\theta_2)\pi_d. \end{aligned}$$

The disagreement points under the two systems have the following relationships,

$$v_1' = v_1 + \theta_1\ell_1 - (1-\theta_1)\ell_2, \quad v_2' = v_2 + (1-\theta_2)\ell_2 - \theta_2\ell_1.$$

Under the English rule, firm 1 is better off by the own litigation cost (ℓ_1) if it wins (with probability θ_1) while it is worse off by defendant's litigation cost (ℓ_2) if it loses (with probability $1-\theta_1$) relative to the American rule. Thus its bargaining power (payoff at disagreement point) will be greater under the English rule if the expected gain ($\theta_1\ell_1$) is greater than the expected loss ($(1-\theta_1)\ell_2$). A similar argument holds for firm 2.

The sums of payoffs under the two rules, which determine if there will be settlement or not, have the following relationship,

$$(v_1' + v_2') - (v_1 + v_2) = (\theta_1 - \theta_2)(\ell_1 + \ell_2).$$

The condition $\theta_1 > \theta_2$ implies that the plaintiff's perception of plaintiff victory is greater than what the defendant believes. The condition can also be interpreted as $1 - \theta_1 < 1 - \theta_2$, i.e., the defendant's perception of defendant victory is greater than what the plaintiff believes. The sum of disagreement payoffs will be greater under English rule when each party's belief about own victory is greater than what the rival believes. When defendants have such beliefs, the expected gain from avoiding legal cost by winning is large enough so that the disagreement point under English rule is more attractive.

As with the American rule, there will be settlement if the disagreement point is in the set S (case $1'$) and no settlement if the point is not in the set (case $2'$). From the preceding argument, it follows that there will be settlement under the American rule but not under the English rule when parities have aggressive beliefs ($\theta_1 > \theta_2$). The opposite is true when parties are conservative in their assessments. That is,

Proposition 3 *The minimum joint litigation cost ($\ell_1 + \ell_2$) that induces settlement is larger [smaller] under American rule of cost allocation than under English rule if $\theta_2 > \theta_1$ [$\theta_1 > \theta_2$]. The minimum litigation cost to induce settlement are equal under the two rules when $\theta_1 = \theta_2$.*

The feasible allocation set (F') is defined as before using the disagreement point and the settlement set S.

$$F' = convex\ hull(S \cup \{(v_1', v_2')\}). \tag{1}$$

Proposition 4 *The Nash Bargaining Solution of the Nash Bargaining Game with English rule of cost allocation is the following:*

Case $1'$**:** *When* $\{1-(\theta_1-\theta_2)\}(\ell_1+\ell_2) \geq \theta_1\pi_m - (\theta_1+\theta_2)\pi_d + (\theta_1-\theta_2)D$, *a settlement is reached and the payoffs are,*

$$\pi_1^{NBS'} = v_1' + \{(1+\theta_2-\theta_1)(\ell_1+\ell_2) + (\theta_1+\theta_2)\pi_d - \theta_1\pi_m + (\theta_2-\theta_1)D\}/2,$$

$$\pi_2^{NBS'} = v_2' + \{(1+\theta_2-\theta_1)(\ell_1+\ell_2) + (\theta_1+\theta_2)\pi_d - \theta_1\pi_m + (\theta_2-\theta_1)D\}/2.$$

Case $2'$**:** *When* $\{1-(\theta_1-\theta_2)\}(\ell_1+\ell_2) < \theta_1\pi_m - (\theta_1+\theta_2)\pi_d + (\theta_2-\theta_1)D$, *a litigation results and the payoffs are,*

$$\pi_1^{NBS'} = v_1', \qquad \pi_2^{NBS'} = v_2'.$$

The payoffs with settlement under the English rule can be rewritten as

$$\pi_1^{NBS'} = \pi_d + T', \quad \pi_2^{NBS'} = \pi_d - T',$$

where $T' = \{\theta_1\pi_m + (\theta_2-\theta_1)\pi_d + (\theta_1+\theta_2-1)(\ell_1+\ell_2) + (\theta_1+\theta_2)D\}/2$. We make the following observation about the transfer payment.

Corollary 1 *Under the English rule, the settlement transfer payment (T')*

is strictly increasing in beliefs of plaintiff victory (θ_1, θ_2) *and damage reward* (D). *It will be increasing [decreasing] in the sum of litigation costs* ($\ell_1+\ell_2$) *if plaintiff [defendant] victory is believed to be very likely* ($\theta_1+\theta_2 > 1$ [$\theta_1+\theta_2 < 1$]). *The transfer payment is independent of legal costs when* $\theta_1 + \theta_2 = 1$.

