10 The Strategic Use of Contracts with Third Parties

Jerry R. Green

One of the most important ideas in modern game theory was first stated systematically in chapter 2 of Thomas Schelling's *The Strategy of Conflict*. Schelling points out that a player may benefit by agreeing to diminish his own payoffs in some circumstances, because this commitment changes his own incentives and hence can influence the equilibria of the game he is playing.[1] Unilateral action to diminish one's own payoffs is not often credible. To make such a commitment credible, a player can sign a contract promising a third party part of the payoff he would otherwise keep for himself. Because the third party will enforce his rights under the contract, the payoff modification has been made credible to other participants in the game or bargaining situation.

This stratagem is of considerable practical importance. When firms have market power, it is well recognized that the ability to commit to a business strategy may be of great competitive advantage.[2] Unfortunately, the most effective threats are often the least credible. Establishing a reputation is one way to bind oneself to such actions.[3] Another way to sustain aggressive strategies is to hire an agent (or a manager of the firm) whose job it is to execute these business plans. By thus separating ownership and control of the firm and by tying the manager's compensation offer to the firm's profits, one might make otherwise incredible threats. Another way to commit to strategically advantageous actions is to become heavily indebted. Because limited profits will be of no value if they cannot cover the indebtedness, the firm will try extreme measures in an attempt to make enough profits that there is something left for the owners. This should convince the competition that the firm will compete aggressively, and in light of this they may back off. In this case the outside "third party" is not a single individual but rather the collectivity of all creditors of the firm.[4]

From Richard J. Zeckhauser (editor), *Strategy and Choice*, The MIT Press (Cambridge, MA), 1991.

Finally, in administrative and political contexts, the credible commitment is commonly effected by making a binding promise to one group that it will be treated exactly like another. It is then possible to avoid acquiescing to either group's demands by arguing that, "if I do it for you I will have to do it for them." In this case each group plays the role of the "third party" vis-à-vis the other.

The idea behind using contracts or irrevocable promises to gain an advantage rests on a two-phase conceptualization of the economic interaction. In the first phase, contracts are used to modify the payoffs of a game or a bargaining situation. They may also modify the control relationships by reassigning the rights to make or reject an agreement with the other side. In the second phase, the modified game is played, or the altered bargaining situation resolved.

Schelling recognizes that contracts made in the initial phase are not automatically credible. Arrangements with the partner must be observable and irrevocable if they are to be incorporated into the other player's understanding of the game and hence to influence the equilibria. Schelling writes,

> When one wishes to persuade someone that he would not pay him more than $16000 for a house that is really worth $20000 to him, what can he do to take advantage of the usually superior credibility of the truth over a false assertion? Answer: make it true. . . . [T]he buyer could make an irrevocable and enforceable bet with some third party, duly recorded and certified, according to which he would pay for the house no more than $16000 or forfeit $5000.[5]

But how is the contract made irrevocable? If secret or private renegotiation is possible, the contract will have no credibility.[6] To prevent renegotiation, one must either invoke a reputational argument or make communication between the principal and his partner impossible.[7] Finally, an effective contract requires that the partner not be able subsequently to contract with the opponent in a way that would undo the incentives originally created. As Schelling notes,

> In the example of the self-inflicted penalty through the bet, it remains possible for the seller to seek out the third party and offer a modest sum in consideration of the latter's releasing the buyer from the bet, threatening to sell the house for $16000 if the release is not forthcoming.[8]

Assuming that the contract can be made observable, irrevocable, and immune to modification by further bilateral contracting between the partner and either the principal or his opponent, how should the resulting economic interaction be modeled? Who are the active players and what communication channels are open? If the principal can remove himself from the situation entirely, a two-person game is now to be played between the partner and the opponent.[9] If, as in Schelling's house purchase example, it is the partner who can be cut off from any remaining interaction, the principal's payoffs have been modified by virtue of his contract, and it is he who still bargains with the seller, the partner playing no active role. Alternatively, the contract can require the assent of both the principal and the partner before an agreement with the opponent can be consummated.

> The effect of the bet—as of most such contractual commitments—is to shift the locus and personnel of the negotiation in the hope that the third party will be less available for negotiation. . . . If all interested parties can be brought into the negotiation the range of indeterminacy remains as it was. . .[10]

When the principal has the power to reach an agreement with the opponent without the partner's consent, we will say that the latter is a "silent partner." (Alternatively, the principal could be a silent partner if he gave an agent irrevocable power to negotiate against the opponent without his further intervention.) If the contract requires that both the principal and the partner agree before any resolution is final, we will call them "cosignatories." Control of negotiations with the opponent is as much a part of the contract design as is the compensation to be paid to the partner when the outcome of the negotiations is known. We ask whether an observable irrevocable contract between a principal and his partner could be beneficial when the parties know that the final result will be obtained through an interaction among all of them. And if a contract is beneficial, should it be one in which one of the two contractually bound agents is the silent partner of the other, or should they be cosignatories?

We will reassess Schelling's statement, asking whether the existence of the contract affects the "range of indeterminacy." That is, is the solution of the resulting three-person bargaining problem the same, as far as the principal and his opponent are concerned, as the solution to their original two-person problem?[11]

Although Schelling's ideas were well known and well appreciated, it is only very recently that the strategic advantages of contracting with third parties have been examined in economic applications. For example, a firm can issue securities that effectively modify the return to the original equity holders much as if a Schelling-like "bet" had been made with an outsider. Here the third party is not any single player but rather is the debt market as a collective entity.[12] Other potential third parties are the firm's employees, especially if a union exists, or even the firm's customers, if a long-term contract can be signed with them. In this line of research the firm's original equity holders continue to be the strategic players in the product market interaction with actual and potential competitors.[13]

The other way of credibly altering product market behavior is to hire managers who are independent of the owners and who are compensated according to contractually determined performance measures.[14] Now the third party is the active player in the second-stage product market game, and it is assumed that the original equity holders can withdraw credibly from further negotiations.[15]

Recent more abstract game-theoretic analyses, closer in spirit to this chapter,[16] ask whether and to what extent the original equilibria of the game between two principals can be altered when the principals are represented by agents whose payoffs are contractually determined.

