Commitment and Conflict in Bilateral Bargaining*

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Abstract

Building on Crawford (1982), we study a model of bilateral bargaining in which negotiators can make binding commitments at a low positive cost c. Our primary solution concept is iterated strict dominance. If commitment attempts never fail, there are three solutions. In two solutions all the surplus goes to one player; in the third solution there is a high probility of conflict. If commitment attempts succeed with probability $q < 1$, the unique solution entails conflict with probability q^2. When $c = 0$, analogous results hold if the requirement of iterated strict dominance is replaced by iterated weak dominance.

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1 Introduction

If negotiators can write binding contracts, why is there ever costly disagreement in bilateral bargaining? Existing formal theory offers two main possibilities. Disagreement arises because of incomplete information or because of irrational negotiators. Thomas Schelling (1956, 1960, 1966) proposes a third reason.[1] Rational negotiators may attempt to increase their share of the available surplus by committing themselves to an aggressive bargaining stance and thereby forcing concessions from an uncommitted opponent. If both negotiators simultaneously make such strategic commitments, there is conflict.

Crawford (1982) pursues Schelling's argument in a formal model. In the case of symmetric information, Crawford concludes that there are often many equilibria, some of which are both efficient and equitable.[2] When both negotiators can credibly commit not to accept any less than half the surplus, there is typically also an equilibrium in which they do so. However, such compromise equilibria fail to exist if commitments are weak—in the sense that they are likely to be revokable at low cost. For example, if any commitment sticks with probability q and is freely revokable with probability $1-q$, then the unique equilibrium entails commitment attempts by both negotiators if q is sufficiently small.[3] The intuition is that if the opponent's commitment is revokable with high probability, the best strategy is to try to exploit the opponent's expected weakness by making an aggressive commitment. When both negotiators succeed in making their commitments stick, there is conflict.

An objection to this theory of conflict is that negotiators often have access to quite efficient commitment technologies. For example, a political leader who publicly and emotionally repeatedly states she will never yield a piece of ter-

[1] Schelling's (1956) seminal essay on bargaining is reprinted as Chapter 2 of *Strategy of Conflict*, Schelling (1960). The book's other chapters, and especially Appendix B, contain substantial additional thoughts on commitments in bilateral bargaining. In *Arms and Influence*, Schelling (1966), the ideas are used to shed light on international relations.

[2] Subsequent work by Muthoo (1996) has investigated ways in which to obtain unique equilibrium selection in a related model when the cost of revoking a commitment is not prohibitive. Muthoo obtains an efficient compromise solution as the unique outcome.

[3] Crawford also studies cases in which it is costly to revoke commitments and where players have private information about the costs of revoking. Subsequent literature has tended to focus on the latter asymmetric information case. By contrast, we focus exclusively on the symmetric information case.

ritory to another country may find it very difficult to revoke this commitment unless something unexpected happens that can serve as an acceptable excuse for doing so. Since both negotiators prefer strong commitments to weak ones, real negotiations may take place with values of q that are high enough for efficient equilibria to exist.

In this paper we show that incompatible commitments pose a severe problem even when commitment technologies are highly credible, that is, when q is close to 1. We demonstrate the point in two ways.

Our first approach is to perturb Crawford's model slightly by introducing a cost of commitment, $c > 0$. In the perturbed model with $q < 1$, we show that only the incompatible commitment equilibrium exists as c goes to zero. Thus, if the commitment cost is sufficiently small relative to the size of the contested surplus, there is conflict with probability q^2 even for large q. In fact disagreement is not only the unique Nash equilibrium outcome, but also the unique outcome to survive iterated elimination of strictly dominated strategies. When $q = 1$, efficient compromises remain unattainable, but in this case there are also equilibria in which one player gets all the surplus (in addition to the conflicting commitment outcome).

Our second approach is to retain all Crawford's assumptions, including $c = 0$, while utilizing a stronger solution concept than Nash equilibrium. To be precise, we show that the above outcomes are the unique outcomes to satisfy the requirement that negotiators only use strategies that are iteratively weakly undominated.

To understand why efficient compromise outcomes fail to exist, consider the case in which both negotiators commit to take exactly half the surplus. If it is costly to make such a commitment, a negotiator is better off by being flexible, as this yields the same share of the surplus. At the same time, it cannot be an equilibrium that both negotiators remain flexible, since one negotiator is then better off by making an aggressive commitment. If commitment costs are zero, essentially the same logic applies, except now moderate commitments are only iteratively weakly dominated.