The transfer payment depends on the sum of litigation costs since this is what is paid by a single firm (the loser) under English rule. As with the American rule, either party believing a victory for plaintiff more likely ($\theta_1 + \theta_2 > 1$) increases the transfer payment. This condition is equivalent to $\theta_1 > 1 - \theta_2$, i.e., the plaintiff's assessment of own victory is greater than the defendant's assessment of own victory. Then the plaintiff's bargaining position will be increasing in the sum of legal costs, enabling him to extract more from the defendant. If the assessments have the opposite relationship, the defendant's bargaining power will be increasing in the sum of legal costs.

5 When Probability of Winning Depends on Litigation Costs

Several authors (Posner(1973), Hause (1989)) have compared the effect of the American and English rules on settlement behavior when the probability of winning is determined by the amount of legal cost expended by both parties. Posner and Hause concluded that the English rule results in higher total Nash equilibrium litigation cost and induces more settlement when the probability distribution function is additively non-separable in litigation costs.

While factors such as the interpretation of the law by the courts will determine the perceived probability of winning (θ_i) it is conceivable that the amount of legal cost expended (ℓ_i) will also influence the probability. We follow the formulation by Hause (1989) of θ_i as a function of ℓ_1 and ℓ_2 which takes into account both of these factors. The probability θ_i has two parts. One is exogenous and determined by the administration and the court. The other is endogenous and is determined by litigation costs of both parties. We augment the distribution slightly in order to guarantee an interior solution to the maximization problem,

$$\theta_1(\ell_1, \ell_2) = A + b\frac{\ell_1}{\ell_1 + \ell_2}, \quad \theta_2(\ell_1, \ell_2) = B + b\frac{\ell_1}{\ell_1 + \ell_2},$$

where $0 \leq A+b \leq 1$, $0 \leq B+b \leq 1$ and $A, B, b \geq 0$. A and B are the subjective beliefs on the lower bound of the plaintiff's prevailing probability. The parameter b is the marginal change in the subjective probability of winning from change in litigation cost. It also determines the range the two litigants can effect above the lower bound of the probabilities.

When the perceived probability of winning is a function of litigation costs, optimal litigation costs must be determined in order to characterize the disagreement point of the Nash Bargaining Game. For this purpose, we assume that in the event of litigation firms play a non-cooperative game in which firms choose (respective) litigation costs simultaneously. We use the corresponding Nash equilibrium litigation costs to determine the expected payoffs from litigation (the disagreement point payoffs). The Nash equilibrium payoffs of this non-cooperative game defines the disagreement point of the Nash Bargaining Game.

5.1 Optimal Litigation Costs under American Rule

The expected payoffs for the plaintiff and the defendant when each firm spends ℓ_1 and ℓ_2 with the American rule are,

$$\theta_1(\ell_1, \ell_2)(\pi_m + D) + (1 - \theta_1(\ell_1, \ell_2))\pi_d - \ell_1,$$

$$-\theta_2(\ell_1, \ell_2)D + (1 - \theta_2(\ell_1, \ell_2))\pi_d - \ell_2.$$

These are the payoffs from the non-cooperative game given strategies ℓ_1 and ℓ_2. It is straightforward to show the following (see Appendix),

Proposition 5 *The Nash equilibrium litigation costs under the American rule of cost allocation are*

$$\ell_1^*|_{American} = b(\frac{\pi_m - \pi_d + D}{\pi_m + 2D})^2(\pi_d + D),$$

$$\ell_2^*|_{American} = b(\frac{\pi_d + D}{\pi_m + 2D})^2(\pi_m - \pi_d + D).$$

The corresponding equilibrium perceived probabilities of plaintiff victory are,

$$\theta_1^*|_{American} = A + b\frac{\pi_m - \pi_d + D}{\pi_m + 2D},$$

$$\theta_2^*|_{American} = B + b\frac{\pi_m - \pi_d + D}{\pi_m + 2D}.$$

Note that the Nash equilibrium litigation costs $(\ell_1^*, \ell_2^*)|_{American}$ are independent of lower bounds A and B which are the public policy variables. The equilibrium litigation costs only depend on profitability (π_m and π_d), damage rewards (D), and the marginal increase in probability from increasing legal costs (b). This is because what matters to the firm is the marginal increase in expected payoff. (See explanation following Proposition 6.) Only a legal reform that changes this marginal effect is effective in reducing litigation costs under the American rule. A shift of the winning probability lower bound (A or B) has no effect on the Nash equilibrium litigation costs under American rule. A straightforward calculation yields,

Corollary 2 *Under the American rule, the plaintiff's optimal litigation cost is no less than that of the defendant, as long as there is the efficiency effect. Specifically,*

$$\ell_1^*|_{American} \gtreqqless \ell_2^*|_{American} \quad \Leftrightarrow \quad \pi_m \gtreqqless 2\pi_d.$$

The corollary implies that the efficiency effect induces the plaintiff to spend more than the defendant in a patent infringement suit under the American rule. If we observe the phenomenon that the plaintiff spends strictly more than the defendant, it implies that the efficiency effect exists. Efficiency effect is essential in determining how much to spend in patent litigation under the American rule.