These papers implicitly follow Schelling in assuming that the principals can isolate themselves from the actual playing of the game—that is, the principals become the silent partners. With contracts in place, the game is played by the partner and the opponent. Here, however, I shall assume that the principals remain active participants. Their incentives may have been modified by the contractual arrangements they have made with their respective representatives, but all players are active in the second-phase game. The crucial decision, it turns out, is not which of the partners shall deal with the opponent, but rather whether agreement shall require the assent of both partners or just one of them.

Is this presumption of active principal behavior realistic? Consider some real-world agency relationships: lawyers under contract to negotiate between potential litigants, for example, or investment bankers retained by a raider and a target firm in a potential takeover, or the realtors acting for the buyer and the seller in a typical sale of a house. There is nothing to prevent one of the litigants from contacting the other and proposing a settlement without going through the attorneys. A target firm could issue a public statement about some defensive actions it might take, effectively communicating with the raider without the investment banker's approval. The buyer could negotiate specific terms directly with the seller of the house. Whether or not these contacts are advantageous, they do seem possible.

In these situations the actual negotiation is more complex than can be modeled by a two-person game involving only the two representatives. Indeed the legal, ethical, and professional prohibitions regarding direct communication between a principal and the agent of the other party, or between the two principals once agents have been retained, testify that these activities are not irrelevant and severe sanctions are required to prevent their occurrence.[17]

These examples teach us a mixed lesson. Genuine isolated bilateral play between the representatives is rarely the right model of interaction, but neither is totally unrestricted three- (or four-) player bargaining. I shall nevertheless explore the latter possibility because previous research has concentrated on the former, and it is useful to establish another benchmark. I hope to discover whether Schelling's conclusions about the effectiveness of agency necessarily hinge on the conditions that renegotiation is impossible and only two of the three players can participate in the second phase of the interaction.

If the principal is able, for example, to cut himself off from all further communication, then the underlying situation is really not a symmetric bargaining model at all. In Schelling's example, if the buyer can offer the third party the incentive contract to buy the house and then become incommunicado, why can he not make a take-it-or-leave-it offer to the opponent, cutting off communication in just the same way? If he can cut himself off from the partner but not from the opponent, could not the opponent become an unwanted intermediary, carrying verifiable enforceable messages between the partner and the principal?

The next section of the paper establishes the basic model, describes the nature of contracts, and discusses four solutions that can be used to resolve the range of indeterminacy and thus to determine the outcome. It will be shown that, in the most plausible models of the second phase of the negotiation process and for the most commonly observed compensation arrangements, a contract that involves a silent partner can potentially shift the outcome in favor of the principal, whereas one in which the principal and his partner are cosignatories cannot be beneficial. The following section shows that a contract requiring cosignatories can benefit the principal only if its results are not monotonically related to the underlying outcome of a bargaining game. A brief summary concludes.

Contracts and Trilaterial Bargaining: Cosignatories and Silent Partners

In this section we pursue Schelling's idea that one of the two bargainers can enter into an observable and irrevocable contract with a third party. We assume that the opposing player cannot offer this agent a contract, nor can he offer to buy him out of the contract he has made with the first player or compensate him for not enforcing all of its provisions. If any of these actions were possible, then, as Schelling shows, the arrangement could not be beneficial to the principal.

For concreteness, we suppose that the principal and the opponent have the opportunity to divide \$1. If they fail to agree on how the dollar is to be divided, they each get zero. In this bargaining situation there is a "range of indeterminacy," the set of all allocations of the dollar in two parts t and $1 - t$, which represents the possible outcomes of the agreement that are at least as good for each of the players as what he would achieve by refusing to agree at all.

A contract between the principal and his partner will transform this two-player situation into a three-player bargaining problem. The principal can agree to divide his share of the underlying bargain t with the partner, giving the partner $x(t)$ and retaining $t - x(t)$ for himself. Thus if the contract specifies that the partner's share shall be $x(t)$ when the principal's share of the underlying bargain is t, the range of indeterminacy of the two-person problem has been translated into a "range of indeterminacy" for the three players given by all payoffs of the form $(t - x(t), 1 - t, x(t))$, for the principal, opponent, and partner, respectively. (Throughout this chapter we will maintain this ordering and will alternatively refer to the participants as players 1, 2, and 3, respectively. This is most often the form followed when we give a geometrical description of contracts and alternative possible payoffs; see below.)

Competitive Partners and Up-Front Contracting Fees

We assume that the principal has access to a number of potential partners before the contracting. Competition among these agents will result in a contract that gives the partner exactly his opportunity cost but no more than that. Any payment that the third party foresees himself getting as a result of the contract can be extracted from him in advance by requiring him to bid against other potential partners for the right to enter the agreement with the principal. In this way the principal's total payoff is one minus the opponent's payoff in the resulting bargain. Thus the best contract will be the one that minimizes the opponent's payoff, irrespective of how it allocates the remainder between the principal and his partner.