These findings turn conventional wisdom on its head. According to most bargaining models, the puzzle is been to explain why there is ever costly conflict under conditions of symmetric information. Given our results, the puzzle is why there is not conflict more often.

2 Certain commitment

There are two negotiators, henceforth called players. Players are indexed $i = 1, 2$ and bargain over a surplus of size 1. The size of the surplus and the rationality of the players are common knowledge.

In the first stage, each player i chooses, simultaneously with the other, either to commit to some demand $s_i \in [0, 1]$ or to wait and remain uncommitted. Let w denote the waiting strategy. Without loss of generality, the cost of remaining flexible is normalized to zero. Committing entails a commitment cost c. We confine attention to the case $c > 0$. In the second stage, two uncommitted players engage in bargaining. Let $\beta_i > 0$ be player i's share if both players are uncommitted in the second stage. We assume that two flexible players are able to coordinate on an efficient outcome, so that $\beta_1 + \beta_2 = 1$. Since many explicit models of non-cooperative bargaining under perfect information result in such an interior solution, this can be taken as a reduced form of an (unmodelled) ensuing bargaining game. Without loss of generality, let $\beta_1 \geq \beta_2$.

In the second stage, a committed player cannot revoke her demand. An uncommitted opponent thus observes the opponent's first stage choice and best responds by demanding the residual share $1 - s_i$. If both players commit, the outcome depends on whether the commitments are compatible or not. If the commitments are compatible, $s_1 + s_2 \leq 1$,we assume that each player i gets a utility of at least $s_i - c$ and at most $1 - s_j - c$. That is, we make no restriction on the allocation of any unclaimed surplus $1 - s_i - s_j$.[4] If the commitments are

[4] Our specification of the compatible commitments outcome nests many special cases. If players always obtain exactly $s_i - c$ under compatible commitments, we have the Nash demand game allocation. This specification is unintuitive, since unclaimed surplus is left on the negotiation table. If the full surplus is allocated according

incompatible, $s_1 + s_2 > 1$, there is disagreement and both players get utility $-c$.

To summarize, each player has the set of pure strategies $S = [0,1] \cup \{w\}$. Letting $x_i(s_i, s_j) \in [s_i, 1 - s_j]$ denote player i's share of the surplus in the compatible commitments case, the payoff of player i depends on these strategies as follows:

$$u_i(s_i, s_j) = \begin{cases} x_i(s_i, s_j) - c & \text{if } s_i + s_j \leq 1; \\ s_i - c & \text{if } s_j = w \text{ and } s_i \neq w; \\ -c & \text{if } s_i + s_j > 1; \\ 1 - s_j & \text{if } s_i = w \text{ and } s_j \neq w; \\ \beta_i & \text{if } s_i = w \ = s_j. \end{cases}$$

The set of mixed strategies is the set of probability distributions on S. We write a mixed strategy of player i as σ_i. Let $p_i(s)$ denote the associated probability that player i plays the pure strategy s.

The following lemma is the key to our main result. It says that if commitment is more costly than flexibility, then nothing but a greedy demand of 1 and waiting, w, is iteratively strictly undominated and thus played with a positive probability in any Nash equilibrium. The logic of the result is straightforward. Observe first that some commitment strategies are strictly dominated. Since commitment is more costly than waiting, player 1 strictly prefers w to any $s_1 \in [0, \beta_1]$, and player 2 strictly prefers w to any $s_2 \in [0, 1 - \beta_1]$. After these strategies are eliminated, player 1 strategies $s_1 \in (\beta_1, 1)$ are strictly dominated by the mixed strategy $\sigma_1 = (p_1(1) = s_1, p_1(w) = 1 - s_1)$. If player 2 plays w, player 1's surplus share is s_1 under the pure strategy s_1; whereas under the mixed strategy σ_1 he gets 1 with probability s_1 and β_1 with probability $(1 - s_1)$. Since the cost of the mixed strategy is only $cs_1 < c$, strict dominance is established. Likewise, player 2 strategies $s_2 \in (1 - \beta_1, 1)$ are dominated by the mixed strategy $(p_2(1) = s_2, p_2(w) = 1 - s_2)$.

Lemma 1 *Suppose $c > 0$. Then, for each player, only 1 and w are iteratively strictly undominated strategies.*

to relative claims, we have instead the special case considered by Ellingsen (1997).