5.2 Optimal Litigation Cost under English Rule

The non-cooperative game expected payoffs for the plaintiff and the defendant under the English rule are,

$$\theta_1(\ell_1, \ell_2)(\pi_m + D) + (1 - \theta_1(\ell_1, \ell_2))(\pi_d - \ell_1 - \ell_2),$$

$$\theta_2(\ell_1, \ell_2)(-D - \ell_1 - \ell_2) + (1 - \theta_2(\ell_1, \ell_2))\pi_d.$$

Proposition 6 *The Nash equilibrium litigation costs under the English rule are*

$$\ell_1^*|_{English} = \frac{bB}{\pi_d + D}[\frac{\pi_m - \pi_d + D}{1 - A - b + B\frac{\pi_m - \pi_d + D}{\pi_d + D}}]^2,$$

$$\ell_2^*|_{English} = b\frac{(1 - A - b)(\pi_m - \pi_d + D)}{(1 - A - b + B\frac{\pi_m - \pi_d + D}{\pi_d + D})^2}.$$

In addition, the Nash equilibrium perceived probabilities of plaintiff victory are

$$\theta_1^*|_{English} = A + b\frac{B(\pi_m - \pi_d + D)}{B(\pi_m - \pi_d + D) + (1 - A - b)(\pi_d + D)},$$

$$\theta_2^*|_{English} = B + b\frac{B(\pi_m - \pi_d + D)}{B(\pi_m - \pi_d + D) + (1 - A - b)(\pi_d + D)}.$$

The proof is in the Appendix.

Under the English rule, the equilibrium litigation costs $(\ell_1^*, \ell_2^*)|_{English}$ are functions of all parameters, in particular they depend on the probability lower bounds A and B. The marginal benefit from increasing the probability of winning is the product of marginal increase in probability and the payoff. Under English rule, the payoff depends on the probability of winning since the cost of litigation is incurred only when the agent loses. Thus the probability lower bound is relevant. With American rule of cost allocation, payoff (not expected payoff) is deterministic and independent of the probability mean. Accordingly, which side spends more depends on the probability as well as the profits as stated below.

Corollary 3 *Under the English rule,*

$$\ell_1^*|_{English} \gtreqless \ell_2^*|_{English} \quad \Leftrightarrow \quad \frac{B}{1-A-b} \gtreqless \frac{\pi_d + D}{\pi_m - \pi_d + D}.$$

5.3 Which Rule Protects the Patent Right Better: American or English?

To illustrate the effect of changing one rule to another on patent protection, we show the numerical examples in Tables 1, 2, and 3.

Under both rules, patentee's bargaining power $(v_1 - v_2)$ [9] increases as A, B and b increase. However, the rule under which the patentee has greater bargaining power depends on the size of parameters. If A, B, b are small,

[9]It is easy to show that the settlement transfer payment is determined by the difference of the disagreement point payoffs, i.e.,$\pi_1^{NBS} = \pi_d + (v_1 - v_2)/2$, $\pi_2^{NBS} = \pi_d - (v_1 - v_2)/2$.

American rule gives greater bargaining power to the patentee. It is the English rule that favors the patentee otherwise. When A and B are large, it is very likely that the defendant will pay the legal costs under the English rule. Therefore, the defendant is willing to pay more to settle under the English rule than the American rule. When b is large, it is then more likely for the patentee to transfer the legal cost to the patentee through the adoption of the English rule. These results suggest that it is possible to increase the bargaining position of a patentee by changing the rule of cost allocation.

Under both rules, the total litigation cost increases in the damage reward. Higher damage reward induces the plaintiff to spend more in obtaining it. The defendant also is willing to expend more to avoid it. Thus higher damage reward makes both litigants more 'militant'. As a result, both parties are more eager to avoid higher litigation costs when damage reward is raised.