Whether a contract is acceptable to the partner, and whether it is better for the principal than the original bilateral bargaining problem, depends on how the "ranges of indeterminacy" created by these contracts will be narrowed down to a unique definitive outcome. The resolution of bargaining indeterminacy is a far more straightforward task in the original two-person game than it is in the post-contract three-person environment. With only two players, and with no reason to believe that one has more bargaining ability than the other, splitting the range in half is the obvious choice. This is the solution that would occur to any outside arbitrator, it has the virtue of simplicity, and it is selected by all formal theories of bargaining. In the three-person case there is no natural midpoint to select. A more elaborate approach to the bargaining problem is required in multilateral cases. We will examine several alternative theories of bargaining, each of which corresponds to a social norm.[18] The players are assumed to understand this norm and to use it to predict the allocation resulting from the contract.[19] Which of these theories is most appropriate depends on whether a silent partner has delegated signature authority or whether both partners must assent in renegotiation, and on whether certain types of extracontractual transfers are observable. These issues will be explored further below, after the solution concepts have been explained.

Before analyzing optimal contracts, one should ask whether a contract will be offered at all. The principal has the option of remaining in the two-person case, which is likely to provide a fifty-fifty split between the opponents, as discussed above. A contract will be beneficial to the principal only if the opponent can be held to a share of less than one-half. As we explore alternative methods of resolving the range of indeterminacy in the presence of a contract, and analyze the effects of different contracts between the principal and his partner, we will focus on whether the final result will give the opponent strictly less than one-half. Only in that case will the contract be executed.

Geometric Description of Three-Person Bargaining Problems

To develop some intuition, let us describe the problem geometrically, as shown in figure 10.1. Figure 10.1a shows how any allocation of a dollar into three parts corresponds to a point in the equilateral triangle. The vertices represent the extremes at which one of the three players receives the whole dollar. A point such as c in the interior shows a division in which the share of player i is the length of the line drawn perpendicular to the side opposite player i's vertex. In any equilateral triangle, the sum of these lengths is the same regardless of the point from which we take these perpendiculars. Thus we can use this two-dimensional figure to display all the possible partitions of a fixed amount into three parts.

Figure 1b shows a contract $x(t)$ between the principal and his partner in which the partner has paid a lump-sum fee of f. Each point on the curve results from the payment of the fee f and the contractually specified transfer $x(t)$ following the underlying division of the dollar into parts t and $1-t$ for the principal and the opponent. If an agreement is reached, the sum of the payoffs is \$1. For example, if $t=0$ is the underlying agreement, the resulting payoffs are at point a, because the opponent gets \$1, the principal gets the fee f minus the contractually agreed amount $x(0)$ that he gives to his partner, leaving $f-x(0)$ as his share of the total. The partner gets $x(0)-f$, and the opponent gets \$1.

If the players fail to reach an agreement, the payoffs will be $(f, 0, -f)$ respectively. The lump-sum fee shifts the original divisions of the dollar, shown as a solid triangle, in favor of the principal and against the partner. In the dotted triangle, which has been shifted to the left by the amount f, we show how the division of the dollar is determined relative to the threat point inclusive of the payment of the lump-sum fee. The relevant region in which an agreement can lie is shown as B. These are all the possible payoff allocations in which no player gets less than he could have achieved in the disagreement outcome, and the terms of the contract have been followed. Note that the option to default to the disagreement outcome may eliminate some ranges of t as possible underlying agreements. (As shown, the agreement to set $t=0$, which would result in point a, is eliminated for this reason.) We do allow the players to agree on a randomization over possible values of t. That is why the shaded region, consisting of all convex combinations of points along the $x(t)$ locus meeting the

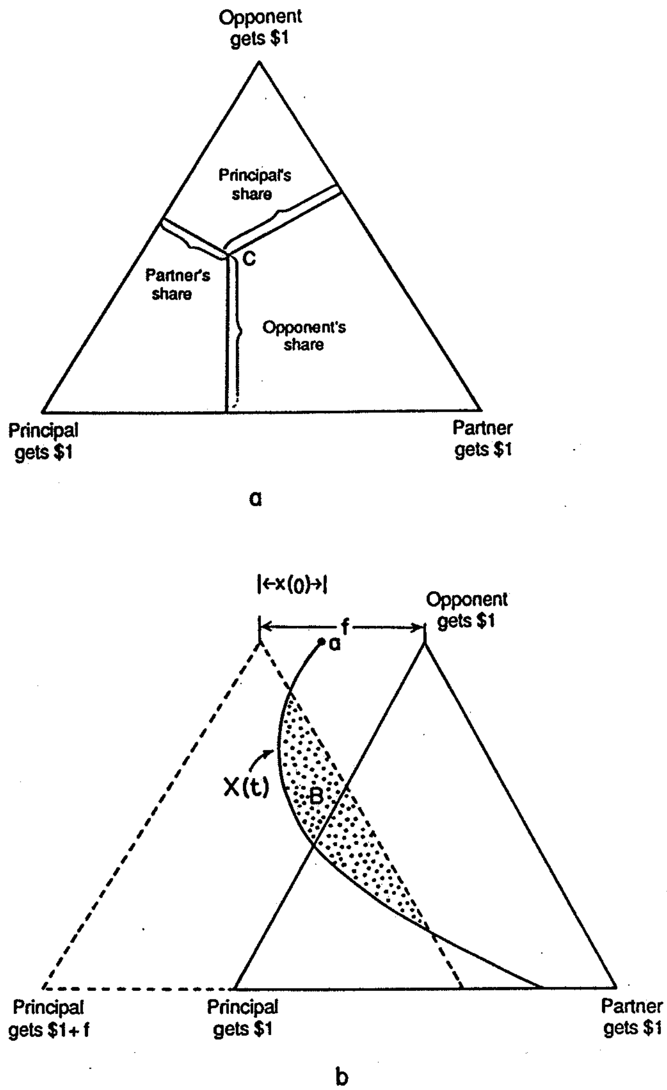

Opponent gets $1
Principal's share
C
Partner's share
Opponent's share
Principal gets $1
Partner gets $1
a
|←x(0)→|
f
Opponent gets $1
a
X(t)
B
Principal gets $1+f
Principal gets $1
Partner gets $1
b

