Inefficiency and Contracts in Multilateral Bargaining

Hongbin Cai*

Department of Economics

UCLA

405 Hilgard Ave

Los Angeles, CA90095-1477

e-mail: cai@econ.ucla.edu

tel: 310-794-6495.

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Abstract

This paper studies a complete-information bargaining model in which an active player (e.g., a firm) bargains sequentially with N passive players (e.g., workers). The model has three key elements: uncertainty about surplus, incomplete contracts and strategic commitment. We show that for any N the game has a unique subgame perfect equilibrium outcome. When $N \geq 2$, the equilibrium outcome is inefficient in the sense that positive gains from trade, even though commonly known, are left unrealized. Transaction inefficiency becomes more severe as the number of the passive players or their bargaining power increases. Trade collapses when N goes to infinity. Several applications are then discussed.

Key Words: bargaining, incomplete contracts, inefficiency, Coase Theorem.

JEL Classification: C78, D23, D62.

> But equally there is no reason why, on occasion, such governmental administrative regulation should not lead to an improvement in economic efficiency. This would seem particularly likely when, as is normally the case with the smoke nuisance, a large number of people are involved and in which therefore the costs of handling the problem through the market or the firm may be high. (Coase 1960, p.18)

1 Introduction

The Japanese city Kobe was hit by a devastating earthquake in 1994. A Wall Street Journal article (December 12, 1996) reported that after two years and inflow of a large amount of money, the rebuilding of the residential areas in Kobe had progressed very little: many people were still living in shelters and 70% of damaged buildings had not been repaired. However, some other rebuilding projects, such as freeway repairs, were finished rather quickly. The reason for the sharp contrast between the two types of projects is that developers of residential projects were unable to reach agreements with existing property right holders while those of freeway projects had relatively easy time in securing the necessary agreements. What made the difference was the presence of a large number of bargainers in residential areas. According to the article, Japan's land law gives every party who has some stake in a piece of land, e.g., tenants, subtenants and landlords, certain property rights over the land. To start rebuilding, a developer had to obtain permission from each of these stakeholders. Yet, many of these stakeholders wanted to hold out the bargaining process in order to get more favorable terms, thus the city was still in ruin. In contrast, the number of stakeholders in highway repair projects was much smaller, hence agreements were easy to be reached.

The Kobe's story is not a single incidence. There is substantial evidence that the number of people involved affects transaction efficiency (see Sections 5-7). Moreover, it is a common belief often expressed in the literature that the more people involved in a transaction, the more difficult to transact efficiently. From the opening quote of Coase in his well-known paper on social costs, it is interesting to note that the key in this unusual concession to government interventions by a leading Chicago school scholar is the presence of "a large number of people". For another example, in discussing bargaining costs, Milgrom and Roberts (1992) write that

> (Bargaining inefficiency) may also arise when there are multilateral bargains when all can participate; two or more bargainers may gang up on the third in an inefficient way to hold him up more 'efficiently'. (p.303)

This paper proposes a simple model to show how the number of bargainers involved in a transaction and their bargaining power affect transaction efficiency. We consider complete information bargaining situations in which one "active" party (e.g., a real estate developer, a firm, an entrepreneur), who has a profitable project, bargains sequentially with multiple "passive" parties (e.g., residents or tenants, creditors, patent-holders) to get their cooperation/permission to implement the project. The model has three key elements: uncertainty, incomplete contracts and strategic commitment. We show that there is a unique subgame perfect equilibrium outcome for the game with any number of passive players. As long as there are more than one passive player, the equilibrium outcome involves inefficiency, in the sense that the profitable project is not implemented with positive probability. Note that inefficiency arises in our model despite that it has complete information and it is common knowledge that the project is socially desirable. We find that both the number of passive players and their relative bargaining power against the active player reduce transaction efficiency.

Specifically, the model has two stages: an initial (ex ante) stage of bargaining and an ex post stage of renegotiations. We suppose that the available surplus is unknown to any bargainer in the initial stage of bargaining. The surplus eventually accrues to the active player and is not verifiable ex ante, so contracts cannot be contingent on the realization of the surplus, but only on whether the project is implemented. With the surplus uncertainty and incomplete contract restriction, the active player bargains with one passive player in alternating-offer fashion until they reach an agreement, then she moves on to bargain with the next passive player. Once the active player reaches agreements with all passive players, the game moves to the ex post stage in which the surplus is revealed to everyone and becomes verifiable. Depending on the realization of the total surplus, there may be a need for renegotiations if the active player's total liabilities to passive players exceed the total surplus. We suppose the bargaining rules in the renegotiation stage are identical to those in the initial stage of bargaining. The renegotiation outcomes may not be favorable to some passive players. Anticipating the renegotiation outcomes, some passive players may want to take actions to avoid renegotiations (e.g., taking a long vacation, striking, hiring a third party such as lawyer). We suppose that after signing a contract with the active player in the initial stage of bargaining, a passive player can choose whether or not to commit to that contract (i.e., commit not to renegotiate his contract). Once a passive player commits to his contract, he will not participate in the renegotiation stage.

If there is only one passive player, he will never commit not to renegotiate his contract, because he always gains from renegotiation. Hence the equilibrium outcome is efficient with only one passive player. When there are more than one passive player, things are quite different. Suppose there are two passive players. If the first passive player chooses not to commit (i.e., stay in the game), then the second passive player will be tempted to commit not to renegotiate in most cases. When he does so, the second passive player's contract is secured in the sense that it has higher "seniority" than the first passive player's contract. Anticipating the second passive player's response, the first passive player will choose to commit not to renegotiate his contract and then the second passive player will choose to stay in the game. The commitment by the first passive player will cause efficiency loss, because when the total surplus turns out to be smaller than his demand, the active player will have to choose not to implement the project. Gains from trade, even though commonly known among all players, are left unrealized. We extend the analysis to any number of passive players. We demonstrate that there is a unique subgame perfect equilibrium outcome for any number of passive players which can be characterized in a very simple form. All passive players except the last one will commit not to renegotiate their contracts. Transaction inefficiency becomes more severe as the number of the passive players increases or as their bargaining power increases. The basic intuition is that every passive player ignores the externalities he imposes on other passive players, and therefore in equilibrium the probability of the project getting implemented decreases in the number of passive players and their bargaining power. In fact, when the number of passive players becomes large, the probability of implementation goes to zero.

In organization theory, uncertainty is often cited as one of the main factors that affect transaction efficiency. In his influential three-factor framework of transaction cost theory, Williamson (1985) puts uncertainty along with frequency and asset specificity as the key determinants of transaction costs. Milgrom and Roberts (1990, 1992) also argue that uncertainty and complexity of the environments increase bargaining costs. However, uncertainty plays almost no role in the bargaining literature.[1] Implicitly, it is assumed that ex post surpluses are verifiable so contingent contracts can be written to divide the surpluses in whatever ways the bargainers agree upon. In this paper, we relax the complete contract assumption. Uncertainty then becomes a critical factor in determining transaction efficiency.

In Section 2 we present the basic model. Then in Section 3 we solve the model, characterize the unique subgame perfect equilibrium outcome of the game and derive the main results of the paper.

The model developed in this paper has the advantage of having sharp predictions (i.e., unique SPE outcome) and easy and intuitive comparative statics. As a result, it is easy to apply the model to real life bargaining situations. In Sections 5-7, we discuss briefly several applications, organized by the types of remedies for bargaining failures found in those applications. As Coase argued, in the presence of transaction costs property right allocations will affect economic efficiency. Since the number of people involved can affect transaction costs, property right allocations should respond in certain ways in order to minimize welfare loss. As an example of this idea, Section 5 presents an application to Eminent Domain Law. In the second group of applications, the remedy for bargaining failures is through government regulations. Section 6 discuss two particular applications: multi-unionism and bargaining under financial distress by firms. We analyze how regulations governing industrial relations and bankruptcy procedures can have impacts on how effectively different parties bargain. In the last group of applications, certain institutional innovations can be seen (at least to certain degree) as the response to the type of bargaining failures studied in our model. Again we discuss two applications in Section 7, one is the Township-Village Enterprises in China, the other is a particular type of service firms called 'despachante" in Brazil.

The general question of what causes bargaining inefficiency has a very long tradition in the economics literature. Our paper is related to many works in this literature, in Section 8 we discuss some of the related bargaining literature. Section 9 concludes the paper with some remarks on future research.

[1] Uncertainty can affect distribution of surplus when bargainers are risk-averse (see, e.g., White (2000) for a recent contribution). In this paper we assume risk neutrality so uncertainty does not affect the bargaining outcomes at all when contracts are complete.

2 The Model and Preliminary Analysis

The model consists of one active player, labeled A, and N other passive players indexed by $i \in [1, 2, \ldots, N]$. Player A has a project. To undertake the project, player A has to obtain some critical assets or services from each of these passive players. The reservation value of each passive player's assets or services is common knowledge, so without loss of generality, can be normalized to be zero. Moreover, assets and services of all passive players are verifiable by the court, so there are no contracting problems regarding exchanges of assets and services.

In the first stage of the game, player A bargains with the passive players to buy their assets and services. The exact bargaining rules are as follows. Starting from player 1, player A bargains with one passive player at a time over a price in exchange for his assets or service as in the standard Rubinstein game. That is, A makes an offer first which the passive player then decides whether to accept or reject. If he rejects, he makes a counter-offer, which in turn A accepts or rejects. One period of bargaining consists of an offer or counter-offer and the other party's response. This process continues until an agreement is reached. If an agreement is reached, they sign a contract and player A then moves on to bargain with the next passive player. If bargaining with any passive player is stalled (i.e., perpetual disagreement), then the whole game ends and everyone gets zero payoff. If A reaches agreements with all the passive players, the game moves to the next stage. The bargaining game is a natural extension of the bilateral Rubinstein game to multilateral bargaining. In this bargaining stage, it is common knowledge that the project is profitable or socially desirable. However, the total surplus π is uncertain. For simplicity, suppose the total surplus is uniformly distributed in $[0, R]$, so the expected total surplus is $0.5R$. The distribution of the total surplus is common knowledge.

Except surplus uncertainty, the bargaining rules described above are very similar to those in Stole and Zwiebel (1996a, b) and Wolinsky (2000). A new feature we introduce now is commitment. We suppose that after a passive player signs a contract with player A, he decides whether to commit not to renegotiate with player A in the future (e.g., taking a long vacation, striking, hiring a third party such as lawyer).[2] For simplicity, we assume that all passive players have access to a perfect

[2]Alternatively we could suppose that commitment decisions by all passive players are made sequentially after all have signed contracts with player A. The analysis would be more involved technically, but the main insights should

commitment technology: if one chooses to commit, he can commit never to negotiate with player A at no cost. The results of the paper can be easily generalized to situations where commitment is imperfect and individual passive players have to pay some commitment costs. A passive player who commits not to renegotiate his contract has no roles to play in the game anymore (except collecting payments if the project is implemented). Commitment decisions are observed by all players. Let M denote both the number and the set of passive players who choose not to commit, i.e., those who choose to stay in the game. Note that sequential commitment decisions rule out simple coordination failures in the form of "since everyone else exists the game, I will also exist the game."

In the second stage of the game, the total surplus is revealed to all players. Then player A has three choices: (1) implement the project, or (2) not to implement the project, or (3) renegotiate the contracts with those passive players who are willing to renegotiate. If A implements the project, then the total surplus is realized after the completion of the project and each passive player is paid according to his contract with A, at which point the game ends. If A decides not to implement the project, then everyone gets a payoff of zero and the game ends.[3] If A chooses to renegotiate, then with mutual consent, the original contracts of the M passive players who are willing to renegotiate are voided, and A will bargain with these M passive players over new contracts.[4] The bargaining rules are the same as in the initial bargaining stage. So, for example, if $M = \{1, 2, 5\}$, then player A first bargains with player 1 in the alternating-offer fashion, and once reaching an agreement moves on to bargain with player 2, and then with player 5. If player A reaches agreements with all M passive players, then she implements the project.[5] If there is perpetual disagreement, then

still be valid.

[3]Since contracts are contingent on the implementation of the project, there is no breaching of contracts and no assets change hands.

[4]Here we suppose that all contracts of the M passive players are voided before renegotiations start. If contracts are voided sequentially as bargaining proceeds, the analysis of the renegotiation outcomes becomes more complicated, but the qualitative results of the model should still hold.

[5]Of course, if after renegotiations player A's total liabilities exceed the total surplus, then she will not implement the project. However, since there is complete and perfect information in this stage of the game, with perfect foresights in equilibrium, player A would just as well choose not to implement the project without renegotiations. We make

everyone gets zero payoff.