Recall that under both rules, the endogenously determined litigation costs (ℓ_1^*, ℓ_2^*) and the beliefs (θ_1^*, θ_2^*) are functions of the damage reward (D). Therefore the magnitude of the damage reward will affect the settlement conditions under both rules. From these numerical examples, it is shown that an increase in D encourages settlement under both rules. A legal reform to encourage settlement (to prevent social loss from litigation costs) should raise the magnitude of damage reward to serve the purpose. This argument is similar to Landes's (1993) result that sequential trials reduce the likelihood that parties settle out of court by restricting range of possible settlements.

Under both rules, the patentee's bargaining power increases in the damage reward. Therefore the patent-legal system can reinforce patent protection by adopting a punitive reward rule. That is, the damage reward can be more than patentee's actual loss $(\pi_m - \pi_d)$. Although the damage reward should be 'adequate to compensate the reward' a punitive reward to the plaintiff can be three times the damage if the patent infringement is intentional in the U.S. [10]

There are also results that are not particular to a patent infringement suit and are consistent with previous literature. The English rule induces higher total litigation costs. This is again due to the fact that the marginal benefit of increasing litigation cost depends on probability of winning in two ways: the marginal increase in probability and the expected payoff. Bang per buck with English rule is larger and increases competition, leading to greater expenditure in equilibrium. However the perceived probabilities of patentee winning or losing may be lower or higher with the English rule (Posner (1973) , Hause (1989)). There is more settlement with English rule. That is, whenever there is settlement under the American rule, there will be settlement under the English rule but not vice versa. Higher equilibrium litigation cost reduces the disagreement payoffs and increases the gain from settling. (Posner (1973) , Shavell (1982), and Hause (1989)).

[10] In India, where patent protection is generally weak (A and B are small), patentee's position will be improved by switching from the English rule to the American rule. On the other hand, if the patentee is already favored (perhaps U.S. very recently, see Warshofsky (1994)), patentee's position can be decreased by switching to English rule.

6 Concluding Remarks

Using medical malpractice claims data from Florida during the period 1980-85 during which English rule was applied, Hughes and Snyder (1995) show that the English rule increased plaintiff success rates at trial, average jury awards, and out-of-court settlements. Our conclusion is consistent with their empirical results provided that both parties believe that the plaintiff is more likely to win (the system is in favor of the plaintiff). This is likely for instance if there is common belief that jury in Florida is in favor of the plaintiff.

By defining the payoff allocations in terms of profits, we have assumed that both the defendant and plaintiff are risk-neutral. However by defining the payoff allocations in terms of utilities, our analysis can be extended to take different levels of risk aversion (including risk-loving) into consideration.

The relative positions of the disagreement point and the boundary of the set S will change according to the utility function. The disagreement point for firm 1 denoting it's utility function by $u_1(\cdot)$ will be

$$\theta_1 u_1(\pi_m - \ell_1) + (1-\theta_1) u_1(\pi_d - \ell_1).$$

A more risk-averse (concave) utility function will increase $u_1(\pi_d)$ more relative to $u_1(\pi_m)$. It has the effect of pulling the disagreement point towards the axis, moving the disagreement point from outside the set S to inside it. [11] This means a settlement is possible (for the same litigation costs) when it

[11]The set S also changes shape with u_1 but it only depends only on $u_1(\pi_d)$, not on

is not possible if the firm were less risk-averse.

Similarly, a risk-loving (convex) utility function has the effect of moving the disagreement point away from the axis, putting the disagreement outside the set S when it would be inside with a less risk-loving utility function. Thus litigation will result when a firm is risk-loving under circumstances in which there will be settlement with a less risk-loving firm (Landes (1971)).

We may apply our approach to cases where there are more than one infringers. Both the difference between winning and losing ($\pi_m - \pi_d$ when there is only one infringer) and the status quo profit (π_d when there is only one infringer) will change. The disagreement point may move outward (if the change in the difference between winning and losing is large relative to that of status quo payoff) or inward (otherwise) relative to the origin. On the other hand, the boundary of the settlement set S will shift towards the origin because what the plaintiff and the defendant can achieve together will be smaller when there are other firms in the market. It is not immediate whether there will be more or less litigation.

It is also possible to change the number of infringers participating in the trial in order to compare the effect of unitary and sequential trials. When the trials are sequential, the beliefs (θ_i) of the players in the second trial will be function of the outcome of the first trial.

We have found that the English rule protects the patent right better only when the patent-legal system is in favor of the patent owner. Yet in most

$u_1(\pi_m)$.

developing countries where the probability for the patentee winning is low, the American rule of legal cost allocation is recommended. Our analysis also indicates that it is possible to strengthen patent protection by introducing a punitive reward system instead of changing the court system which may be time consuming and costly.