Figure 10.1

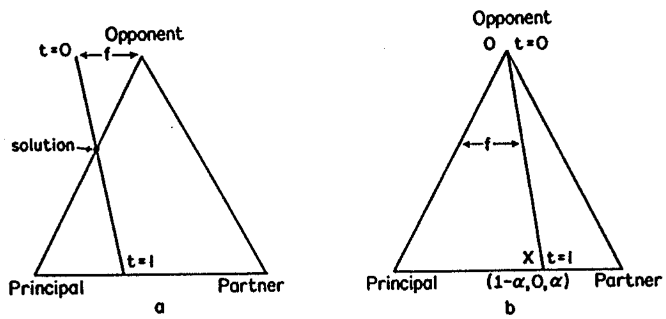
criterion of no default to disagreement, is included in the bargaining region.

The magnitude of the fixed fee does not affect the subsequent bargaining outcome. If the principal and his partner negotiate a fixed fee for signing the contract, it is a form of sunk cost, or a bygone. It will have shifted payoffs in the game and the location of the disagreement point by exactly the same amount. Therefore we neglect the fixed fee when discussing solutions to the bargaining game. We will solve the bargaining problem and examine the payoff of the opponent. If and only if this falls short of one-half, the principal's results—the fixed fee combined with the bargaining outcome—will be better than he could have achieved without a contract.

Alternative Solutions to Three-Person Bargaining Problems with Cosignatories and Silent Partners

A simple example of a contract will help us examine four solution concepts, two each for the cases of cosignatories and silent partners. In the context of this example we will see the differences among these solutions and the way they incorporate the rights of the partner to participate in the agreement, to enforce the contract, and to observe the activities of the principal and the opponent. We conclude that one of the two solutions discussed in each case is to be preferred and base the analysis in the next section on these two.

First consider the simple "sharing contract" in which the principal promises the partner a fixed share α of any portion of the allocation he receives. If the principal and the opponent achieve shares t and $1-t$ respectively, the partner receives αt and the principal retains $(1-\alpha)t$. The underlying allocations for this problem are shown in figure 10.2a. The fixed fee f is determined endogenously, in such a way that the total payment received by the partner, net of any fee he has paid, is zero. This is because there are a large number of potential third parties ready to enter into contracts with this principal if there are positive rewards to be had and willing to compete with each other for the right to do so. As described above, we can neglect the fixed fee in our analysis of whether the opponent's share falls short of one-half. Thus we consider the contract as shown in figure 10.2b, which is the same as in figure 10.2a but without the transfer from the principal to the partner in the amount f.



Sharing contract with fee equal to partner's receipts at solution

Sharing contract without fee: partner's share is f at solution

Figure 10.2

Consider first the case in which the partner is a cosignatory. Unless all three players agree, the disagreement outcome results; groups of two players are powerless. Therefore the description of the set of underlying allocations contains all the information relevant to this problem and determines the final allocation. Once t is determined, the contract is enforced and results in the final allocation $((1-\alpha)t, (1-t), \alpha t)$.

If, on the other hand, the third party is a silent partner, the principal and the opponent can threaten to impose an agreement that they reach without consulting or compensating him. They have the right to do so because the principal has not given the partner the right to veto the agreement. This case requires a more detailed analysis of the situation, with an explicit examination of the power of coalitions comprising a subset of the players. A description of the feasible set of underlying agreements is not a complete picture of the bargaining environment.

For the example of a sharing contract, this analysis is particularly simple. Only the coalition consisting of the principal and the opponent has the power to reach and enforce an underlying agreement. Neither of the two-person coalitions involving the partner has any power at all. Therefore to model contracting with a silent partner, we need to look at the set of allocations that are obtainable by the three players together and the set that can be reached by the principal and the opponent as a pair.

Let us now return to the case of a cosignatory in which the bargaining region is the sole determinant of the outcome. The selection of a unique outcome from a set of possibilities is the classical bargaining problem. Analysts of bargaining and negotiation, observing actual outcomes and defining desirable guiding principles, have sought to identify the allocations that will or should result. The rule by which an outcome is generated from the underlying possibilities is called a bargaining solution. The most well-known bargaining solutions are those discovered and analyzed by Nash, Shapley, and Harsanyi. We will explore these, and one other solution, to see what they predict about the benefits of strategic contracting with a third party. Specifically, we will see what they predict about which point on the segment OX in figure 10.2b will result.

The Nash bargaining solution[20] would select the underlying allocation in which $t = 2/3$, resulting in the payoffs $(2(1-\alpha)/3,\ 1/3,\ 2\alpha/3)$. This outcome results because the Nash solution is invariant to the scale in which any player's payoffs are measured.[21] Thus the zero-sum situation shown in figure 10.2b is the same as the non-zero-sum situation in which the principal and the partner gain a unit of utility *each* for every unit given up by the opponent.[22] Symmetry across individuals therefore requires that the two individuals who benefit from higher values of t get twice the weight in determining the outcome as the one individual who loses as t rises. Under the Nash solution the principal stands to gain from a contract such as the one proposed. The mere presence of the partner as a passive player is enough to shift the solution to the opponent's disadvantage.