All players are risk neutral and try to maximize the present value of his/her expected payoff. Let δ_i be player i's discount factor, and δ be player A's discount factor. For simplicity, we assume that all passive players have the same discount factor δ_1. Without loss of generality, only bargaining takes real time and is subject to discounting. Furthermore, for convenience, we suppose that acceptance in bargaining does not take real time, but rejection does. This has no real consequence for the analysis. Note that with N passive players, it takes at least N periods to reach agreements with all of them in the first stage of bargaining; and similarly for M passive players in the renegotiation stage, it takes at least M periods to reach all agreements. If more periods are used than necessary, the bargaining outcome involves rejections and hence costly delay. Sometimes it is convenient to represent a bargaining outcome in the initial bargaining stage as (s, t_1), where $s = \{(f_1, f_2, \ldots, f_N) | f_i \geq 0\}$ is the price vector with f_i being the price to be paid to player i (contingent on the implementation of the project), and $t_1 \in \{N, N+1, \ldots, \}$ is the final date at which player A reaches an agreement with the last passive player. In case of perpetual disagreement with any of the passive player, $t_1 = \infty$. Similarly an outcome in the renegotiation stage can be represented by (y, t_2), where $y = \{y_i\}_{i \in M}$ and $t_2 \in \{M, M+1, \ldots, \}$. Suppose the total surplus turns out to be π. If the first stage bargaining outcome is (s, t_1) and player A implements the project in the second stage without renegotiation, then player i's payoff is $u_i = \delta_i^{t_1 - N} f_i$, and player A's payoff is $u = \delta_i^{t_1 - N}(\pi - \sum_i f_i)$. If the first stage bargaining outcome is (s, t_1) and player A renegotiates with M passive players and reachs an outcome of (y, t_2), then player i's payoff is $u_i = \delta_i^{t_1 - N + t_2 - M} f_i$ if i is not in M, $u_i = \delta_i^{t_1 - N + t_2 - M} y_i$ if i is in M, and player A's payoff is $u = \delta_i^{t_1 - N + t_2 - M}(\pi - \sum_{i \notin M} f_i - \sum_{i \in M} y_i)$.

Throughout the paper we maintain the contractual assumption that implementation of the project is verifiable, but the total revenue accrues to player A and is not verifiable ex ante.[6] Thus contracts can only be contingent on project implementation but not on the realized total revenue in the first stage of bargaining. This assumption seems quite natural in many contexts (e.g., a developer versus landowners, a firm versus creditors, an entrepreneur versus patent-holders, a lobbyist versus politicians), particularly in situations when (1) it is costly for the passive players to

the immaterial tie-breaking assumption that player A will avoid renegotiations if it is not profitable.

[6]As will be clear shortly, the bargaining problem becomes trivial if the total revenue is verifiable.

audit the books of player A, or (2) the active player can engage in accounting manipulation, (3) or the surplus contains non-monetary elements. Note that our contractual assumption is very much in the spirit of the incomplete contract literature (Hart and Moore 1988, Hart 1995), in the sense that the state variable (the total surplus) is not verifiable ex ante but becomes verifiable ex post. However, unlike the standard models in that literature, in our model contracts are not entirely incomplete ex ante (since project implementation is contractible) and ex post renegotiations do not automatically lead to efficient solutions due to possible commitments by passive players. In fact, the focus of the paper is precisely on the interactions among ex ante negotiations, endogenous commitment decisions and ex post renegotiations, which are not studied in the existing literature.

We assume that player A cannot commit to always implementing the project. One reason is that commitment by player A to always implementing the project may not be efficient if the total surplus of the project is not always positive. For simplicity we assumed that the project is always profitable, but this assumption is not necessary for our main results. Another justification is that player A may face big penalties (e.g., career concerns) if the project loses money. In other words, player A faces an ex post participation constraint or no-bankruptcy constraint. Given such a constraint, player A cannot credibly commit or be forced to always implement the project, or else she would quite ex ante.

In the analysis of the model, we will encounter repeatedly the following "generic" bargaining game with K passive players. In this game, the total surplus is known to be $r > 0$. Player A sequentially bargains with each of the K passive players one at a time in the alternating-offer fashion. Once an agreement is reached, she moves on to bargain with the next passive player, all the way to player K. When $K = 1$, the model is reduced to the standard Rubinstein bargaining game. The unique subgame perfect equilibrium outcome is $u_1 = f_1 = r\delta_1(1-\delta)/(1-\delta\delta_1)$ and $u = r(1-\delta_1)/(1-\delta\delta_1)$, and the agreement is reached immediately at $t = 1$. Write $\lambda = \delta_1(1-\delta)/(1-\delta\delta_1)$, so λ represents the relative bargaining power of passive players against player A. For $K > 1$, the result is the following.

Proposition 1 *In the generic bargaining game with K passive players and a total surplus of r, the game has a unique subgame perfect equilibrium with the outcome $(\{f_i\}, t = K)$, where $u_i = f_i = r\lambda(1-\lambda)^{i-1}$, and player A's payoff is $u = r(1-\lambda)^K$.*

Proof: See the Appendix. *Q.E.D.*

Not surprisingly, Proposition 1 shows that the unique equilibrium outcome of the generic bargaining game is efficient. Efficiency is a quite robust feature of complete information bargaining. The basic reason is that due to complete information, rational expectation (as required in equilibrium) implies that bargainers usually are able to capture the benefits of earlier agreements.[7]

To solve for subgame perfect equilibria of the model, we start with the renegotiation stage of the game. Suppose $\{f_i\}_{i \in N}$ are the original contracts signed in the first stage of bargaining and M passive players decide to stay in the game. When the total surplus π turns out to be not greater than the total liabilities of player A to those passive players who have committed not to renegotiate, then player A has to choose not to implement the project, resulting in zero payoff for everyone. When the total surplus turns out to be greater than the total liabilities of player A to all N passive players, then those M passive players who stay in the game will not be willing to tear up their contracts and renegotiate. Since contract renegotiation requires mutual consent, there will be no renegotiations and player A will implement the project and honor all the original contracts. When the total surplus is in between the above two cases, then player A will try to renegotiate with the M passive players. This renegotiation game is a generic bargaining game with M passive players and a total surplus of $\pi - \sum_{i \notin M} f_i$. Therefore, we have

Proposition 2 *Suppose $\{f_i\}_{i \in N}$ are the original contracts signed in the first stage of bargaining and M passive players decide to stay in the game. When $\pi \leq \sum_{i \notin M} f_i$, player A will choose not to implement the project; when $\pi \geq \sum_{i \in N} f_i$, player A will implement the project directly. When $\sum_{i \notin M} f_i < \pi < \sum_{i \in N} f_i$, then player A will renegotiate with the M passive players. The bargaining outcome is $(\{y_j\}_{j \in M}, t_2 = M)$, where $y_j = (\pi - \sum_{i \notin M} f_i)\lambda(1-\lambda)^{j-1}$, and player A's payoff is $u = (\pi - \sum_{i \notin M} f_i)(1-\lambda)^M$, where j is the jth player in M. After reaching all the agreements, player A implements the project.*

Before moving on to solve the model in the next section, we note that there are two special cases in which the first best solution is achieved. The first best solution of the model requires that (1) there is no delay in reaching agreements, and (2) the project is always implemented.

[7] A few exceptions have been pointed out in the literature. See Section 7 for discussion.

Proposition 3 *In the following two cases, for any N, the game has a unique subgame perfect equilibrium with the outcome $(\{f_i\}, t_1 = N)$, where $u_i = f_i = r\lambda(1-\lambda)^{i-1}$, and player A's payoff is $u = r(1-\lambda)^N$. After reaching agreements with all N players, player A implements the project without renegotiations. The equilibrium outcome is efficient.*

(i) There is no uncertainty: the total surplus is known to be r at the begining of the game.

(ii) The total surplus is uncertain but verifiable ex ante, so contracts in the first stage of bargaining can be contingent on the total surplus.

Proof: This proposition follows Propositions 1 and 2 straightforwardly. Note that in both cases, player A can be guaranteed positive payoffs no matter whether any passive player has committed not to renegotiate his contract. Thus renegotiations will not take place. In the second case, player A and the passive players write contracts contingent on the realization of the total surplus, i.e., the price to be paid to player i is a function $f_i : [0, R] \rightarrow [0, R]$. With contingent contracts, the bargaining problem can be thought of as bargaining over each possible surplus realization $r \in [0, R]$. *Q.E.D.*

3 Main Results

In this section we suppose the total surplus is uncertain and not verifiable ex ante. We first consider the bilateral bargaining case: $N = 1$. Suppose an agreement of f_1 is reached in the first stage of bargaining. For $f_1 > 0$, player 1 is strictly better off by staying in the game (not to commit).[8] To see this, note that if he commits not to renegotiate, then he will get f_1 when the total surplus $\pi \geq f_1$ and zero otherwise. If he stays in the game, by Proposition 2, he will still get f_1 when $\pi \geq f_1$ (no renegotiation) but will also get $\lambda\pi$ through renegotiation when $\pi < f_1$. Clearly, staying in the game strictly dominates committing to not to renegotiate.

In the first stage of bargaining, for a bargaining outcome (f_1, t_1), player 1's expected payoff is

[8]For $f_1 = 0$, player 1 is indifferent since he is going to get zero no matter what he chooses. Obviously $f_1 = 0$ cannot happen in equilibrium, so it is irrelevant.

$$Eu_1 = \delta_1^{t_1-1}[(R-f_1)f_1/R + \int_0^{f_1} \lambda r/Rdr] = \delta_1^{t_1-1}[R-(1-0.5\lambda)f_1]f_1/R \quad (1)$$

where the first term is his expected payoff when $\pi \geq f_1$ ($(R-f_1)/R$ is the probability of this event) and the second term is his expected payoff when $\pi < f_1$. Similarly, player A's expected payoff is

$$Eu = \delta^{t_1-1}[\int_{f_1}^{R}(r-f_1)/Rdr + \int_0^{f_1}(1-\lambda)r/Rdr] = \delta^{t_1-1}[(R-f_1)^2 + (1-\lambda)f_1^2]/(2R) \quad (2)$$

Note that due to renegotiation, player 1's payoff function is non-monotonic: it first increases and peaks at $f_1 = R/(2-\lambda)$ and decreases from there. When $f_1 = R/(2-\lambda)$, player 1's expected payoff is $Eu_1 = 0.5R/(2-\lambda)$. The reason Eu_1 can be decreasing in f_1 is that for large f_1, the chance of renegotiation is large. For example, if $f_1 = R$, then the contract will be renegotiated with probability one, and hence player 1 will get an expected payoff of $0.5\lambda R$. Despite this non-monotonicity, it can be shown that the Rubinstein type result still holds.

Theorem 1 *For $N = 1$, the game has a unique subgame perfect equilibrium outcome. In the initial stage of bargaining, player A and player 1 sign a contract of $f_1 = \lambda R/(2-\lambda)$ or $f_1 = R$. Player 1 chooses to stay in the game. In the second stage, they renegotiate the contract if the total surplus is less than f_1 with an outcome of $y_1 = \lambda\pi$. The equilibrium outcome is efficient. Player 1 gets an expected payoff of $0.5\lambda R$, while player A's expected payoff is $0.5(1-\lambda)R$.*

Proof: See the Appendix.

Theorem 1 shows that when there is only one passive player, the equilibrium outcome is always efficient despite that the total surplus is uncertain and not verifiable and that the passive player has the option to commit not to renegotiate. It is never in the interest of player 1 to forgone the opportunity of renegotiation by exiting the game. So renegotiation will always result in efficient trade ex post. The two players can trade efficiently in two ways. They can either sign a meaningful first contract $f_1 = \lambda R/(2-\lambda)$ and renegotiate only when the total surplus turns out to be smaller than f_1, or sign a nominal contract $f_1 = R$ (or anything greater than R) with the understanding that the real terms are to be decided in renegotiation.

Now we consider the case with two passive players: $N = 2$. Suppose player 1 has signed a contract of f_1 where $0 < f_1 < R$ in the initial stage of bargaining and has committed not to renegotiate.[9] Suppose player 2 has signed a contract of f_2. If player 2 also commits not to renegotiate, then he will get f_2 when the total surplus $\pi \geq f_1 + f_2$ and zero otherwise. If he stays in the game, by Proposition 2, he will still get f_2 when $\pi \geq f_1 + f_2$ (no renegotiation) but will also get $\lambda(\pi - f_1)$ through renegotiation when $f_1 < \pi < f_1 + f_2$. Thus, staying in the game strictly dominates committing to not to renegotiate for player 2. In this case, by Proposition 2, the equilibrium outcome is $\{f_1, f_2, \pi - f_1 - f_2\}$ when $\pi \geq f_1 + f_2$; $\{f_1, \lambda(\pi - f_1), (1-\lambda)(\pi - f_1)\}$ when $f_1 \leq \pi < f_1 + f_2$; and $\{0, 0, 0\}$ when $\pi < f_1$. In terms of expected value, we have (i) if $f_1 + f_2 \leq R$, $Eu_1 = f_1(R - f_1)/R$, $Eu_2 = f_2(R - f_1 - f_2)/R + \lambda f_2^2/(2R)$, and $Eu = (R - f_1 - f_2)^2/(2R) + (1-\lambda) f_2^2/(2R)$; and (ii) if $f_1 < R < f_1 + f_2$, $Eu_1 = f_1(R - f_1)/R$, $Eu_2 = \lambda(R - f_1)^2/(2R)$, and $Eu = (1-\lambda)(R - f_1)^2/(2R)$.

Proposition 4 *Consider the game with two passive players. Suppose player 1 has signed a contract of f_1 where $0 < f_1 < R$ in the initial stage of bargaining and has committed not to renegotiate. Then player A and player 2 will sign a contract of $f_2 = \lambda(R - f_1)/(2-\lambda)$ or $f_2 = R$ and player 2 will choose to stay in the game. In the second stage, player A and player 2 renegotiate if $f_1 < \pi < f_1 + f_2$. The expected payoffs are $Eu_1 = f_1(R - f_1)/R$, $Eu_2 = \lambda(R - f_1)^2/(2R)$, and $Eu = (1-\lambda)(R - f_1)^2/(2R)$, respectively.*

Proof: Note that given player 1 has committed to f_1, the rest of the game between player A and player 2 is equivalent to a bilateral bargaining game in which the total surplus is distributed over $[0, R - f_1]$, since they cannot do anything if $\pi \leq f_1$. The proposition follows Theorem 1 and the fact that the project is implemented with probability of $(R - f_1)/R$. *Q.E.D.*

Proposition 4 shows that as long as player 1 has committed not to renegotiate, then player 2 will sign a contract with player A and then stay in the game for renegotiation. The idea is very simple. By committing not to renegotiate, player 1 has chosen to exit the game with a fixed payoff of f_1 if the total surplus turns out to be greater than f_1. The game between players 2 and A becomes a bilateral bargaining game with a joint surplus of $\pi - f_1$ if π is greater than f_1. In this game player 2 will choose to stay in the game to take advantage of any renegotiation opportunities.