In addition to the rule of legal cost allocation, other aspects in legal procedure can also effectively affect patent protection. For example, Aoki and Hu (1996 b) consider the time-span of litigation to patent protection. How the time to imitate, the time to obtain a verdict, and the length of patent right determine the licensing and infringement decision, patent lawsuit settlement rate, and patent license fee are analyzed.

The price of the intellectual property is a function of legal factors. Higher IP protection effectively raises the price of IP. However existing IP pricing models contain cash flow of expenditures and revenues, independent of legal institutions (Smith and Parr (1993)). We have characterized the transfer payment (license fee of a patent) that varies with legal procedure and costs. Further development should yield an IP pricing model with legal factors.

Table 1:Numerical Examples under the American and the English Rules ($D = 0$)

Rule	π_m	π_d	b	A	B	ℓ_1^*, ℓ_2^*	$\ell_1^* + \ell_2^*$	θ_1^*	θ_2^*	Settle	$v_1 - v_2$
American	2.2	1	.1	.45	.45	.0298, .0248	.0545	.5045	.5045	NS	1.1050
English						.0661, .0551	.1212	.5045	.5045	S	1.1111
American	2.0	1	.1	.45	.45	.0205, .0205	.0500	.5	.5	S	1
English						.0556, .0556	.1111	.5	.5	S	1
American	2.2	1	.1	.1	.1	.0298, .0248	.0545	.1545	.1545	S	.3350
English						.0170, .1134	.1304	.1130	.1130	S	.1478
American	2.2	1	.1	.3	.3	.0298, .0248	.0545	.3545	.3545	NS	.7750
English						.0469, .0781	.1250	.3375	.3375	S	.7019
American	2.2	1	.1	.5	.5	.0298, .0248	.0545	.5545	.5545	NS	1.2150
English						.0720, .0480	.1200	.5600	.5600	S	1.2464
American	2.2	1	.1	.7	.7	.0298, .0248	.0545	.7545	.7545	NS	1.6550
English						.0932, .0222	.1154	.7808	.7808	NS	1.7825
American	2.2	1	.1	.9	.9	.0298, .0248	.0545	.9545	.9545	NS	2.0950
English						.1111, .0000	.1111	1	1	NS	2.3111
American	2.2	1	.1	.7	.5	.0298, .0248	.0545	.7545	.5545	NS	1.4550
English						.1125, .0375	.1500	.7750	.5750	NS	1.5575
American	2.2	1	.1	.9	.5	.0298, .0248	.0545	.9545	.5545	NS	1.6950
English						.2000, .0000	.2000	1.0000	.6000	NS	1.9200
American	2.2	1	.1	.5	.3	.0298, .0248	.0545	.5545	.3545	NS	1.0150
English						.0748, .0831	.1579	.5474	.3474	NS	.9876
American	2.2	1	.1	.5	.1	.0298, .0248	.0545	.5545	.1545	NS	.8185
English						.0533, .1775	.2308	.5231	.1231	NS	.6691
American	2.5	1	.1	.5	.5	.0360, .0240	.0600	.5600	.5600	NS	1.3880
English						.0851, .0454	.1305	.5652	.5652	NS	1.4301
American	2.2	1	.3	.5	.5	.0893, .0744	.1636	.6636	.6636	S	1.4451
English						.3375, .1125	.4500	.7250	.7250	S	1.7975

Table 2: Numerical Examples under the American and the English Rules ($D = 0.6$)