An alternative to the Nash solution is the iterated Steiner solution defined in Green 1983. This solution is based on the idea that in a zero-sum situation the trade-off between the players should be determined by the maximization of a linear weighting of the individuals' utilities.[23] Because we have no theory of which weights to use for the three players,[24] we should admit any possible weighting scheme and then ensure the anonymity and fairness of the procedure by randomizing the assignment of weights to players. This procedure selects a subset of the set of possible allocations but does not, in general, result in a unique solution. It narrows down the possibilities. If we accept the premise that the ultimate solution should be the same whether the problem is as originally given or whether the narrowed-down set of allocations were the specified set from which a selection is to be made, we are led naturally to the idea of repeating the process (randomizing weights and maximizing weighted utilities), using at each step the allocations that survived the prior stage. When this has been repeated over and over again, it has been shown that a unique outcome emerges. We call this outcome the *iterated Steiner solution*.[25]

In the example at hand, for any weights w_1, w_2, w_3 not all equal, the maximal allocation is at $t = 0$ if $w_1 + w_3 < w_2$ and at $t = 1$ if this inequality is reversed. Thus, randomizing the roles of the players we get a randomized outcome of $t = 0$ with probability 1/3 and $t = 1$ with probability 2/3 if the second-largest weight is high relative to the smallest, and the randomized outcome with the probabilities reversed if the second-largest weight is close to the lowest. (The exact conditions will depend on α, but this is not important for our argument.) Thus taking one step of this process limits the result to the middle third of the segment *OX* in figure 10.2b. By iteration we clearly converge to the midpoint, where the opponent's payoff is exactly one-half. Thus, unlike the Nash solution, the iterated Steiner solution predicts that there is no advantage for this particular fixed-share contract between the principal and his partner. We will show that this property holds for an important class of contracts, but that for a more general set of contracts there is an advantage.

In the case of silent partners the bargaining outcome depends on the abilities of smaller coalitions to achieve results independent of the coalition of the whole. In the present example the only two-player coalition that has any power at all is that of the principal and the opponent. Their attainable set is shown in figure 10.3.

How might the possibilities for this two-player coalition affect the outcome of the three-player bargain? One possibility is that the principal and the opponent see that they can guarantee for themselves the maximum total payoff of 1 without cooperating with the partner. To achieve this they must agree to set $t = 0$. Then the principal does not have to share with the partner at all. Were they to agree to anything else, the three-person coalition would be strictly more advantageous than their two-person coalition; consequently the partner could rightfully claim a share of the surplus his cooperation in the three-person coalition helped to generate. Thus the principal and the opponent could agree to pretend that they have settled on $t = 0$ and argue that therefore the partner should get nothing. But they could then effect a secret transfer from the opponent to the principal, compensating him for colluding in this fictitious and unfair division. If such a secret transfer is possible, they can credibly claim that they do not need the partner's cooperation in order to achieve for the two of them the full

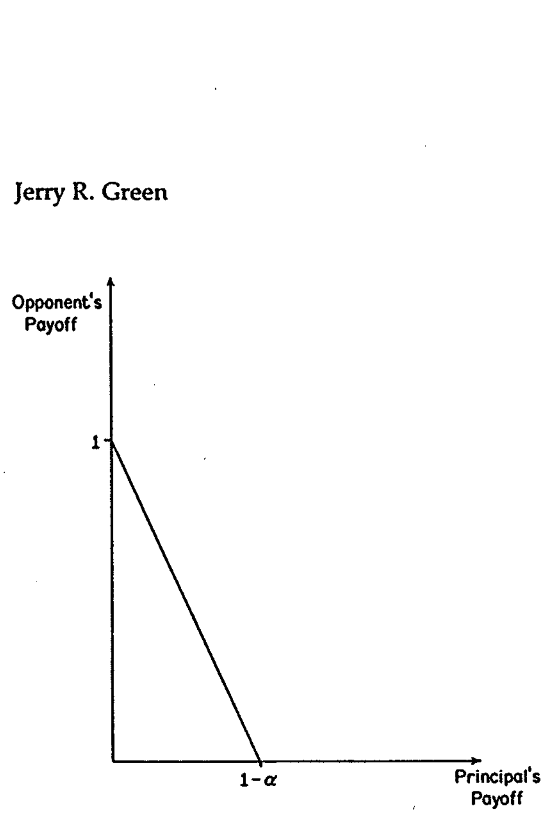


Figure 10.3

payoff that the three-person coalition could reach. By symmetry the principal and the opponent share the total of one equally. This solution concept coincides with the Shapley value.[26] Under this solution the opponent gets one-half, and thus the principal would gain nothing by offering a contract to a partner.

The notion of surreptitious transfers can be criticized on two grounds. First, our analysis of the contracting problem depends on the fact that the contract is observable. It seems contrary to the spirit of this analysis that the transfer could be kept a secret, thus undermining the contract. Second, even if a secret transfer were feasible, there is no reason to expect that it would take place after the agreement between the principal and the opponent has openly been reached. Having obtained all the gains from trade in full view of the partner and any enforcement powers that the partner has brought to monitor the contractual arrangements, the opponent has no reason to give anything to the principal under the table. And the principal has no legal claim to enforce against him because the promise of such a transfer was clandestine. For this reason we reject the analysis based on the Shapley value and must look for another solution concept for the games (with nontransferable utility) that result from contracting with a silent partner.