Suppose player 1 has signed a contract of $\{f_1\}$ in the initial stage of bargaining and has decided to stay in the game. Suppose player 2 has signed a contract of f_2. If player 2 also stays in the game,

[9] Either $f_1 = 0$ or $f_1 \geq R$ can be easily ruled out as a part of equilibrium since player 1 gets zero payoff.

then he will get f_2 when $\pi \geq f_1 + f_2$ (no renegotiation), $\lambda(1-\lambda)\pi$ when $\pi < f_1 + f_2$ (renegotiation with both passive players). This results in the following expected payoffs: (i) when $R \geq f_1 + f_2$, $Eu_1 = f_1(R - f_1 - f_2)/R + \lambda(f_1 + f_2)^2/(2R)$, $Eu_2 = f_2(R - f_1 - f_2)/R + \lambda(1-\lambda)(f_1 + f_2)^2/(2R)$, and $Eu = (R - f_1 - f_2)^2/(2R) + (1-\lambda)^2(f_1 + f_2)^2/(2R)$; (ii) when $R < f_1 + f_2$, $Eu_1 = 0.5\lambda R$, $Eu_2 = 0.5\lambda(1-\lambda)R$, and $Eu = 0.5(1-\lambda)^2 R$. If player 2 commits not to renegotiate, then he will get f_2 when $\pi \geq f_2$ (no renegotiation with player 2) and zero when $\pi < f_2$. This results in the following expected payoffs: (i) if $f_2 \geq R$, $Eu_1 = Eu_2 = Eu = 0$; (ii) if $f_2 < R < f_1 + f_2$, $Eu_1 = \lambda(R - f_2)^2/(2R)$, $Eu_2 = f_2(R - f_2)/R$, and $Eu = (1-\lambda)(R - f_2)^2/(2R)$; and (iii) if $f_1 + f_2 \leq R$, $Eu_1 = f_1(R - f_1 - f_2)/R + \lambda f_1^2/(2R)$, $Eu_2 = f_2(R - f_2)/R$, , and $Eu = (R - f_1 - f_2)^2/(2R) + (1-\lambda)f_1^2/(2R)$.

We now analyze player 2's commitment decision. Consider the case when $f_1 + f_2 > R$. Given that player 1 has decided to stay in the game, obviously player 2 will stay in the game if $f_2 \geq R$. If $f_2 < R$, then player 2 will commit to not to renegotiate if and only if $f_2(R - f_2)/R \geq 0.5\lambda(1-\lambda)R$, or,

$$\tau_1 R \leq f_2 \leq \tau_2 R \tag{3}$$

where $\tau_1 = 0.5[1 - \sqrt{1 - 2\lambda(1-\lambda)}]$ and $\tau_2 = 0.5[1 + \sqrt{1 - 2\lambda(1-\lambda)}]$. Note that $\tau_1 + \tau_2 = 1$, $0 \leq \tau_1 \leq (2 - \sqrt{2})/4$ and $(2 + \sqrt{2})/4 \leq \tau_2 \leq 1$. When Equation 3 holds, player 2 will commit not to renegotiate, and the expected payoffs for players 1, 2 and A are $Eu_1 = \lambda(R - f_2)^2/(2R)$, $Eu_2 = f_2(R - f_2)/R$, and $Eu = (1-\lambda)(R - f_2)^2/(2R)$, respectively. When Equation 3 does not hold, player 2 will stay in the game, and the expected payoffs for players 1, 2 and A are $Eu_1 = 0.5\lambda R$, $Eu_2 = 0.5\lambda(1-\lambda)R$, and $Eu = 0.5(1-\lambda)^2 R$, respectively.

Consider the case when $f_1 + f_2 \leq R$. Then, given that player 1 has decided to stay in the game, player 2 will commit to not to renegotiate if and only if $f_2(R - f_2)/R \geq f_2(R - f_1 - f_2)/R + \lambda(1-\lambda)(f_1 + f_2)^2/(2R)$, or,

$$f_1 f_2 \geq \lambda(1-\lambda)(f_1 + f_2)^2/2 \tag{4}$$

It can be shown that Equation 4 is equivalent to[10]

[10]To see this, let $q = f_2/f_1$ and $\gamma = [\lambda(1-\lambda)]^{-1}$. Then Equation 4 can be rewritten as $2\gamma q \geq (1+q)^2$. This

$$\tau_1 \leq f_2/(f_1+f_2) \leq \tau_2 \quad \text{or equivalently} \quad \tau_1 \leq f_1/(f_1+f_2) \leq \tau_2 \tag{5}$$

When Equation 5 holds, player 2 will commit not to renegotiate, and the expected payoffs for players 1, 2 and A are $Eu_1 = f_1(R-f_1-f_2)/R + \lambda f_1^2/(2R)$, $Eu_2 = f_2(R-f_2)/R$, and $Eu = (R-f_1-f_2)^2/(2R) + (1-\lambda)f_1^2/(2R)$, respectively. When Equation 5 does not hold, player 2 will stay in the game, and the expected payoffs for players 1, 2 and A are $Eu_1 = f_1(R-f_1-f_2)/R+\lambda(f_1+f_2)^2/(2R)$, $Eu_2 = f_2(R-f_1-f_2)/R+\lambda(1-\lambda)(f_1+f_2)^2/(2R)$, and $Eu = (R-f_1-f_2)^2/(2R)+(1-\lambda)^2(f_1+f_2)^2/(2R)$, respectively.

Insert Figure 1 here.

Player 2's commitment decision is illustrated in Figure 1. Player 2 will commit not to renegotiate in areas (2) and (4), where in area (2) Equation 5 holds and $f_1+f_2 \leq R$ and in area (4) Equation 3 holds and $f_1+f_2 > R$. Player 2 will choose to stay in the game in areas (1) and (3), where in area (1) $f_1+f_2 \leq R$ and Equation 5 does not hold and in area (3) $f_1+f_2 > R$ and Equation 3 does not holds. Since τ_1 can take a maximum value of about 0.15 and τ_2 can take a minimum value of about 0.85 at $\lambda = 0.5$, the range of f_2 such that player 2 chooses to stay in the game is fairly small at least for $f_1 \geq \tau_1 R$.[11]

The next step is to analyze the bargaining game between players A and 2 while taking into account future contingencies as summarized in Figure 1. Since for each f_1 both players A and 2 have quite non-regular payoffs due to regime changes, solving for the solution of this bargaining game is rather involved and not even tractable. To avoid this technical difficulty, we make the following simplifying assumption:

Assumption 1 *In the first stage of bargaining player A and passive players can use side cash payments.*

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means that $\gamma-1-\sqrt{\gamma(\gamma-2)} \leq q \leq \gamma-1+\sqrt{\gamma(\gamma-2)}$. Note that $\gamma-1-\sqrt{\gamma(\gamma-2)} = \gamma(1-\sqrt{1-2/\gamma})-1 = 2/[1+\sqrt{1-2/\gamma}]-1 = \tau_2{}^{-1}-1 = \tau_1/\tau_2$. Similarly, $\gamma-1+\sqrt{\gamma(\gamma-2)} = \tau_2/\tau_1$. Therefore, Equation 4 is equivalent to $\tau_1/\tau_2 \leq q = f_2/f_1 \leq \tau_2/\tau_1$, which in turn is equivalent to Equation 5.

[11]Note that $f_2 > R$ is identical to $f_2 = R$ in strategic sense.

We make several observations about Assumption 1. First, none of the previous results, in particular Theorem 1, is affected by this assumption. Secondly, side cash payments made between player A and passive player i does not affect the subsequent plays of the game, because "bygones are bygones". Thirdly, this is a simplifying assumption because we expect the results of the model will still hold at least qualitatively without it. Specifically, without Assumption 1, even though Proposition 5 below would not hold literally, it should still be true that player 1 and player A would reach an agreement such that player 1 would commit not to renegotiate. As a result, Theorem 2 below would still be valid qualitatively. See more detailed discussions below. Finally, we suppose that in the renegotiation stage players do not use side cash payments. This may fit the reality in some cases when renegotiations are conducted under the supervision of a court or under public scrutiny. If instead players can also use side cash payments in the renegotiation stages, the results of the paper would still hold. The reason is the following. When side cash payments are allowed, in the renegotiation stage the first passive player in M and player A will divide the total surplus π at the ratio of $\lambda/(1-\lambda)$ with the following scheme: they will sign a contract that gives π to the first passive player, who will pay $(1-\lambda)\pi$ cash to player A. When player A goes to bargain with other passive players, there is nothing she can offer them since she gets nothing from the implementation of the project. So all other passive players must accept zero offers. With this renegotiation outcome, there should be only one passive player who chooses to stay in the game, all others should commit not to renegotiate their contracts. As will be clear later, this argument leads to Theorems 2 and 3 below.

Under Assumption 1, once player 1 has signed a contract of f_1 and decided to stay in the game, the bargaining game between players A and 2 becomes essentially a Rubinstein game. That is, the two players will reach an agreement that maximizes their joint expected payoff and use side payments to ensure each gets a proper share of the joint expected surplus. Nevertheless, figuring out the Pareto frontier for each f_1 is not a trivial matter. We have the following result.

Proposition 5 *Consider the game with two passive players. Suppose player 1 has signed a contract of f_1 in the initial stage of bargaining and has decided to stay in the game.*

(i) For $f_1 \leq 0.5R$, players A and 2 will reach an agreement on $f_2 = f_1$ and player 2 will commit not to renegotiate his contract. The expected payoffs are $Eu_1 = [2f_1R - (4-\lambda)f_1^2]/(2R)$,

$Eu_2 = \lambda[(R - f_1)^2 + (2 - \lambda)f_1^2]/(2R)$, and $Eu_2 = (1 - \lambda)[(R - f_1)^2 + (2 - \lambda)f_1^2]/(2R)$.

(ii) For $0.5R \leq f_1 \leq R/(1 + \lambda)$, players A and 2 will reach an agreement on $f_2 = R - f_1$ player 2 will commit not to renegotiate his contract. The expected payoffs are $Eu_1 = 0.5\lambda f_1^2/R$, $Eu_2 = \lambda f_1[2R - (1 + \lambda)f_1]/(2R)$ and $Eu = (1 - \lambda)f_1[2R - (1 + \lambda)f_1]/(2R)$.

(iii) For $f_1 \geq R/(1+\lambda)$, players A and 2 will reach an agreement on $f_2 = \lambda R/(1+\lambda)$ and player 2 will commit not to renegotiate his contract. The expected payoffs are $Eu_1 = 0.5\lambda R/(1 + \lambda)^2$, $Eu_2 = 0.5\lambda R/(1 + \lambda)$ and $Eu = 0.5(1 - \lambda)R/(1 + \lambda)$.

Proof: See the Appendix.

Proposition **??** shows that as long as player 1 has decided to stay in the game, player 2 will sign a contract with player A and then commit not to renegotiate his contract. Fundamentally, the idea is that since player 1's claim is not secured, player 2 and player A can always find a secured contract for player 2 so that both players get the best payoffs at the expense of player 1. A secured contract for player 2 changes the "seniority" of the two passive players' claims, thus benefiting player 2 but harming player 1. Some efficiency loss incurs when player A and player 2 sign a secured contract for player 2. This inefficiency is not avoidable since efficiency requires renegotiations whenever feasible, but player 1 benefits the most from renegotiations.

Insert Figure 2 here.

Figure 2 illustrates the contract line of players 2 and A in this case. When $f_1 \leq 0.5R$, players A and 2 will reach a contract of $f_2 = f_1$ and player 2 commits not to renegotiate his contract. Given perfect foresights, this amounts to a "secured" contract for player 2. This incurs efficiency loss since the project will not be implemented when $\pi < f_1$. But the loss to players A and 2 is smaller, because otherwise player 1 would get a large share from renegotiations. When $f_1 \leq \pi \leq 2f_1$, player 1 would get $\lambda\pi$ if player 2 also stayed in the game, but gets only $\lambda(\pi - f_1)$ since player 2's contract is secured. By player 2 committing not to renegotiate the contract, Players A and 2 gain more in this case than the loss from no-implementation of the project. When $0.5R \leq f_1 \leq R/(1 + \lambda)$, players A and 2 will reach a contract of $f_2 = R - f_1$ and player 2 commits not to renegotiate his contract. Again, there will be efficiency loss from no-implementation of the project when $\pi < f_2$, part of which will be shared by players A and 2. But when $\pi > f_2$, player 2 will get f_2 first and then player 1 can only get $\lambda(\pi - f_2)$ from renegotiation. It is in the interests of players A and 2 to make a secured contract for player 2. For $f_1 \geq R/(1+\lambda)$, the story is the same. By having a secured contract of $f_2 = \lambda R/(1+\lambda)$, players A and 2 can guarantee that player 2 gets f_2 whenever $\pi \geq f_2$ and then player A will renegotiate with player 1 over the remaining surplus.

Given Propositions 4 and 5, it is easy to figure out the commitment decision by player 1.