Rule	π_m	π_d	b	A	B	ℓ_1^*, ℓ_2^*	$\ell_1^* + \ell_2^*$	θ_1^*	θ_2^*	Settle	$v_1 - v_2$
American	2.2	1	.1	.45	.45	.0448, .0399	.0847	.5029	.5029	NS	1.7050
English						.0997, .0886	.1882	.5029	.5029	S	1.7111
American	2.0	1	.1	.45	.45	.0400, .0400	.0800	.5	.5	S	1.6000
English						.0899, .0899	.1778	.5	.5	S	1.6000
American	2.2	1	.1	.1	.1	.0448, .0399	.0847	.1529	.1529	S	.5150
English						.0243, 1.729	.1973	.1123	.1123	S	.2290
American	2.2	1	.1	.3	.3	.0448, .0399	.0847	.3529	.3529	S	1.1950
English						.0691, .1229	.1920	.3360	.3360	S	1.0794
American	2.2	1	.1	.5	.5	.0448, .0399	.0847	.5529	.5529	NS	1.8750
English						.1093, .0777	.1970	.5584	.5584	S	1.9206
American	2.2	1	.1	.7	.7	.0448, .0399	.0847	.7529	.7529	NS	2.5550
English						.1454, .0369	.1823	.7797	.7797	S	2.7531
American	2.2	1	.1	.9	.9	.0448, .0399	.0847	.9529	.9529	NS	3.2350
English						.1778, .0000	.1778	1	1	NS	3.5778
American	2.2	1	.1	.7	.5	.0448, .0399	.0847	.7529	.5529	NS	2.2350
English						.1741, .0619	.2361	.7738	.5738	NS	2.3929
American	2.2	1	.1	.9	.5	.0448, .0399	.0847	.9529	.5529	NS	2.5950
English						.3200, .0000	.3200	1	.6	NS	2.9520
American	2.2	1	.1	.5	.3	.0448, .0399	.0847	.5529	.3529	NS	1.5550
English						.1117, .1324	.2441	.5458	.3458	NS	1.5091
American	2.2	1	.1	.5	.1	.0448, .0399	.0847	.5529	.1529	NS	1.2350
English						.0771, .2741	.3512	.5220	.1220	NS	1.0096
American	2.5	1	.1	.5	.5	.0515, .0393	.0908	.5568	.5568	NS	2.0477
English						.1235, .0753	.1988	.5621	.5621	NS	2.1046
American	2.2	1	.3	.5	.5	.1345, .1196	.2541	.6588	.6588	S	2.2251
English						.5224, .1858	.7082	.7213	.7213	S	2.7659

Table 3: Numerical Examples under the American and the English Rules ($D = 1.2$)

Rule	π_m	π_d	b	A	B	ℓ_1^*, ℓ_2^*	$\ell_1^* + \ell_2^*$	θ_1^*	θ_2^*	Settle	$v_1 - v_2$
American	2.2	1	.1	.45	.45	.0599, .0549	.1148	.5022	.5022	S	2.3050
English						.1331, .1221	.2551	.5022	.5022	S	2.3111
American	2.0	1	.1	.45	.45	.0550, .0550	.1100	.5	.5	S	2.2000
English						.1222, .1222	.2444	.5	.5	S	2.2000
American	2.2	1	.1	.1	.1	.0599, .0549	.1148	.1522	.1522	S	.6950
English						.0317, .2323	.2640	.1120	.1120	S	.3103
American	2.2	1	.1	.3	.3	.0599, .0549	.1148	.3522	.3522	S	1.6150
English						.0913, .1675	.2588	.3353	.3353	S	1.4571
American	2.2	1	.1	.5	.5	.0599, .0549	.1148	.5522	.5522	S	2.5350
English						.1464, .1074	.2538	.5577	.5577	S	2.5947
American	2.2	1	.1	.7	.7	.0599, .0549	.1148	.7522	.7522	NS	3.4550
English						.1974, .0517	.2491	.7792	.7792	S	3.7236
American	2.2	1	.1	.9	.9	.0599, .0549	.1148	.9522	.9522	NS	4.3750
English						.2444, .0000	.2444	1	1	S	4.8444
American	2.2	1	.1	.7	.5	.0599, .0549	.1148	.7522	.5522	NS	3.0150
English						.2456, .0864	.3220	.7732	.5732	NS	3.2281
American	2.2	1	.1	.9	.5	.0599, .0549	.1148	.9522	.5522	NS	3.4950
English						.4400, .0000	.4400	1	.6	NS	3.9840
American	2.2	1	.1	.5	.3	.0599, .0549	.1148	.5522	.3522	NS	2.0950
English						.1485, .1815	.3300	.5450	.3450	NS	2.0307
American	2.2	1	.1	.5	.1	.0599, .0549	.1148	.5522	.1522	NS	1.6550
English						.1010, .3704	.4714	.5214	.1214	NS	1.3502
American	2.5	1	.1	.5	.5	.0668, .0514	.1212	.5551	.5551	NS	2.7076
English						.1613, 1051	.2664	.5605	.5605	NS	2.7789
American	2.2	1	.3	.5	.5	.1797, .1647	.3443	.6565	.6565	S	3.0050
English						.7067, .2591	.9659	.7195	.7195	S	3.7338

Appendix

Proof of Proposition 1 Case 1: The NBS is the solution to the following constrained maximization problem:

$$\max_{(\pi_1,\pi_2)} (\pi_1 - v_1)(\pi_2 - v_2)$$

$$\begin{aligned} \text{subject to} \quad & \pi_1 \geq v_1, & (2)\\ & \pi_2 \geq v_2, & (3)\\ & \pi_1 + \pi_2 \leq 2\pi_d, & (4) \end{aligned}$$

Since the disagreement point is an interior point of the set S constraints (2) and (3) are not binding. Let the Lagrangean multiplier for (4) be λ.