What threat by the coalition of the principal and the opponent is possible when they must honestly stick with the agreed-upon division? One possibility is that the two players would choose the allocation at which they receive the same payoff, in this case $1 - \alpha/2 - \alpha$ each. This leaves a surplus of $\alpha/(2 - \alpha)$ that can be obtained by the coalition of the whole. It is natural that the partner have a claim on this equal to that of the other players. Thus the overall solution is $((3 - 2\alpha)/3(2 - \alpha), (3 - 2\alpha)/3(2 - \alpha), \alpha/3(2 - \alpha))$. The other notable bargaining solution that can be applied to nontransferable utility games in characteristic function form is the Harsanyi value.[27] Because the opponent's share is less than one-half for all values of α, sharing contracts are advantageous to the principal.

Whether the egalitarian allocation between the principal and the opponent will be used as their threat against the partner is not obvious. It does have considerable normative appeal. However, there is a clear trade-off between efficiency and equity, a trade-off that might very well lead to a credible choice of threat that gives the opponent somewhat more than the principal.[28] Indeed, if there is even a relatively minor departure toward efficiency in the present example, the opponent will get more than one-half, in which case the contract will have been disadvantageous to the principal. Thus, unless one can be sure that equal division will be used as the threat, the efficacy of sharing contracts is an empirical matter.

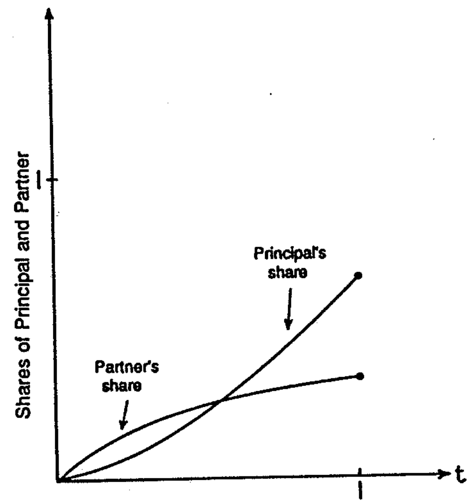
To summarize, we have presented four solutions, two for the case of cosignatories and two for the case of silent partners. When the third party is a cosignatory, we looked at the Nash solution and at the iterated Steiner solution. The former, although seeming to lead to the conclusion that contracts are beneficial, gives excessive power to the partner because of the assumption that the solution is invariant to linear transformations of the payoffs.[29] This solution is more likely to be appropriate when payoffs are in utility units than when the payoffs are directly comparable, as in the zero-sum problem we have presented. The iterated Steiner solution leads to the conclusion that contracts with cosignatories cannot help the principal do any better than he could by bargaining with the opponent in the absence of a contract.

In the case of silent partners we looked at the Shapley λ-transfer value and the Harsanyi value. We reject the former as a model of this situation because it implicitly allows for secret side payments, which are not credible, even if they were feasible. The latter solution seems quite appropriate if the resolution of the threat is likely to be determined on egalitarian grounds as between the threatening parties. Under that assumption the contract with a silent partner will be unambiguously beneficial. In more general circumstances in which the threat embodies a compromise between equity and efficiency, and no secret side payments can be made, the efficacy of the contract is possible but not by any means certain.

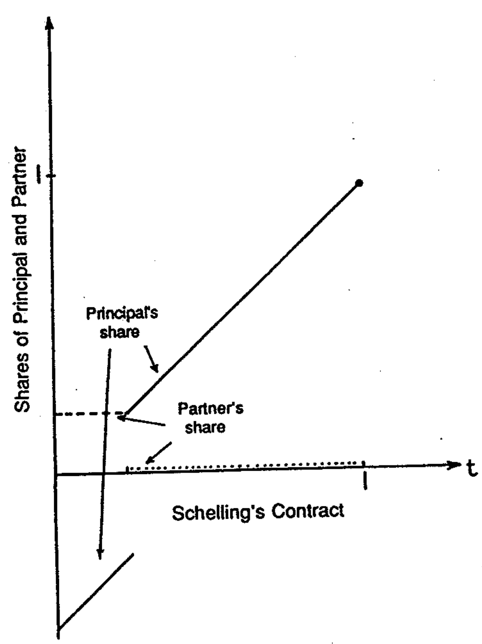
More General Contracts

In this section we will look at contracts more general than the simple sharing contract of the last section to see what the iterated Steiner solution and the Harsanyi value (and its generalizations) imply about the potency of contracts with cosignatories and silent partners. We will see that the effectiveness of contracts with cosignatories depends essentially on whether the interests of the principal and his partner are always coincident, as in the fixed-share contract of the last section, or whether their interests are in some cases opposed, as in the contract discussed by Schelling as described in the introduction. The former type of contract will be called *monotonic* because both the principal and the partner have payoffs that are strictly increasing with (hence monotonic in) t. The latter type is called *nonmonotonic*. In figure 10.4 we show the payoffs for the principal and the partner in a general monotonic contract and in the particular nonmonotonic contract of chapter 2 of *The Strategy of Conflict*.