Proposition 6 *Consider the game with two passive players. Suppose player 1 has signed a contract of f_1 in the initial stage of bargaining. Then he will commit not to renegotiate his contract if and only if $f_1 \leq 0.5R[1 + \sqrt{1+\lambda^2}/(1+\lambda]$. If player 1 commits not to renegotiate his contract, the expected payoffs are $Eu_1 = f_1(R-f_1)/R$, $Eu_2 = \lambda(R-f_1)^2/(2R)$, and $Eu = (1-\lambda)(R-f_1)^2/(2R)$. If player 1 chooses to stay in the game, the expected payoffs are $Eu_1 = 0.5\lambda R/(1+\lambda)^2$, $Eu_2 = 0.5\lambda R/(1+\lambda)$ and $Eu = 0.5(1-\lambda)R/(1+\lambda)$.*

Proof: See the Appendix.

Proposition 6 says that unless f_1 is very large, player 1 will commit not to renegotiate his contract. When f_1 is very large, player 1 would rather stay in the game since his expected payoff from commitment $f_1(R-f_1)/R$ is quite small.

Now we turn back to the bargaining game between players A and 1. The following theorem characterizes the equilibrium outcome of the whole game for $N = 2$.

Theorem 2 *For $N = 2$, the game has a unique subgame perfect equilibrium outcome. In the initial stage of bargaining, player A and player 1 sign a contract of $f_1 = \lambda R/(1+\lambda)$ in the first period. Player 1 commits not to renegotiate the contract. Then player A and player 2 will sign a contract of $f_2 = \lambda R/[(2-\lambda)(1+\lambda)]$ or $f_2 = R$ and player 2 will choose to stay in the game. In the second stage, player A and player 2 renegotiate if $f_1 < \pi < f_1 + f_2$. The expected payoffs are $Eu_1 = 0.5\lambda R/(1+\lambda)$, $Eu_2 = 0.5\lambda R/(1+\lambda)^2$ and $Eu = 0.5(1-\lambda)R/(1+\lambda)$.*

Proof: See the Appendix.

Theorem 2 shows that player 1 and player A will reach an agreement and player 1 will commit not to renegotiate his contract. Given Propositions 4, 5 and 6, this should not come as a surprise.

If player 1 chooses to stay in the game, he would be "ripped off" by players A and 2. To protect himself, player 1 will commit not to renegotiate his contract in most cases. In the bargaining game between player 1 and player A, they will try to reach an agreement to maximize their joint expected payoffs. A secure contract of $f_1 = \lambda R/(1+\lambda)$ for player 1 serves that purpose.

Since there is a unique equilibrium outcome, it is easy to study its efficiency property.

Proposition 7 *When $N = 2$, in the unique subgame perfect equilibrium outcome of the game, the project is not implemented with probability of $\lambda/(1+\lambda)$, resulting in an expected welfare loss of $0.5R\lambda^2/(1+\lambda)^2$. Transaction inefficiency increases in passive players' bargaining power (i.e., δ_1) and decreases in player A's bargaining power (i.e., δ).*

Proof: The project is not implemented when $\pi < f_1$, which occurs with probability of $f_1/R = \lambda/(1+\lambda)$. The welfare loss associated with no-implementation of the project is $\int_0^{f_1} \pi/R d\pi = 0.5f_1^2/R = 0.5R\lambda^2/(1+\lambda)^2$, which is increasing in λ. Note that λ is increasing in δ_1 and decreasing in δ, this proves the proposition. *Q.E.D.*

Proposition 7 shows that even with only two passive players, the equilibrium outcome involves inefficiency. The difference with the case of $N = 1$ is that both passive players want to gain advantage by committing not to renegotiate if the other stays in the game, while with only one passive player such externality does not arise. Inefficiency is caused by uncertainty of the total surplus and strategic commitment of player 1. The degree of inefficiency is determined by the level of player 1's commitment, which increases in the passive players' bargaining power and decreases in player A's bargaining power.

Theorem 2 can be generalized to any $N \geq 3$.

Theorem 3 *For any $N \geq 3$, the game has a unique subgame perfect equilibrium outcome. In the initial stage of bargaining, player A and player $i \geq N-1$ sign a contract of $f_i = \lambda R/(1+\lambda)^i$. After signing a contract, each passive player from 1 to $N-1$ commits not to renegotiate his contract. Then player A and player N will sign a contract of $f_N = R$ and player N will choose to stay in the game. In the second stage, player A and player N renegotiate if $\sum_{j<N} f_j = [1 - 1/(1+\lambda)^{N-1}]R < \pi$. The expected payoffs are $Eu_1 = 0.5\lambda R/(1+\lambda)^{N-1}$, $Eu_i = 0.5\lambda R/(1+\lambda)^{N+i-2}$ and $Eu = 0.5R(1-\lambda)/(1+\lambda)^{N-1}$.*

Proof: See the Appendix.

Theorem 3 provides a very simple characterization of the bargaining game with N passive players. In the unique equilibrium outcome, all passive players except the last one choose to secure their contracts by committing not to renegotiate their contracts. This follows the same logic of Theorem 2: if any passive player $i \geq N-1$ does not secure his contract, he will be taken advantage of by passive players after him, all of whom would commit not to renegotiate their contracts. Given the commitment decisions of all passive players, the equilibrium contracts $\{f_i\}$ can be solved with mathematical induction.

Theorem 3 allows us to measure welfare loss quite easily.

Proposition 8 *In the unique equilibrium outcome of the game with N passive players, the project is not implemented with probability of* $1 - 1/(1+\lambda)^{N-1}$*, resulting in an expected welfare loss of* $0.5[1 - 1/(1+\lambda)^{N-1}]^2 R$*. Transaction inefficiency increases in passive players' bargaining power and decreases in player A's bargaining power. Moreover, transaction inefficiency increases in the number of passive players. When N goes to infinity, the probability of no-implementation goes to one and all social surplus is lost.*

Proof: Let $F = \sum_{i<N} f_i = [1 - 1/(1+\lambda)^{N-1}]R$. The project is not implemented when $\pi < F$, which occurs with probability of $F/R = 1 - 1/(1+\lambda)^{N-1}$. The welfare loss associated with no-implementation of the project is $\int_0^F \pi/R d\pi = 0.5F^2/R = 0.5[1 - 1/(1+\lambda)^{N-1}]^2 R$. The welfare loss is increasing in λ, so therefore is increasing in δ_1 and decreasing in δ. It is easy to see that the welfare loss is also increasing in N. As long as $\lambda > 0$, when N approaches zero, the probability of no-implementation goes to one and the welfare loss approaches $0.5R$, the total feasible ex ante social surplus. *Q.E.D.*

Proposition 8 conveys the main message of this paper that transaction efficiency is affected by the number of people involved and the relative bargaining power of passive players against the active player. Fearing that they would be taken advantage of by passive players after him if they do not commit, all passive players except the last one commit not to renegotiate their contracts. The greater their relative bargaining power, the larger the shares they can get and then commit to, and hence the greater the efficiency loss. Moreover, in committing to their original contracts, they do not take into account the externalities on each other. That is, a lower probability of implementation affects everybody, not just himself. This additional effect makes bargaining with a large number of passive players more difficult because those negative externalities add up quickly. When N becomes large, the project is implemented with a probability approaching zero in equilibrium. In other words, trade can collapse with a large number of passive players. In contrast to no-trade results of Rob (1989) and Mailath and Postlewaite (1990), this collapse of trade result is obtained in a setting where there is complete information and there is always positive gain from trade.

4 Application: Property Right Allocations—Eminent Domain Law

Private property rights are regarded as a foundation for free market economies. A legal system of property rights provides proper protection for property owners and lays out a framework for private parties to contract freely in pursuit of any positive gain from trade. The Coase Theorem maintains that in the absence of transaction costs, decentralized bargaining will lead to efficient resource allocations no matter how property rights are allocated, provided property rights are well defined. When there are transaction costs, property right allocations will then affect economic efficiency. As we show in this paper, the number of people involved can affect transaction efficiency adversely. In this section, we use this idea to shed light on the Eminent Domain Law.

Eminent Domain Law applies to large scale infrastructure or real estate development projects. Under this law, the government has the authority to take away private properties (e.g., land and houses), provided that "just" compensation is paid. Although it is usually some government agencies (e.g., planning bureaus or department of transportation) that go out and take properties, Eminent Domain law is applicable no matter whether the real project undertaker is a government agency or a private entity. Once its project proposal is approved by the government, the developer is guaranteed that it can obtain the properties needed for the project at a cost not exceeding their "fair" market values.

Eminent Domain Law is widely adopted by the developed economies around the world. It is clearly a very strong form of government intervention, and is often portrayed in the popular press as a brutal governmental process that undermines private property rights. But why and when it is useful is not made clear in the literature. Why not just let the developer and all the other affected parties engage in decentralized bargaining and work out some deals?

Any justification for Eminent Domain Law must be based on some notion that decentralized bargaining by private parties cannot effectively achieve efficient resource allocations under the circumstances the law is applied to. Our results indicate that the bargaining outcomes are more likely to be inefficient when a large number of people is involved and they have relatively large bargain power. This is consistent with the typical situations where Eminent Domain law is applicable: large projects (hence surpluses are uncertain and hard to verify ex post, and more people are involved) and choices of locations are limited (hence property owners have large bargaining power). Under Eminent Domain Law, the need of bargaining simply disappears.[12]

Rosenthal (1990) provides a lively historical account of how Eminent Domain Law can resolve bargaining inefficiency among private parties. In this paper, Rosenthal compares the development of irrigation projects in France before and after the French Revolution (1789). Although the economic and technological conditions were very similar between the periods of about 80 years before and after the Revolution, the increase in irrigated area between 1780 and 1860 was more than 4 times that between 1700 and 1780. The most important cause for this difference, as Rosenthal convincingly argues, was changes in the institutional environment brought by the Revolution, in particular, authority over rights to build canals was dispersed before the Revolution but centralized after. In the pre-Revolution Regime, a canal builder had to seek approval from every community the proposed canal would cross and bargain with each one of them about compensation. In contrast, only approval from the central government agency was needed to implement an irrigation project in the post-Revolution Regime. The evidence presented by Rosenthal suggests that without Eminent Domain Law, many potentially beneficial projects were simply deterred in the pre-Revolution era.

Through case studies of projects undertaken in the pre-Revolution Regime, Rosenthal shows that "the more institutional boundaries canals crossed, the more difficult they were to build." Among the cases studied, two small canals built by landowners primarily for self use encountered little trouble; two other canals of medium scale that involved a few communities (one canal involved only three communities) had some trouble and entailed lengthy legal suits. A large scale project incurred a significant amount of additional costs including choosing a rocky route over a much easier one,

[12]In a related paper, Gertner (1996) explains the importance of Eminent Domain Law with an incomplete-information multilateral bargaining model. Our approach complements Gertner since we do not rely on incomplete information.

in order to avoid potential problems with the many communities along the technologically easier route. Finally, Rosenthal studies another large scale project that eventually went to bankruptcy because each of the many communities affected by the canal demanded a large share of the benefits. Overall, Rosenthal's historical analysis points out the importance of Eminent Domain Law and provides supporting evidence for our model.

5 Application: Regulatory Responses

In the previous section, we argue that the legal system of property rights should be responsive to the bargaining structure of underlying economics situations in order to reduce welfare loss associated with bargaining with a large number of people. However, the legal system in principle cannot be very flexible or tailored to specific situations. Alternatively, changes in regulations and government policies may help mitigate the problem by affecting the bargaining structure. In this section, we discuss two applications of this sort, one regarding industrial relation policy, the other about regulations of bankruptcy procedures.

5.1 Multi-unionism

Our first application concerns comparative industrial relations, specifically, single- versus multi-unionism. In countries such as the United States where labor relation regulations require single union representation within a firm or a plant, most collective bargaining is undertaken between one employer and one union. In other countries such as Britain, it is common for multiple unions to exist in a plant or a firm, each representing one or more occupations. For example, according to Machin, Stewart and Van Reenen (1993), 35% of unionized plants in Britain had at least two manual trade unions in both 1980 and 1984; in 66% of those multiple union plants in 1980 and 51% in 1984, unions bargained separately. Assume that each union acts as a single entity that maximizes its share of the total surplus from production, then multiple unionism with unions bargaining separately corresponds to the multilateral bargaining case of our model, while single unionism or multiple recognized unions bargaining together as one bargaining unit correspond to the bilateral bargaining case.

Since each union normally represents one or more occupations under multiple unionism (especially when there are multiple bargaining units), individual unions are likely to be complementary, and each has a certain degree of bargain power. Firm profit is usually hard to predict (i.e., ex ante uncertainty), and is greatly affected by management decisions (i.e., unverifiable ex post by unions). Our results predict that other things being equal, the incidence of strikes will be higher when an employer bargains with two or more unions separately than with one collective bargaining unit. In addition, compared to single unionism, multiple unionism will generally be correlated with firms getting a smaller share of the total surplus from production.