The necessary and sufficient first order condition[12] is,

$$\begin{aligned} \pi_1 &= v_1 + \lambda, & (5)\\ \pi_2 &= v_2 + \lambda, & (6)\\ \pi_1 + \pi_2 &= 2\pi_d. \end{aligned}$$

Equations (5) and (6) show that each player must receive something (λ) in addition to what it would get from a litigation. From all three equations, $\lambda = \{2\pi_d - (v_1 + v_2)\}/2$. The two players split equally the surplus they achieve by a settlement. □

Proof of Proposition 5: The first-order conditions of expected payoffs maximization given a level of rival legal cost are,

$$\frac{b\ell_2}{(\ell_1+\ell_2)^2}(\pi_m - \pi_d + D + \ell_1 + \ell_2) - (1 - A - b\frac{\ell_1}{\ell_1+\ell_2}) = 0, \quad (7)$$

$$\frac{b\ell_1}{(\ell_1+\ell)^2}(\pi_d + D + \ell_1 + \ell_2) - (B + b\frac{\ell_1}{\ell_1+\ell_2}) = 0.$$

Since the second-order conditions,

$$-\frac{2\ell_2}{(\ell_1+\ell_2)^3}(\pi_m - \pi_d + D) < 0, \quad (8)$$

$$-\frac{2\ell_1}{(\ell_1+\ell_2)^3}(\pi_d + D) < 0,$$

[12]It is easy to show that the second order condition is satisfied.

are satisfied, equations (7) and (8) characterize the best-response functions from which the unique pure strategy Nash equilibrium can be found. By substituting the equilibrium legal costs into the probability functions, we obtain θ_1^* and θ_2^*. □

Proof of Proposition 6: The first-order conditions of expected payoffs maximization under the English rule are

$$\frac{b\ell_2}{(\ell_1+\ell_2)^2}(\pi_m-\pi_d+D+\ell_1+\ell_2)-(1-A-b\frac{\ell_1}{\ell_1+\ell_2}) \quad =0, \tag{9}$$

$$\frac{b\ell_1}{(\ell_1+\ell_2)^2}(\pi_d+D+\ell_1+\ell_2)-(B+b\frac{\ell_1}{\ell_1+\ell_2}) \quad =0. \tag{10}$$

The second-order conditions under the English rule are

$$-\frac{2\ell_2}{(\ell_1+\ell_2)^2}(\pi_m-\pi_d+D)<0,$$

$$-\frac{2\ell_1}{(\ell_1+\ell_2)^2}(\pi_d+D)<0.$$

With the two first-order conditions, the analytical solution for the Nash equilibrium litigation expenses under the English rule can be solved. Plugging the analytical solution of the Nash equilibrium litigation costs into the belief functions, we then obtain the Nash equilibrium beliefs. □