In any monotonic contract with cosignatories the principal gets exactly one-half when we resolve the indeterminacy by using the iterated Steiner solution. This can be seen by referring to figure 10.5. The original monotonic contract is shown by the shaded region. After one application of the maximization of a linear function of the payoffs, the set of allocations shrinks to the region indicated between points X and Y. The exact shape of this region depends on the contract. However, the interval XY is always precisely the middle third of the segment OZ, and the boundary of the region between X and Y is monotonic in the sense that as one moves along either side of it (from X to Y), both the principal's and the partner's payoffs increase. Thus this set has all of the characteristics of a bargaining region generated by a monotonic contract to allocate the division of \$1 subject to the constraint that the principal and the opponent both receive at least one-third. Clearly, successive iterations of this problem will converge



A Monotonic Contract



Schelling's Contract

Figure 10.4

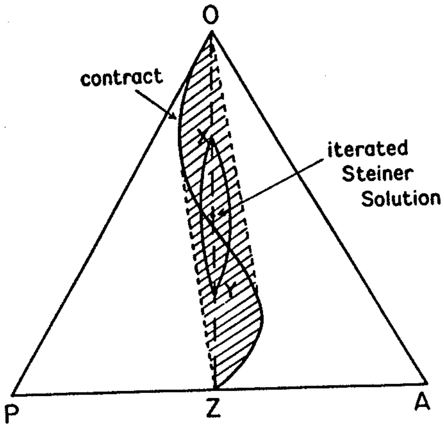
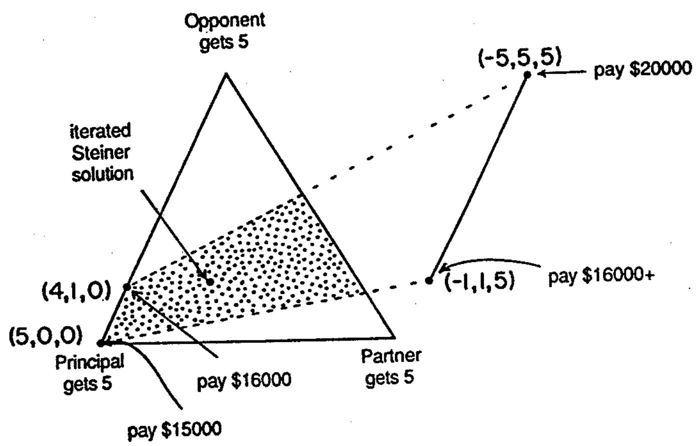
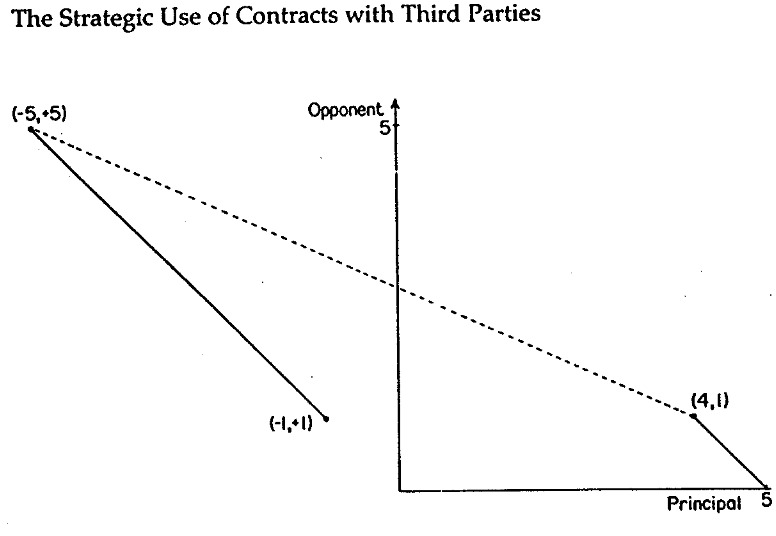


Figure 10.5



Payoffs are shares of $5000 surplus (in thousands).
Shaded area is the bargaining region for Schelling's contract.

Figure 10.6



Feasible utilities (with randomization) for Principal and Opponent when Agent is a Silent Partner in Schelling's house-sale contract.

Figure 10.7

upon the midpoint of OZ, at which point the opponent receives exactly one-half.[30]

Nonmonotonic contracts with cosignatories may benefit the principal. For example, consider the contract suggested in chapter 2 of *The Strategy of Conflict*, as described in the introduction. This contract is nonmonotonic, because the partner's payoff falls from $5,000 to zero as the price paid by the principal drops below $16,000. The allocations generated by this contract are shown in figure 10.6. Assuming that all agreements must give players a payoff at least as great as they would achieve at the disagreement point, the bargaining region is the set of outcomes spanned by the underlying agreements that give all players at least a non-negative share of the $5,000 surplus that can be generated by the trade. This region is shown as the shaded area in figure 10.5. It can be shown that the iterated Steiner solution as applied to this bargaining region is approximately (2,670, 950, 1,480). Note that the opponent can be held to a value far below his $2,500 share of the $5,000 surplus available.[31]

Now let us consider the case of contracts with a cosignatory and the associated resolution of the range of indeterminacy associated with the Harsanyi value. Figure 10.7 shows the utility possibility set available to the principal and the opponent under the contract that Schelling suggests. Here the egalitarian solution would select $t = 2/3$, and the Harsanyi value for the opponent would be $2,222. If the threat of this coalition is not egalitarian but rather reflects a balance between the egalitarian allocation and a more efficient one, the opponent's payoff is further reduced. This is an essential difference between monotonic contracts (such as the fixed-share contract of the last section) and nonmonotonic contracts (such as the Schelling contract of *The Strategy of Conflict*). As usual, Schelling's insights were correct: there is substantial power to be gained by making an observable and irrevocable nonmonotonic contract with either a cosignatory or a silent partner.