The studies by Machin *et al.* (1993a, b) provide empirical evidence that is largely consistent with these predictions (other studies such as Ingram, Metcalf, and Wadsworth 1993 present similar evidence). Using establishment-level data from the 1984 Workplace Industrial Relations Survey in Britain, Machin *et al.* (1993) investigate the possible links between multiple unionism and economic performance of firms. They do not find any significant difference in economic performance between plants that have multiple unions bargaining as a single unit and plants that have only a single union, indicating that what really matters is the bargaining structure, namely, single versus multiple bargaining units. Comparing plants having one bargaining unit with plants having multiple bargaining units, they find that plants that have to bargain with multiple unions separately are "more likely to experience strikes of at least a day's duration"; "have inferior financial performance (in manufacturing)" and "pay higher wages". Among these findings, the most relevant is the incidence of strikes: while single union firms and firms with jointly bargaining multiple unions do not exhibit difference in terms of likelihood of strikes, "a serious strike is 10.2 percent more likely to occur in separate bargaining establishments than in comparable single bargaining group establishments." (Machin *et al.* 1993b, p65)

5.2 Bargaining under financial distress

When a firm is in financial distress, it can either file for bankruptcy or renegotiate debt in a private workout. In the U.S. bankruptcy code, a firm has two options when filing for bankruptcy: it can liquidate its assets by filing under Chapter 7, or reorganize itself by filing under Chapter 11. If a firm in financial distress is economically viable, then the socially optimal solution is to restructure its capital structure and let it survive and continue production. Given that there are considerable costs associated with reorganizing under Chapter 11 (e.g., legal costs, time and resources used in the procedure, forgone business opportunities, inefficient court interventions), it appears that renegotiating a private workout is a better alternative. In fact, before filing bankruptcy, firms do try to work out a debt restructuring plan through bargaining with its creditors. However, many such attempts are unsuccessful. In a sample of 169 companies used by Gilson, Kose and Lang (1990), half of the firms that tried private workouts ended up filing bankruptcy under Chapter 11. In sharp contrast, over 95% of civil lawsuits are settled before trial.

Why are private workouts so difficult to be worked out? Although there are many possible explanations, we argue that one important reason is that the number of involved parties is quite large.[13] Firms typically borrow from many sources. The average number of creditors among firms in the Gilson *et al.* sample is about 6.4 (the median is 5). The US bankruptcy regulation requires unanimous approval of every class of debtholders for a private debt restructuring.[14] Thus, to work out a private restructuring, a firm has to reach agreements with every one of its creditors (treating one class of creditors as one bargaining unit). The total surplus from a private workout may be hard to estimate accurately (i.e., ex ante uncertainty) and hard to verify by the creditors ex post. The results of our model suggest that there can be severe inefficiency and inefficiency will likely become more severe as the number of creditors rises.

This prediction seems to be consistent with available empirical evidence. For example, Gilson *et al.* (1990) studied factors that affect the bargaining outcomes of private workouts. Holding other things constant, they found that the fewer lenders a firm had, the more likely it could successfully restructure its debt privately.[15] As another example, private workouts appear much more common in Japan than in the U.S. To be sure, like American firms, Japanese firms also borrow from many sources (Hoshi, Kashyap, and Scharfstein 1990). But a unique feature of the Japanese financial system is that each firm is usually affiliated with a main bank, who acts as a leader and coordinator

[13]Other reasons given in the literature include asymmetric information, the free-rider problem among creditors, control issues, etc; see, e.g., Gertner and Scharfstein (1991) for a theoretical analysis of workouts. Gertner (1996) also discusses the bargaining difficulties in the Chapter 11 procedure when there are multiple creditors.

[14]In comparison, acceptance of a reorganization plan under Chapter 11 requires the approval of a two-third majority in value and one-half majority in number of each class of claimholders.

[15]The marginal effect of one additional creditor on the likelihood of successful private workout is not reported. Other things found to positively affect the likelihood of success are intangible assets and proportion of bank loans.

of the firm's overall borrowing activities (see Aoki and Patrick (1994) for extensive studies on the main bank system). Workouts by Japanese firms are usually conducted by main banks with which financially distressed firms are affiliated. So the main banks serve as the representatives of all creditors, much like multiple unions bargaining jointly as a single entity. Hoshi *et al.* (1990) find evidence that bank affiliation indeed helps Japanese firms in financial distress restructure their debts and recover from the distress.[16]

6 Application: Institutional Innovations

Aside from remedies by the legal system or government regulations, parties that are directly involved should have all the incentives to try to change the underlying institutional environments in order to improve transaction efficiency (see, e.g., North 1990). Initiatives to make such efficiency-enhancing institutional innovations by private parties are especially important when the legal system and governments do not function properly. In this section, we present two examples of institutional innovations in developing countries that try to cope with the problem of bargaining with a large number of parties.

Consider an entrepreneur who wants to get a business license. Because of rampant corruption and heavy regulations which plague many developing countries, to get a business license (or many other permits) often requires permissions from a large number of government agencies. The entrepreneur has to bribe each of them to get their permission, but since bribery is illegal, no government official wants to accept a bribe in the presence of other people; hence bargaining can only take place between the entrepreneur and each of the officials. Once a license is granted, many of the government agencies may not be able to get hold on the entrepreneur anymore, making

[16]Bolton and Scharfstein (1996) present an interesting theoretical study of the optimal number of creditors a firm should have. The central tradeoff is between providing *ex ante* efficient incentives for the manager and obtaining *ex post* efficient liquidation decisions. The optimal contract usually involves a certain degree of inefficient liquidation to punish the manager for exerting low effort. The number of creditors affects ex post inefficiency in liquidation and hence how severe the punishment is. In their paper, Bolton and Scharfstein assume exogenous bargaining costs to generate inefficient liquidation. Instead of assuming ad hoc bargaining costs, one may be able to extend the model and enrich its predictions by using a bargaining game similar to ours to derive endogenously bargaining inefficiency.

payments contingent on its future profit unfeasible. Before the business starts, it is usually hard to have a precise idea about future profit. Therefore, the bargaining problem the entrepreneur faces fits pretty well into our bargaining framework.

Our results indicate that there can be serious efficiency losses in bargaining with many government agencies. Evidence of such inefficiency can be found in many developing countries. For example, in some cases reported in the media, a few hundred stamps and a couple of years are needed to get a regular business license in China. Business communities, both domestic and foreign, often complain about bureaucracy and corruption as the main factors that deter business opportunities.

We argue that a particular institutional innovation in China, Township and Village Enterprises (TVEs), is partially a response to the problem associated with bargaining with numerous government agencies. A distinctive characteristic of TVEs is that top government officials at the township and village level are closely involved in those enterprises. Since 1978, these TVEs have considerably outperformed both state-owned and private enterprises and are considered the driving force behind China's remarkable economic growth in reform years. Yet why this peculiar institutional arrangement can succeed in the Chinese economy is not completely clear.[17] We argue that TVEs can be viewed as partnerships between entrepreneurs and township and village government officials. By engaging in township and village government officials, these enterprises can deal with various government agencies much more easily than entrepreneurs themselves, making them more efficient than private firms. On the other hands, entrepreneurs have better incentives and more autonomy than managers in state enterprises because township and village government officials share the surplus generated by TVEs and hence have incentives to allow entrepreneurs to maximize profit.

From the perspective of entrepreneurs, government officials in the township and villages act much like a representative of all the government agencies. Without those government officials in TVEs, entrepreneurs have to bargain with each of many government agencies (including officials in the township and villages). With those officials in TVEs, entrepreneurs only need to bargain with them. In a sense, TVEs institutionalize a change in the bargaining structure from multilateral

[17]See Che and Qian (1998) for an explanation based on state predation and proper incentives for entrepreneurs and the references cited thereafter for other explanations. The simple argument offered here is not necessarily incompatible with any of the existing theories.

bargaining with bilateral agreements to bilateral bargaining. How is this transformation of the bargaining structure possible? If permissions have to be obtained from the township and village government level, the top officials at that level can simply use their authority to consolidate different bargaining units. For permissions from higher level government agencies (e.g., county, municipal, province), township and village officials can deal with them more effectively. Because of their working relationships, higher level officials can easily get hold on officials in the township and villages, making it possible to condition bribery on future profit. Moreover, because of the nature of their working relations and long-term personal relations, reputation can take effects to make it much easier for them to collude in so far as not to exploit enterprises too aggressively. In contrast, each bureaucrat will extort an individual entrepreneur as much as possible because they will not be able to extract rents from him again if she is "let go".

We should emphasize that this simple argument is not intended to provide a complete theory of TVEs, but rather to point out one source of the cost-effectiveness of this particular institutional form relative to private firms. As China's legal system improves and arbitrary expropriation by government agencies is reduced over the years, the benefits of having township and village government officials involved in TVEs decline. We expect a trend towards more clearly defined ownership specifications, in particular, total separation of entrepreneurs and government officials through privatization. This is taking place in China now.

In other developing countries, different institutional forms have emerged to cope with similar problems. For instance, in Brazil, there are special agencies called "despachantes" who get business licenses for entrepreneurs for a fee. To get a business license, an entrepreneur needs only to pay a single moderate fee to a despachante, instead of going through numerous government agencies. Stone, Levy and Paredes (1992) describe the functions of despachantes as follows:

> The word "despachante" means dispatcher, but refers to an individual whose job is to obtain government permits and authorizations on behalf of clients. Formally, their expertise derives from their knowing the legal requirements and administrative procedures for obtaining permits. Informally, their expertise also includes knowing which government officials can be persuaded to side-step the rules in exchange of a gratuity. Despachantes are used, not only by individuals and businesses, but also by lawyers and

> accountants, who regards despachantes as a distasteful but necessary means of doing their dirty work while keeping their hands clean (p. 29, Endnote 29).

Therefore, an important part of the service a despachante provides is to bargain with numerous government officials on behalf of his client. A despachante can bargain with the officials more efficiently because he has personal relationships with them and interacts with them repeatedly. Stone *et al.* provide evidence showing that the mean costs involved in the formal registration process is about the same in Brazil and Chile, despite that Brazil has a much more complex and confusing legal and regulatory system.[18] Clearly, the costs saved from going through a cumbersome procedure in Brazil must be attributed largely to the despachantes' ability in bargaining with officials more efficiently. From the perspective of an entrepreneur, a despachante acts as a representative of all government agencies, thus transforming a multilateral bargaining problem with bilateral agreements into a single bilateral bargaining problem. "Distasteful" or not, despachantes serve as an institution promoting transaction efficiency in an ill-functioning legal and regulatory environment.

7 Related Literature

Our paper is related to a large literature that investigates bargaining efficiency. Since 1980's, many papers show that with incomplete information inefficient bargaining outcomes can arise in equilibrium, see, e.g., Abreu and Gul (2000), Admati and Perry (1987), Ausubel and Deneckere (1989), Compte and Jehiel (forthcoming), Cramton (1992), Fudenberg, Levine and Tirole (1985), Gul and Sonnenschein (1988), Hart (1989), Rubinstein (1985), and many others (Kennan and Wilson 1993 provide an excellent review). While these works generate important insights about how and when bargaining inefficiency arises under incomplete information, their applicability is limited because analysis of incomplete information bargaining models is usually quite involved and usually there are many equilibria.[19] Little can be said about how inefficiency varies with the

[18] As an example, " '1,470 separate legal actions with thirteen government ministries and fifty agencies' are required for an export license in 1981"(Stone *et al.*, p. 5).

[19] An important exception is Abreu and Gul (2000), who show that there is a unique equilibrium with delay when bargainers can be of irrational types. Compte and Jehiel (forthcoming) show that the presence of outside options can restore efficiency in such a setting.

institutional variables that are of central interests in applications.

Here we should mention Rob (1989), Mailath and Postlewaite (1990), and Gertner (1995), all are concerned with the connections between transaction efficiency and the number of people involved. The most important difference is that asymmetric information is critical in all of these papers, while our model has complete information. Rob (1989) and Mailath and Postlewaite (1990) use the mechanism design approach and hence has great generality. On the other hand, they assume that gains from trade are not certain and their results are mainly concerned with the limit case when the number of bargainers goes to infinity. Most closely related to our paper in spirit is Gertner (1996), who studies an incomplete information bargaining game in which the uninformed party makes take-it-or-leave-it offers to several informed players. Our paper complements these works by using a rather different approach.

The existing literature has also pointed out several reasons for bargaining inefficiency under complete information. When offers are made simultaneously, coordination failure (e.g., every bargainer making non-serious offers) may cause delay in reaching agreement, see, e.g, Perry and Reny (1993). In a second case, when there are multiple efficient equilibria, inefficient equilibria can be constructed by boot-strapping, see, e.g., van Damme, Selten and Winter (1990), Fernandez and Glazer (1991) and Haller and Holden (1990), Busch and Wen (1995). Equilibrium strategies are usually quite complicated and bargainers have to coordinate on those strategies in the inefficient equilibria. A third reason is that there may be identity-related externalities (e.g., player A gets a utility of x if B owns a good, a utility of $y \neq x$ if C owns the good), see Jehiel and Moldovanu (1995a,b). Inefficiency can also arise in bargaining under deadlines combined with exogenous commitment, see Fershtman and Seidmann (1993). Another case of inefficiency is pointed out by Cai (1997, 2000a), where in a multilateral bargaining environment with bilateral agreements it is shown that inefficient bargaining outcomes can arise in even stationary SPE due to strategic maneuvering of bargaining positions. To various degrees, these complete information models are hard to apply too because of multiple equilibria or the specific bargaining rules used in these models.

In terms of the bargaining structure of the game, our model is closely related to Horn and Wolinsky (1988), Stole and Zwiebel (1996a, b), and Wolinsky (2000). All these papers study models in which a firm bargains with multiple workers (unions) sequentially. Their focuses are very different from ours. Horn and Wolinsky (1988) investigate when collusion among unions is profitable. Stole and Zwiebel (1996a, b) and Wolinsky (2000) examine the effects of union bargaining on employments and other organizational design issues. A large number of papers has also studied multilateral bargaining problems with somewhat different rules, see, e.g., Gul (1989), Chae and Yang (1994), Jun (1989), Krishna and Serrano (1996) (Osborne and Rubinstein (1990) offer an excellent survey of earlier works).