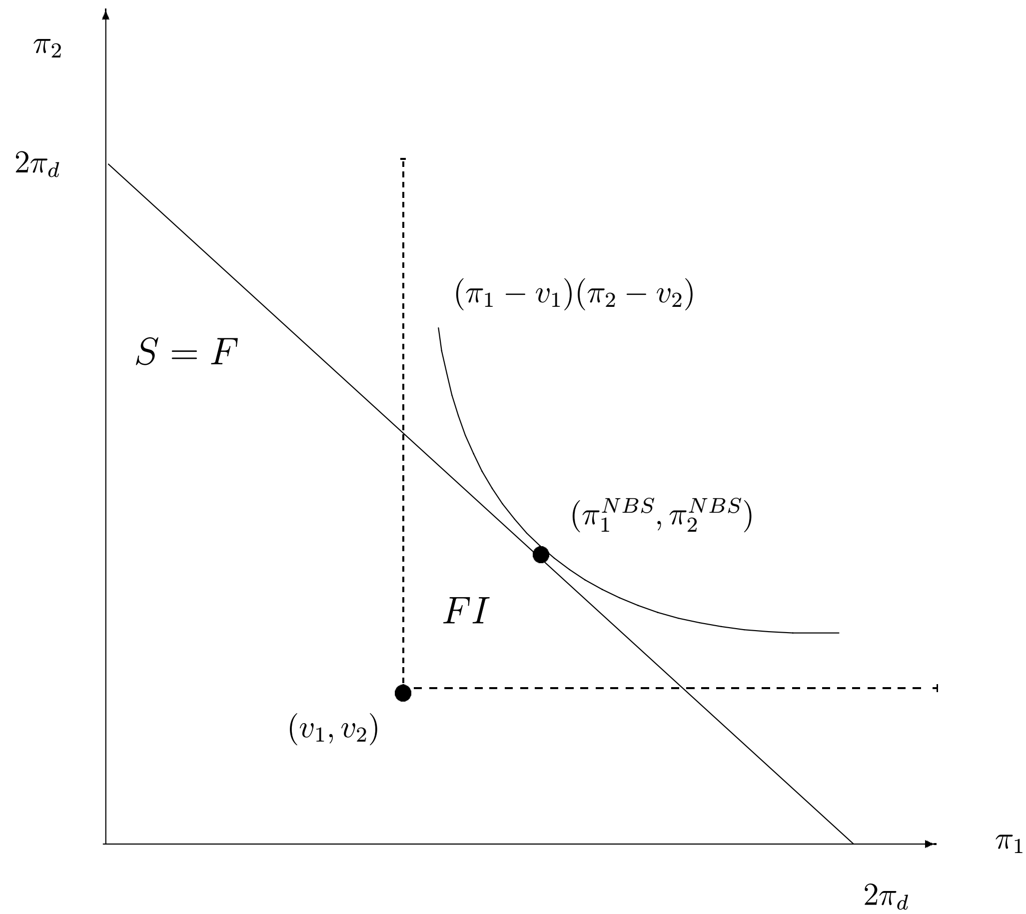

Figure 1 (Case 1)

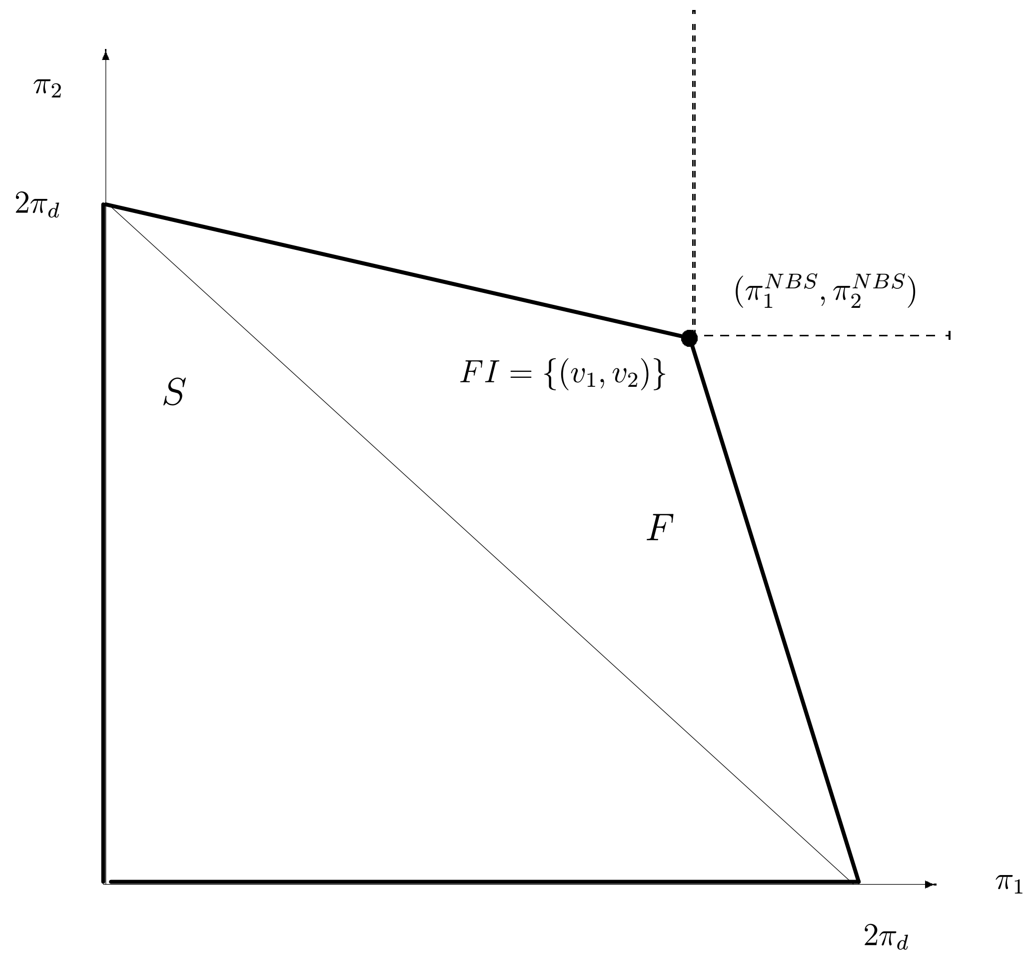

Figure 2 (Case 2)

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