Conclusions

Schelling asked whether the outcome of a bargaining problem can be favorably influenced by contracting with a third party in an observable and irrevocable manner. Reexamining this question, we find that if the contract is monotonic, in that the contracting parties' interests are always aligned, then a beneficial result is possible only if the partner is silent, unable to veto the agreement between the principal and the opponent. If the third party is made a cosignatory, the contract will not be beneficial. Even in the monotonic case with a silent partner, favorable results are not assured. They depend on the nature of the threats that the principal and the opponent are able to make. To the extent that credible threats will embody efficiency considerations rather than equity, these contracts will likewise be impotent.

Matters are quite different if nonmonotonic contracts, such as the contract discussed by Schelling in *The Strategy of Conflict*, are possible. Then either cosignatories or silent partners can be used to influence the results of the bargaining problem in favor of the principal.

Notes

1. Indeed Schelling shows this to be the case for payoff modifications that are, in every case, decreases, and hence easily credible when there is a form of free disposal of utility. This theme has recently been explored by Ben-Porath and Dekel (1988).

2. These commitments may affect the payoff of the competitors as well as the payoff of the firm in question, as for example in the case of preemptory, strategic building of excess capacity to deter entry; see Spence 1977. In this chapter we will be concerned with strategies that alter one's own payoffs but do not directly affect the payoffs of competitors or opponents.

3. Reputational effects are also a theme that can be traced to Schelling; indeed they are featured in *The Strategy of Conflict* as well. Much recent research has been devoted to how threats based on reputation might become sustainable in dynamic contexts, in the presence of imperfections of information or when mutually damaging deterrent strategies exist.

4. These two examples and the relevant related literature are discussed further, later in this section.

5. Schelling 1960, p. 24.

6. See Katz 1987 or Dewatripont 1988.

7. With an explicit extensive form model of the contracting process, such as that in Hart and Moore 1988, there is a last moment at which legally binding commitments can be made; making a commitment at that time is a way of ensuring that it cannot be modified. We shall not follow this route.

8. Schelling 1960, p. 25.

9. This is the situation assumed in most of the recent purely theoretical literature; see Katz 1987 and Fershtman, Judd, and Kalai 1989. Some of the applied literature presumes that the agent takes over the principal's possible moves in the game, while other contributions assume that the principal continues to act on his own behalf. See the further discussion below.

10. Schelling 1960, p. 25.

11. The one asymmetry between the principal and his opponent is that the former has a first-mover advantage in contracting with an agent. If the opponent could react by taking an agent of his own in response, a four-person bargaining problem, instead of a three-person problem, would result. Does the principal gain from his first-mover advantage in this case? This problem is discussed in Green 1989.

12. The effect of such financial market strategies on product market behavior has been studied by Brander and Lewis (1986) and Maxsimovic (1986).

13. Contracts with employees are studied in Dewatripont 1987, 1988 and contracts with customers are examined in Aghion and Bolton 1987. These papers are primarily concerned with the issue of credible commitments between the equity holders and the third party. Therefore their main focus is on making the contract secure against renegotiation.

14. See Williamson 1964, 1985.

15. This situation has been studied by Sklivas (1987) and Fershtman and Judd (1987a). Complications arise when there is incomplete information about firm characteristics that are relevant both to the third party and to the product market rivals. Signaling and contractual precommitment become intertwined. See Poitevin 1989a, 1989b, 1989c and Gertner, Gibbons, and Scharfstein 1988.

16. See Katz 1987, Fershtman and Judd 1987b, and Fershtman, Judd, and Kalai 1989.

17. It would be interesting to study the creation and policing of the institutions through which such forbidden communication is monitored. This process probably involves the reputation of the agents, who are the long-run players, and the competitive environment in which they operate.

18. Each of these theories of bargaining, or solutions, can be based on a set of axioms that uniquely determine the nature of the solution. Space limitations preclude any more than the briefest discussion and comparison of the axioms here.

19. The saliency of certain norms, such as "split the difference," may be useful in that negotiation costs are reduced. Although our analysis ignores negotiation and bargaining costs, we note that one important justification for assuming all players understand that a particular norm will apply is that they know which norms are efficient in avoiding such costs.

20. See Nash 1950.

21. This is because utilities are determined only up to linear transformation and because the Nash solution is based, among other axioms, on the hypothesis that the solution should be independent of this representation.

22. Take the utility weights to be $1/(1-\alpha)$ and $1/\alpha$ for the principal and the agent.

23. A central axiom of that theory is called linearity, or additivity. This axiom and its consequences for bargaining problems without transferable utility have been explored by Maschler and Perles (1981), among others.

24. The obvious choice, equal weights, would not yield a determinate answer. Because the problem is one of pure division, all divisions would result in the same value of the objective function being maximized.

25. This nomenclature is due to the Steiner point, a related concept in the geometry of convex sets. The Steiner point is that point obtained when the weights are random and uniformly distributed over the set of all possible weighting schemes. Because the uniform distribution of weights does not have a firm normative foundation, we consider all possible symmetric weighting methods. Without a specific distribution of weights, iteration is needed to overcome the non-uniqueness problem.

26. See Shapley 1969. He called this solution the λ-transfer value because there may not have been a way to transfer utility freely among the players and he was looking for the scaling of utilities (the λ's) such that transfers would not be necessary at the solution point.

27. See Harsanyi 1959.

28. There is a fair amount of experimental evidence on problems very similar to the two-person situation faced by the principal and the opponent. When α

is high, reasonable players will depart from equal division in favor of the player who has the more to gain.

29. Invariance to the units of measurement means, for example, that the solution does not change if one player keeps whatever share of the dollar he attains but another can exchange his share at a highly favorable rate, say $10 for every penny.

30. See Green 1989.

31. The author has created a computer program that calculates the iterated Steiner solution. This program, and several enlightening examples calculated using it, are available from the author upon request.

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