8 Conclusion

In this paper we propose a simple bargaining model with uncertainty and incomplete contracts that allows a clean characterization of equilibrium and makes it possible to analyze the determinants of transaction efficiency. We find that transaction efficiency is affected by the number of people involved and the relative bargaining power of passive players against the active player. For future research, the model should be extended to include more general distribution of surplus and allow risk averse preferences. This will enrich the model's predictions about how the degree of uncertainty and risk aversion affect transaction efficiency, which may provide theoretical guidance for empirical work in explaining bargaining failures such as strike activities.

Much research also needs to be done in incorporating bargaining theories into the study of organizations and the theory of the firm. For example, in the property right theory of the firm (e.g., Hart and Moore 1990, Hart 1995), bargaining outcomes are assumed to be efficient in both ex ante and ex post stages and bargaining theory is only used in determining distribution of surplus. On the other hand, many scholars argue that the issue of bargaining efficiency plays an important role in understanding organizations and the boundaries of the firm. As mentioned before, the transaction cost theory originated by Williamson focuses on factors such as uncertainty that determine bargaining efficiency in the market. Pushing that idea further, Milgrom and Roberts (1990) argue that a critical difference between transacting in the market and within the firm is precisely that the bargaining structure differs. In the market, trade is done through decentralized bargaining, and "bargaining costs" must be incurred. Within the firm, trade is done by the chief executive office without the consent of other parties in the firm as long as contractual, legal and social constraints are respected. However, many parties within the firm whose welfare is affected by the decisions of the chief executive office, e.g., division managers, may try to influence the decisions towards their favor, leading to wasteful "influence costs" (Milgrom 1988). Milgrom and Roberts argue that the trade-off between bargaining costs and influence costs determine the boundary of the firm. To advance these ideas, what is needed is a bargaining theory that provides sharp theoretical predictions about what institutional factors determine transaction efficiency in various organizational forms. Our simple model suggests some clue in that direction, but clearly there is a long way to go.

APPENDIX

Proof of Proposition 1: Suppose $K = 2$. If A and player 1 reach an agreement of f_1 in period t, A will reach an agreement with player 2 in $t+1$ because the bargaining game between A and 2 is the standard Rubinstein game with a joint surplus of $r - f_1$. In this case, valued at t, player 1's payoff is f_1, player 2's payoff is $(r - f_1)\delta_1(1-\delta)/(1-\delta\delta_1) = \lambda(r - f_1)$ and player A's payoff is $(r - f_1)(1-\delta_1)/(1-\delta\delta_1) = (1-\lambda)(r - f_1)$. Therefore, the whole three-player bargaining game can be reduced to a bargaining game between A and 1 with the following payoff functions: for any outcome (f_1, t), $u_1 = \delta_1^{t-1} f_1$ and $u = \delta^{t-1}(1-\lambda)(r - f_1)$. This is another Rubinstin game. Let A's offer be x and 1's counter-offer be z in the unique SPE of the game. Then by Rubinstein (1982),

$$\begin{aligned} x &= \delta_1 z \\ (1-\lambda)(r-z) &= \delta(1-\lambda)(r-x) \end{aligned}$$

The solution to these equations is $x = r\delta_1(1-\delta)/(1-\delta\delta_1) = \lambda r$. Thus, the equilibrium outcome of the game is $f_1 = \lambda r$, $f_2 = (1-\lambda)\lambda r$ and $u = (1-\lambda)^2 r$. Mathematical induction argument can easily prove the proposition for $K > 2$. *Q.E.D.*

Proof of Theorem 1: The only thing remaining to be shown is the equilibrium outcome of the initial stage of bargaining. Despite the fact that Eu_1 and Eu are non-monotonic in f_1 over some range, the result of Rubinstein (1982) still applies (one can also use the Skaked and Sutton (1984) method to verify this). Let A's offer be x and 1's counter-offer be z in a SPE of the bargaining game. Then by Rubinstein (1982) and by Equations 1 and 2,

$$[R-(1-0.5\lambda)x]x/R=\delta_1[R-(1-0.5\lambda)z]z/R$$

$$[(R-z)^2+(1-\lambda)z^2]/(2R)=\delta[(R-x)^2+(1-\lambda)x^2]/(2R)$$

To solve these equations, a short cut is to note that $[R-(1-0.5\lambda)x]x/R+[(R-x)^2+(1-\lambda)x^2]/(2R)=0.5R$ for all x. Therefore, the solution must satisfy

$$[R-(1-0.5\lambda)x]x/R=0.5\lambda R$$

Or, equivalently, $[(1-0.5\lambda)x^2-xR+0.5\lambda R^2=0$. The left hand side can be rewritten as $(x-R)[(1-0.5\lambda)x-0.5\lambda R]$. Therefore, there are two solutions $x=R$ or $x=\lambda R/(2-\lambda)$, both of which result in $Eu_1=0.5\lambda R$ and $Eu=0.5(1-\lambda)R$. *Q.E.D.*

Proof of Proposition 5: Let us define $w_2^{(j)}(f_1,f_2)=Eu+Eu_2$ in area j, $j=1,2,3,4$. Define $W_2^{(j)}(f_1)$ as the maximum of $w_2^{(j)}(f_1,f_2)$ in each area j. It is easy to see that $w_2^{(3)}=0.5\lambda(1-\lambda)R+0.5(1-\lambda)^2R=0.5(1-\lambda)R$, so $W_2^{(3)}(f_1)=0.5(1-\lambda)R$ is a constant.

Since $w_2^{(4)}=f_2(R-f_2)/R+(1-\lambda)(R-f_2)^2/(2R)$, the first order condition for a maximal f_2 is $R-2f_2+(1-\lambda)(f_2-R)=\lambda R-(1+\lambda)f_2=0$. So its solution is $f_2=R\lambda/(1+\lambda)$. For this solution to fall in area (4), it must be that $f_1\geq R/(1+\lambda)R$ (so $f_1+f_2\geq R$) and $f_2\in[\tau_1 R,\tau_2 R]$. It can be verified that the latter condition is satisfied. Since $\lambda/(1+\lambda)\leq 0.5$, it is clearly less than τ_2. To see $\lambda/(1+\lambda)\geq\tau_1$, it is equivalent to

$$\begin{aligned}\sqrt{1-2\lambda(1-\lambda)} &\geq (1-\lambda)/(1+\lambda)\\(1-2\lambda+2\lambda^2)(1+\lambda)^2 &\geq (1-\lambda)^2\\(1-\lambda)^2[(1+\lambda)^2-1]+\lambda^2(1+\lambda)^2 &\geq 0\end{aligned}$$

Therefore, if $f_1\geq R/(1+\lambda)$, then $f_2=\lambda/(1+\lambda)R$ maximizes $w_2^{(4)}$, resulting in $W_2^{(4)}=0.5R/(1+\lambda)$. Since $w_2^{(4)}$ is decreasing in f_2 for $f_2>R\lambda/(1+\lambda)$, so when $\tau_1 R\leq f_1<R/(1+\lambda)$, $f_2=R-f_1$ maximizes $w_2^{(4)}$, resulting in $W_2^{(4)}=f_1(R-f_1)/R+(1-\lambda)f_1^2/(2R)=f_1[2R-(1+\lambda)f_1]/(2R)$.

Since $w_2^{(2)} = f_2(R-f_2)/R + (R-f_1-f_2)^2/(2R) + (1-\lambda)f_1^2/(2R)$, the first order condition for a maximal f_2 is $R - 2f_2 + f_1 + f_2 - R = f_1 - f_2 = 0$. So its solution is $f_2 = f_1$. For this solution to fall in area (2), it must be that $f_1 \leq 0.5R$ (so $f_1 + f_2 \leq R$) and $f_2 \in [\tau_1 f_1/\tau_2, \tau_2 f_1/\tau_1]$. The latter condition is clearly satisfied. Hence, if $f_1 \leq 0.5R$, then $f_2 = f_1$ maximizes $w_2^{(2)}$, resulting in $W_2^{(2)} = [(R-f_1)^2 + (2-\lambda)f_1^2]/(2R)$. Since $w_2^{(2)}$ is increasing in f_2 for $f_2 < f_1$, so when $0.5R < f_1 < \tau_2 R$, $f_2 = R - f_1$ maximizes $w_2^{(2)}$, resulting in $W_2^{(2)} = f_1(R-f_1)/R + (1-\lambda)f_1^2/(2R) = f_1[2R - (1+\lambda)f_1]/(2R)$.

Since

$$\begin{aligned} w_2^{(1)} &= f_2(R-f_1-f_2)/R + \lambda(1-\lambda)(f_1+f_2)^2/(2R) + (R-f_1-f_2)^2/(2R) + (1-\lambda)^2(f_1+f_2)^2/(2R) \\ &= [(R-f_1)^2 + (1-\lambda)(f_1+f_2)^2 - f_2^2]/(2R) \end{aligned}$$

the first order condition for a maximal f_2 is $-f_2 + (1-\lambda)(f_1+f_2) = (1-\lambda)f_1 - \lambda f_2 = 0$. So its solution is $f_2 = (1-\lambda)f_1/\lambda$. For this solution to fall in area (1), it must be that $f_1 \leq \lambda R$ (so $f_1 + f_2 \leq R$) and $f_2 \notin [\tau_1 f_1/\tau_2, \tau_2 f_1/\tau_1]$. The latter condition is violated (except on the boundary). To see this, first note that $\tau_1 \leq \lambda$ because it is equivalent to $\sqrt{1-2\lambda(1-\lambda)} \geq 1 - 2\lambda$, or equivalently, $1 - 2\lambda + 2\lambda^2 \geq 1 - 4\lambda + 4\lambda^2$, or equivalently, $2\lambda(1-\lambda) \geq 0$, which must hold. Note also that $\tau_2 \geq \lambda$ because it is equivalent to $\sqrt{1-2\lambda(1-\lambda)} \geq 2\lambda - 1$, which must hold from the above inequalities. Since $\tau_1 \leq \lambda \leq \tau_2$, it must be that $\tau_1/\tau_2 \leq (1-\lambda)/\lambda \leq \tau_2/\tau_1$. Therefore $f_2 \notin [\tau_1 f_1/\tau_2, \tau_2 f_1/\tau_1]$ will be binding constraints.

For $f_1 \in [\tau_1 R, \tau_2 R]$, $f_2 \leq \tau_1 f_1/\tau_2$ is the only constraint, so $f_2 = \tau_1 f_1/\tau_2$ maximizes $w_2^{(1)}$, resulting in $W_2^{(1)} = [(R-f_1)^2 + (1-\lambda-\tau_1^2)f_1^2/\tau_2^2]/(2R)$. For $f_1 \geq \tau_2 R$, the boundary $f_2 = R - f_1$ maximizes $w_2^{(1)}$, resulting in $W_2^{(1)} = 0.5(1-\lambda)R$. For $f_1 \leq \tau_1 R$, either $f_2 = \tau_2 f_1/\tau_1$ or $f_2 = \tau_1 f_1/\tau_2$ maximizes $w_2^{(1)}$. When $f_2 = \tau_2 f_1/\tau_1$, $W_2^{(1)} = [(R-f_1)^2 + (1-\lambda-\tau_2^2)f_1^2/\tau_1^2]/(2R)$; and when $f_2 = \tau_1 f_1/\tau_2$, $W_2^{(1)} = [(R-f_1)^2 + (1-\lambda-\tau_1^2)f_1^2/\tau_2^2]/(2R)$. One can show that $(1-\lambda-\tau_2^2)/\tau_1^2 \leq (1-\lambda-\tau_1^2)/\tau_2^2$, because it is equivalent to $(1-\lambda)(\tau_2^2-\tau_1^2) - (\tau_2^4 - \tau_2^4) = (\tau_2^2-\tau_1^2)(1-\lambda-\tau_1^2-\tau_2^2) \leq 0$, which follows from $1-\lambda-\tau_1^2-\tau_2^2 = 1-\lambda-0.5[2-2\lambda(1-\lambda)] = -\lambda^2 \leq 0$. Therefore, For $f_1 \leq \tau_1 R$, $f_2 = \tau_1 f_1/\tau_2$ maximizes $w_2^{(1)}$, resulting in $W_2^{(1)} = [(R-f_1)^2 + (1-\lambda-\tau_1^2)f_1^2/\tau_2^2]/(2R)$.

Combining these subcases, we can see that for $f_1 \leq \tau_2 R$, $f_2 = \tau_1 f_1/\tau_2$ maximizes $w_2^{(1)}$, resulting in $W_2^{(1)} = [(R-f_1)^2 + (1-\lambda-\tau_1^2)f_1^2/\tau_2^2]/(2R)$. For $f_1 \geq \tau_2 R$, $f_2 = R - f_1$ maximizes $w_2^{(1)}$, resulting in $W_2^{(1)} = 0.5(1-\lambda)R$.

The next step is to figure out for each f_1, which f_2 maximizes w^2 globally (i.e., across areas).

For $f_1 \leq \tau_1 R$, we need to compare $W_2^{(1)} = [(R-f_1)^2 + (1-\lambda-\tau_1^2)f_1^2/\tau_2^2]/(2R)$, $W_2^{(2)} = [(R-f_1)^2 + (2-\lambda)f_1^2]/(2R)$ and $W_2^{(3)} = 0.5(1-\lambda)R$. It is easy to see that $W_2^{(2)} \geq W_2^{(1)}$, because $(2-\lambda)\tau_2^2 - (1-\lambda-\tau_1^2) = \lambda + \tau_1^2 + \tau_2^2 - 1 + (1-\lambda)\tau_2^2 \geq 0$. It can also be shown that $W_2^{(2)} \geq W_2^{(3)}$. To see this, note that $W_2^{(2)}$ is convex in f_1, so it has the minimum value at the boundary points of f_1. Hence it is sufficient to show that $W_2^{(2)} \geq W_2^{(3)}$ holds at $f_1 = 0$ and $f_1 = \tau_1 R$. At $f_1 = 0$, this is trivial since $W_2^{(2)} = 0.5R \geq W_2^{(3)}$. At $f_1 = \tau_1 R$, $W_2^{(2)} \geq W_2^{(3)}$ if $(1-\tau_1)^2 + (2-\lambda)\tau_1^2 \geq 1-\lambda$. The latter holds because $(1-\tau_1)^2 + (2-\lambda)\tau_1^2 - 1 + \lambda = \lambda + \tau_1^2 + \tau_2^2 - 1 + (1-\lambda)\tau_1^2 \geq 0$. Therefore, for $f_1 \leq \tau_1 R$, it is optimal for players A and 2 to reach an agreement on $f_2 = f_1$, resulting in a joint payoff of $W_2^{(2)} = [(R-f_1)^2 + (2-\lambda)f_1^2]/(2R)$.

For $f_1 \in [\tau_1, \tau_2]R$, we need to compare all four areas. For $\tau_1 R \leq f_1 \leq 0.5R$, $W_2^{(1)}$, $W_2^{(2)}$ and $W_2^{(3)}$ are all the same as in the previous case when $f_1 \leq \tau_1 R$. As before, $W_2^{(2)} \geq W_2^{(1)}$. To show $W_2^{(2)} \geq W_2^{(3)}$, now we needs to show it holds at the new boundary point $f_1 = 0.5R$. At $f_1 = 0.5R$, $W_2^{(2)} = 0.5R - (1+\lambda)R/8$, and it is greater than $W_2^{(3)} = 0.5(1-\lambda)R$ when $\lambda \geq 1/3$. Hence when $\lambda \geq 1/3$, $W_2^{(2)}$ is the largest among the three, so we only need to compare it with $W_2^{(4)} = f_1[2R - (1+\lambda)f_1]/(2R)$. It is easy to show that $W_2^{(2)} \geq W_2^{(4)}$, because it is equivalent to $(R-f_1)^2 + (2-\lambda)f_1^2 - f_1[2R - (1+\lambda)f_1] = (R-2f_1)^2 \geq 0$. Therefore, for $\tau_1 R \leq f_1 \leq 0.5R$, $W_2^{(2)}$ is the maximum joint payoff for players A and 2.

For $0.5R \leq f_1 \leq R/(1+\lambda)$, $W_2^{(2)} = W_2^{(4)} = f_1[2R-(1+\lambda)f_1]/(2R)$, and $W_2^{(1)}$ and $W_2^{(3)}$ are the same as in the previous case when $f_1 \leq \tau_1 R$. Note that $W_2^{(2)} = f_1[2R-(1+\lambda)f_1]/(2R)$ is increasing in f_1 for $f_1 \leq R/(1+\lambda)$, so for $0.5R \leq f_1 \leq R/(1+\lambda)$, $W_2^{(2)} \geq 0.5R-(1+\lambda)R/8$. We know that when $\lambda \geq 1/3$, $0.5R - (1+\lambda)R/8 \geq W_2^{(3)}$, so $W_2^{(2)} \geq W_2^{(3)}$ for all $0.5R \leq f_1 \leq R/(1+\lambda)$. To show that $W_2^{(2)} \geq W_2^{(1)}$, note that at $f_1 = 0.5R$, $W_2^{(2)} = [(R-f_1)^2+(2-\lambda)f_1^2]/(2R) \geq W_2^{(1)}$. At $f_1 = R/(1+\lambda)$, $2(1+\lambda)^2[W_2^{(2)} - W_2^{(1)}]/R = 1+\lambda-\lambda^2-(1-\lambda-\tau_1^2)/\tau_2^2 = [\lambda+\tau_1^2+\tau_2^2-1+\lambda(1-\lambda)\tau_2^2]/\tau_2^2 \geq 0$. If $W_2^{(2)} - W_2^{(1)}$ is concave in f_1, then $W_2^{(2)} \geq W_2^{(1)}$ for $0.5R \leq f_1 \leq R/(1+\lambda)$. Since $2R[W_2^{(2)} - W_2^{(1)}] = 4f_1R - R^2 - [(2+\lambda)\tau_2^2 + 1 - \lambda - \tau_1^2]f_1^2/\tau_2^2$, $W_2^{(2)} - W_2^{(1)}$ is concave if $(2+\lambda)\tau_2^2 + 1 - \lambda - \tau_1^2 > 0$, which clearly holds because $1-\lambda \geq 0$ and $(2+\lambda)\tau_2^2 - \tau_1^2 > (1+\lambda)\tau_2^2 > 0$. Therefore, for $0.5R \leq f_1 \leq R/(1+\lambda)$, $W_2^{(2)} = W_2^{(4)}$ is the maximum joint payoff for players A and 2.

For $R/(1+\lambda) \leq f_1 \leq \tau_2 R$, $W_2^{(2)}$, $W_2^{(1)}$ and $W_2^{(3)}$ are the same as in the previous case when

$0.5R \le f_1 \le R/(1+\lambda)$, but $W_2^{(4)} = 0.5R/(1+\lambda)$. Since $1/(1+\lambda) > 1-\lambda$, so $W_2^{(4)} \ge W_2^{(3)}$. At $f_1 = \tau_2 R$, $2[W_2^{(2)} - W_2^{(1)}]/R = 2\tau_2 - (1+\lambda)\tau_2^2 - (1-\lambda) = 1+\lambda-2\tau_1-(1+\lambda)(1-\tau_1)^2 = \tau_1[(1+\lambda)(2-\tau_1)-2] = \tau_1[2\lambda-(1+\lambda)\tau_1] > 0$. From the previous case, since$W_2^{(2)} - W_2^{(1)}$ and $W_2^{(2)} - W_2^{(1)} \ge 0$ at $f_1 = R/(1+\lambda)$, so $W_2^{(2)} \ge W_2^{(1)}$ for $R/(1+\lambda) \le f_1 \le \tau_2 R$. Now we want to prove $W_2^{(4)} \ge W_2^{(2)}$. Since $W_2^{(2)} = f_1[2R-(1+\lambda)f_1]/(2R)$ is decreasing in f_1 for $f_1 \ge R/(1+\lambda)$, it is sufficient to show $W_2^{(4)} \ge W_2^{(2)}$ at $f_1 = R/(1+\lambda)$. But since at $f_1 = R/(1+\lambda)$, $W_2^{(2)} = 0.5R/(1+\lambda) = W_2^{(4)}$, so $W_2^{(4)} \ge W_2^{(2)}$ for all $R/(1+\lambda) \le f_1 \le \tau_2 R$. Therefore, for $R/(1+\lambda) \le f_1 \le \tau_2 R$, $W_2^{(4)}$ is the maximum joint payoff for players A and 2.

Finally, for $f_1 \ge \tau_2 R$, it is easy to see that $W_2^{(4)}$ is the maximum joint payoff for players A and 2, because for $f_1 \in [\tau_1 R, R]$, $W_2^{(1)} = W_2^{(3)} = 0.5(1-\lambda)R < W_2^{(4)}$, and for $f_1 > R$, $W_2^{(3)} = 0.5(1-\lambda)R < W_2^{(4)}$.

To sum up, for $f_1 \le 0.5R$, it is optimal for players A and 2 to reach an agreement on $f_2 = f_1$, resulting in a joint payoff of $W_2^{(2)} = [(R-f_1)^2 + (2-\lambda)f_1^2]/(2R)$. For $0.5R \le f_1 \le R/(1+\lambda)$, it is optimal for players A and 2 to reach an agreement on $f_2 = R - f_1$, resulting in a joint payoff of $W_2^{(2)} = W_2^{(4)} = f_1[2R-(1+\lambda)f_1]/(2R)$. For $f_1 \ge R/(1+\lambda)$, it is optimal for players A and 2 to reach an agreement on $f_2 = \lambda R/(1+\lambda)$, resulting in a joint payoff of $W_2^{(4)} = 0.5R/(1+\lambda)$. In all these cases, player 2 will commit not to renegotiate his contract. In each of these cases, player 2 will get λ of the joint payoff and player A will get $1-\lambda$ of the joint payoff. Player 1's expected payoff is determined accordingly. *Q.E.D.*

Proof of Proposition 6: By Proposition 4, Player 1's expected payoff is always $f_1(R-f_1)/R$ if he commits not to renegotiate. Proposition 5 gives his expected payoff if he chooses to stay in the game. Comparing these payoffs, we have

(i) For $f_1 \le 0.5R$, one can easily see that $f_1(R-f_1)/R \ge [2f_1 R - (4-\lambda)f_1^2]/(2R)$, player 1 will commit not to renegotiate his contract.

(ii) For $0.5R \le f_1 \le R/(1+\lambda)$, one can easily show that $f_1(R-f_1)/R \ge 0.5\lambda f_1^2/R$, since $f_1[2R-(2+\lambda)f_1] > 0$. Hence player 1 will commit not to renegotiate his contract.

(iii) For $f_1 \ge R/(1+\lambda)$, player 1 will commit not to renegotiate if $f_1(R-f_1)/R \le 0.5\lambda R/(1+\lambda)^2$. It can be shown that this implies that $f_1 \le 0.5R[1+\sqrt{1+\lambda^2}/(1+\lambda]$.

In the first two cases, the expected payoffs are given by Proposition 4, and in the last case, the expected payoffs are given by Proposition 5. This proves the proposition. *Q.E.D.*

Proof of Theorem 2: Let us define $w_1^{(1)}(f_1) = Eu + Eu_1$ for $f_1 \leq R/(1+\lambda)$ and $w_1^{(2)}(f_1) = Eu + Eu_1$ for $f_1 \geq R/(1+\lambda)$. Define $W_1^{(j)}$ as the maximum of $w_1^{(j)}(f_1)$ for $j = 1, 2$. By Proposition 6, $w_1^{(1)}(f_1) = f_1(R - f_1)/R + (1-\lambda)(R - f_1)^2/(2R)$. The first order condition for a maximal f_1 is $R - 2f_1 + (1-\lambda)(f_1 - R) = \lambda R - (1+\lambda)f_1 = 0$. So its solution is $f_1 = R\lambda/(1+\lambda)$, which is clearly less that $R/(1+\lambda)$. The resulting joint expected payoff is $W_1^{(1)} = 0.5R/(1+\lambda)$. Also from Proposition 6, $w_1^{(2)}(f_1) = 0.5\lambda R/(1+\lambda)^2 + 0.5(1-\lambda)R/(1+\lambda) = 0.5(1+\lambda-\lambda^2)R/(1+\lambda)^2$, so trivially $W_1^{(2)} = 0.5(1+\lambda-\lambda^2)R/(1+\lambda)^2$. Clearly $W_1^{(1)} > W_1^{(2)}$. So it is optimal for player 1 and player A to reach an agreement on $f_1 = R\lambda/(1+\lambda)$. Player 1 will commit not to renegotiate his contract. Player 1 and player A will divide $W_1^{(1)}$ by the ratio of $\lambda/(1-\lambda)$. *Q.E.D.*

Proof of Theorem 3: For concreteness, first consider $N = 3$. Suppose A and player 1 have reached an agreement of f_1 and player 1 commits not to renegotiate his contract. The subsequent subgame is isomorphic to the bargaining between A and players 2 and 3 with the payoff uniformly distributed over $[0, R - f_1]$, conditional on the real surplus is greater than f_1. By Theorem 2, player A and player 2 sign a contract of $f_2 = \lambda(R - f_1)/(1+\lambda)$ and player 2 commits not to renegotiate the contract. Then player A and player 3 will sign a contract of $f_3 = R$ and player 3 will choose to stay in the game and renegotiate his contract whenever possible. Since the real surplus is greater than f_1 with probability of $(R - f_1)/R$, the expected payoffs in the subgame with passive players 2 and 3 are $Eu_2 = 0.5\lambda(R - f_1)^2/[(1+\lambda)R]$, $Eu_3 = 0.5\lambda(R - f_1)^2/[(1+\lambda)^2 R]$ and $Eu = 0.5(1-\lambda)(R - f_1)^2/[(1+\lambda)R]$. For player 1, since the project is implemented with probability of $(R - f_1 - f_2)/R = (R - f_1)/[(1+\lambda)R]$, $Eu_1 = f_1(R - f_1)/[(1+\lambda)R]$.

The joint payoff of players A and 1 is $f_1(R - f_1)/[(1+\lambda)R] + 0.5(1-\lambda)(R - f_1)^2/[(1+\lambda)R]$. This is maximized at $f_1 = \lambda R/(1+\lambda)$, resulting in the maximum joint payoff of $0.5R/(1+\lambda)^2$. Player 2's contract is $f_2 = \lambda(R - f_1)/(1+\lambda) = \lambda R/(1+\lambda)^2$. So player A's expected payoff is $Eu = 0.5(1-\lambda)R/(1+\lambda)^2$, passive players' expected payoffs are $Eu_1 = 0.5\lambda R/(1+\lambda)^2$, $Eu_2 = 0.5\lambda(R - f_1)^2/[(1+\lambda)R] = 0.5\lambda R/(1+\lambda)^3$, and $Eu_3 = 0.5\lambda(R - f_1)^2/[(1+\lambda)^2 R] = 0.5\lambda R/(1+\lambda)^4$.

By the logic of Proposition 5, it is easy to see that as long as at least one passive player has chosen to stay in the game, the remaining passive players will choose to commit not to renegotiate their contracts. If A and player 1 have reached an agreement and player 1 chooses to stay in the game, then players 2 and 3 will both commit not to renegotiate their contracts. By a similar argument of Proposition 6 and Theorem 2, one can show that player 1 staying in the game results in smaller joint payoff for players A and 2 than player 1 committing not to renegotiate his contract. This same argument applies to any $N \geq 3$, therefore for any $N \geq 3$, in equilibrium it must be that all passive players except N commit not to renegotiate their contracts, and player N chooses to stay in the game.

We use mathematical induction to prove the equilibrium contracts and payoffs in the theorem for any N. Suppose the theorem holds for $N = K \geq 3$. For $N = K+1$, consider the subgame after player 1 has signed a contract f_1 and committed not to renegotiate his contract. Conditional on the real surplus is greater than f_1, the subgame is isomorphic to the bargaining game with K passive players. Then for $i = 2, 3, ...K$, $f_i = \lambda(R - f_1)/(1 + \lambda)^{i-1}$, $Eu_i = 0.5\lambda(R - f_1)/(1 + \lambda)^{K+i-3}$ and $Eu = 0.5(1 - \lambda)(R - f_1)/(1 + \lambda)^{K-1}$. It can be easily checked that $\sum_{j=2}^{j=K} f_j = [1 - 1/(1 + \lambda)^{K-1}]R$. Since the real surplus is greater than f_1 with probability of $(R - f_1)/R$, player A's unconditional expected payoff is $Eu = 0.5(1 - \lambda)(R - f_1)^2/[(1 + \lambda)^{K-1}R]$. For player 1, since the project is implemented with probability of $(R - f_1 - \sum_{j=2}^{j=K} f_j)/R = (R - f_1)/[(1 + \lambda)^{K-1}R]$, $Eu_1 = f_1(R - f_1 - \sum_{j=2}^{j=K} f_j)/R = f_1(R - f_1)/[(1 + \lambda)^{K-1}R]$.

The joint payoff of players A and 1 is $f_1(R - f_1)/[(1+\lambda)^{K-1}R] + 0.5(1-\lambda)(R - f_1)^2/[(1+\lambda)^{K-1}R]$. This is maximized at $f_1 = \lambda R/(1 + \lambda)$, resulting in the maximum joint payoff of $0.5R/(1 + \lambda)^K$. Hence, for $N = K + 1$, $Eu_1 = 0.5\lambda R/(1 + \lambda)^K$ and $Eu = 0.5(1 - \lambda)R/(1 + \lambda)^K$. For other passive players, $Eu_i = 0.5\lambda(R - f_1)/(1 + \lambda)^{K+i-3} = 0.5\lambda R/(1 + \lambda)^{K+i-2}$. So the theorem holds for $N = K + 1$. Therefore, the theorem holds for any N. *Q.E.D.*

REFERENCES

ABREU, D. and GUL, F. (2000), "Bargaining and Reputation", *Econometrica*, 68:85-117.

ADMATI, A. R. and PERRY, M. (1987), "Strategic Delay in Bargaining", *Review of Economic Studies*, **54**, 345-364.

AUSUBEL, L. M. and DENECHERE, R. (1989), "Reputation in Bargaining and Durable Good

Monopoly", *Econometrica*, **57**,511-532.

BINMORE, K., RUBINSTEIN, A. and WOLINSKY, A. (1986), "The Nash Bargaining Solution in Economic Modeling", *Rand Journal of Economics* **17**, 176-188.

BOLTON, P. and SCHARFSTEIN, D. (1996), "Optimal Debt Structure and the Number of Creditors", *Journal of Political Economy* **104**, 1-25.

BUSCH, L. and WEN, Q. (1995), "Perfect Equilibria in a Negotiation Model", *Econometrica* **63**, 545-565.

CAI, H. (1997), *Bargaining Inefficiency with More Than Two Parties*, Ph.D. dissertation, Stanford University.

CAI, H. (2000a), "Delay in Multilateral Bargaining under Complete Information", *Journal of Economic Theory* **93**, 260-276.

CAI, H. (2000b), "Bargaining on Behalf of a Constituency", *Journal of Economic Theory* **92**, 234-273.

CHAE, S. and YANG, J. (1994), "An N-person Pure Bargaining Game", *Journal of Economic Theory*, **62**, 86-102.

COASE, R. (1960), "The Problem of Social Cost", *The Journal of Law and Economics* **3**, 1-44.

COMPTE, O. and JEHIEL, P., "On the Role of Outside Options in Bargaining with Obstinate Types", *Econometrica*, forthcoming.

CRAMTON, P. (1992), "Strategic Delay in Bargaining with Two-Sided Uncertainty", *Review of Economic Studies* **59**, 205-225.

FERNANDEZ, R. and GLAZER, J. (1991), "Striking for a Bargain Between Two Completely Informed Agents", *American Economic Review* **81**, 240-252.

FERSHTMAN, C. and SEIDMANN, D.J. (1993), "Deadline Effects and Inefficient Delay in Bargaining with Endogenous Commitment", *Journal of Economic Theory* **60**, 306-321.

FUDENBERG, D., LEVINE, D. and TIROLE, J. (1985), "Infinite-horizon Models of Bargaining with One-sided Incomplete Information", in ROTH, A. (ed.), *Game-Theoretic Models of Bargaining* (Cambridge: Cambridge University Press).

GERTNER, R. (1995), "Externalities, Delay, and Coalition Formation in Multilateral Bargaining", Working Paper, University of Chicago.

GERTNER, R. and SCHARFSTEIN, D. (1991), "A Theory of Workouts and the Effects of

Reorganization Law", *Journal of Finance* **46**, 1189-1222.

GILSON, S., KOSE, J. and LANG, L. (1990), "Troubled Debt Restructurings: An Empirical Study of Private Reorganization of Firms in Default", *Journal of Financial Economics* **27**, 315-353.

GUL, F. (1989), "Bargaining Foundations of Shapley Value", *Econometrica* **57**, 81-95.

GUL, F. and Sonnenschein, H. (1988), "On Delay in Bargaining with One-sided Uncertainty", *Econometrica*, **57**, 81-95.

HALLER, H. and HOLDEN, S.(1990), "A Letter to the Editor on Wage Bargaining", *Journal of Economic Theory*, **52**, 232-236.

HART, O. (1989), "Bargaining and Strikes", *Quarterly Journal of Economics*, **104**, 25-43.

HART, O. (1995), *Firms, Contracts, and Financial Structure*, Oxford University Press, Oxford.

HART, O. and MOORE, J. (1988), "Incomplete Contracts and Renegotiation", *Econometrica* **56**,755-785.

HOLMSTROM, B. and ROBERTS, J. (1998), "The Boundaries of the Firm Revisited", *Journal of Economic Perspective* **12**, 73-94.

HORN, H. and WOLINSKY, A. (1988), "Worker Substitutability and Patterns of Unionization", *Economic Journal* **98**, 484-497.

HOSHI,T., KASHYAP, A. and SCHARFSTEIN, D. (1990), "The Role of Banks in Reducing the Costs of Financial Distress in Japan", *Journal of Financial Economics* **27**, 67-88.

INGRAM, P., METCALF, D. and WADSWORTH, J. (1993), "Strike Incidence in British Manufacturing in the 1980s", *Industrial and Labor Relations Review* **46**, 704-17.

JEHIEL,P. and MOLDOVANU, B. (1995a), "Cyclical Delay in Bargaining with Externalities", *Review of Economic Studies* **62**, 619-37.

JEHIEL,P. and MOLDOVANU, B. (1995b), "Negative Externalities May Cause Delay in Negotiation", *Econometrica* **63**, 1321-35.

JUN, B. (1989), "Non-cooperative Bargaining and Union Formation", *Review of Economic Studies* **56**, 59-76.

KENNAN, J. and WILSON, R. (1993), "Bargaining with Private Information", *Journal of Economic Literature* **31**, 45-104.

KRISHNA, V. and SERRANO, R. (1996), "Multilateral Bargaining", *Review of Economic Studies* **63**, 61-80.

MACHIN, S., STEWART, M. and VAN REENAN, J. (1993), "The Economic Effects of Multiple Unionism: Evidence from the 1984 Workplace Industrial Relations Survey", *Scandinavian Journal of Economics*, **95**, 279-296.

MACHIN, S., STEWART, M. and VAN REENAN, J. (1993), Multiple Unionism, Fragmented Bargaining and Economic Outcomes in Unionised UK Establishments, in *New Perspectives on Industrial Disputes*, ed. David Metcalf and Simon Milner, Routledge: London.

MAILATH, G. and POSTLEWAITE, A. (1990), "Asymmetric Information Bargaining Problems with Many Agents", *Review of Economic Studies* **57**, 351-367.

MCAFEE, P.R. and SCHWARTZ, M. (1994), "Opportunism in Multilateral Vertical Contracting: Nondiscrimination, Exclusivity, and Uniformality", *American Economic Review* **84**, 210-230.

MILGROM, P. (1988), "Employment Contracts, Influence Activities, and Efficient Organizational Design", *Journal of Political Economy* **96**, 42-60.

MILGROM, P. and ROBERTS, J. (1990), "Bargaining Costs, Influence Costs, and the Organization of Economic Activity", in *Perspectives on Positive Political Economy*, edited by James E. Alt and Kenneth A. Shapsle, Cambridge University Press, Cambridge.

MILGROM, P. and ROBERTS, J. (1992), *Economics, Organization, and Management*, Englewood Cliffs, NJ: Prentice Hall.

NORTH, D. (1990), *Institutions, Institutional Change and Economic Performance*, Cambridge University Press, Cambridge.

OSBORNE, M. and RUBINSTEIN, A. (1990), *Bargaining and Markets*, San Diego: Academic Press.

PERRY, M. and RENY, P. J. (1993), "A Non-cooperative Bargaining Model with Strategically Timed Offers", *Journal of Economic Theory* **59**, 50-77.

ROB, R. (1989), "Pollution Claim Settlements under Private Information", *Journal of Economic Theory* **47**, 307-333.

ROSENTHAL, J. (1990), "The Development of Irrigation in Province, 1700-1860: The French Revolution and Economic Growth", *Journal of Economic History* **50**, 615-638.

RUBINSTEIN, A. (1982), "Perfect Equilibrium in a Bargaining Model", *Econometrica* **50**, 97-109.

SEGAL, I. (1999), "Contracting with Externalities", *Quarterly Journal of Economics* **114**, 337-388.

SEGAL, I. (2000), "Collusion, Exclusion, and Inclusion in Random-Order Bargaining", mimeo, Stanford University.

SHAKED, A. and SUTTON, J. (1984), "Involuntary Unemployment as a Perfect Equilibrium in a Bargaining Model", *Econometrica* **52**, 1351-1364.

STOLE, L. and ZWIEBEL, J. (1996), "Intrafirm Bargaining under Nonbinding Contracts", *Review of Economic Studies* **63**,375-410.

STOLE, L. and ZWIEBEL, J. (1996), "Organizational Design and Technology Choice Under Intrafirm Bargaining", *American Economic Review* **86**, 195-222.

VAN DAMME, E., SELTEN, R. and WINTERR, E. (1990), "Alternating Bid Bargaining with a Smallest Money Unit", *Games and Economic Behavior* **2**, 188-201.

Wall Street Journal, "Building Blocked: Quake-Hobbled Kobe Shows How Land Law Can Paralyze Japan", December 12, 1996.

WHITE, L. (2001), "Prudence in Bargaining: The Effect of Uncertainty on Bargaining Outcomes", mimeo, GREMAQ, France.

WILLIAMSON, O. (1985), *The Economic Institutions of Capitalism*, New York: Free Press.

WOLINSKY, A. (2000), "A Theory of the Firm with Non-Binding Employment Contracts", *Econometrica* **68**, 875-910.

Figure 1 Player 2's Commitment Decision

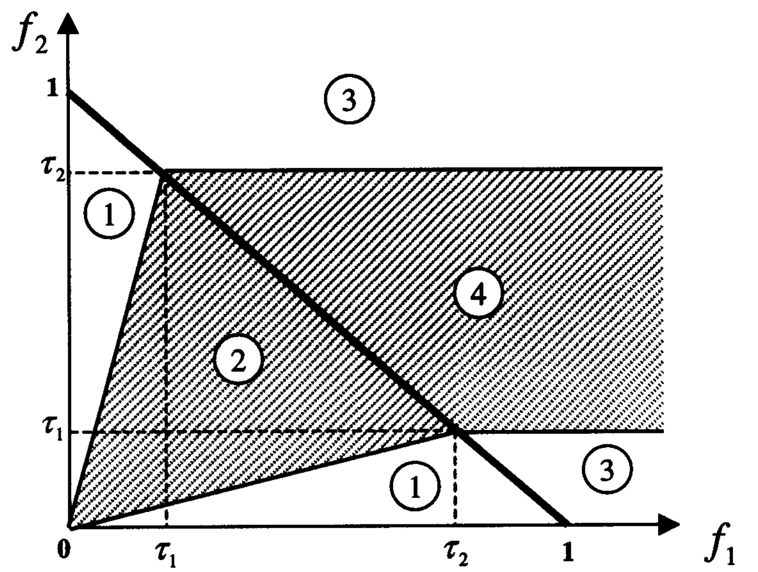

Figure 2 Contract Line of Players 2 and A