Proof. Observe first that player 1 strictly prefers w to any $s_1 \in [0, \beta_1]$, and player 2 strictly prefers w to any $s_2 \in [0, 1 - \beta_1]$: The commitment strategy gives player i a payoff $s_i - c < \beta_i$ when player j chooses w. It gives at most $1 - s_j - c < 1 - s_j$ when player j chooses a compatible commitment $s_j \in [0, 1 - s_i]$. Finally it gives $-c < 1 - s_j$ when player j chooses an incompatible commitment.

After these strategies are eliminated, it is easy to check that player 1 strategies $s_1 \in (\beta_1, 1)$ are strictly dominated by the mixed strategy $\sigma_1 = (p_1(1) = s_1, p_1(w) = 1 - s_1)$. If player 2 plays w, player 1's payoff to the pure strategy s_1 is $s_1 - c$; whereas under the mixed strategy σ_1 he gets $s_1 + (1 - s_1)\beta_1 - s_1 c$. If player 2 plays $s_2 \in (1 - \beta_1, 1]$, then the payoff to a pure commitment strategy in $s_1 \in (\beta_1, 1)$ is $-c$ whereas the payoff to the mixed strategy is $(1 - s_1)(1 - s_2) - s_1 c$ where the latter is clearly strictly greater.

Likewise, player 2 strategies $s_2 \in (1 - \beta_1, 1)$ are dominated by the mixed strategy $(p_2(1) = s_2, p_2(w) = 1 - s_2)$. Thus, only w and 1 are iteratively undominated.
■

The iterative elimination of strictly dominated strategies ultimately induces a game of Chicken:[5] In this game, neither $(1, 1)$ nor (w, w) constitute an equilibrium. If $c < \beta_i$, $s_i = 1$ is the unique best response to $s_j = w$, and $s_i = w$ is the unique best response to $s_j = 1$. There is thus a unique pair of asymmetric pure strategy equilibria. In these equilibria one player commits to demanding all the surplus and the other player waits. There is no symmetric pure strategy equilibrium, however. In addition to the asymmetric pure strategy equilibria, there is one in mixed strategies. In a mixed strategy equilibrium, the expected payoff from $s_i = 1$, which is $1 - p_j(1) - c$, must equal the expected payoff from waiting, which is $(1 - p_j(1))\beta_i$. Clearly, for $\beta_1 = \beta_2$, this mixed strategy equilibrium is symmetric.

Proposition 1 *Suppose $c \in (0, \beta_2)$. (i) For any pair (β_1, β_2), there is a mixed strategy equilibrium, $p_i(1) = (\beta_i - c)/\beta_i$ and $p_i(w) = c/\beta_i$. (ii) In the unique*

[5] In Section 4 of Crawford (1982), he proves the related result that, under a minor relaxation of rationality, iterative elimination of strictly dominated commitment strategies leads to a prisoner's dilemma where a unique commitment strategy dominates the waiting strategy. In our model players are fully rational.

pair of pure strategy equilibria, either $p_1(1) = 1$ *and* $p_2(w) = 1$ *or* $p_2(1) = 1$ *and* $p_1(w) = 1$.

As noted already by Crawford (1982) there is a plethora of efficient equilibria when $c = 0$. The discontinuity at $c = 0$ may seem strange. However, if we refine the set of Nash equilibria, the discontinuity vanishes.

Lemma 2 *Suppose* $c = 0$*. Then, for each player* i*, only* $s_i \in \{1, w\}$ *are iteratively weakly undominated strategies.*

Proof. Step(i). Any first stage commitment $s_i \leq \beta_i$ is weakly dominated by w, because w earns at least as much against all opponent's commitments $s_j \neq 1 - s_i$ and the same against $s_j = 1 - s_i$, and either more or the same against $s_j = w$. Step (ii). Given that opponent strategies $s_j \leq \beta_j$ are likewise eliminated, any commitment strategy $s_i \in (\beta_i, 1)$ is now weakly dominated by 1, since 1 earns the same as s_i for all weakly undominated opponent strategies except w; in the latter case 1 earns more. ■

With the lemma in hand, it is trivial to prove our next result.[6]

Proposition 2 *Suppose* $c = 0$*. For any pair* (β_1, β_2)*, only three subgame perfect Nash equilibrium outcomes are consistent with two rounds of elimination of weakly dominated strategies. These equilibria are (i)* $p_1(1) = p_2(1) = 1$ *(ii)* $p_1(1) = 1$ *and* $p_2(w) = 1$*, and (iii)* $p_2(1) = 1$ *and* $p_1(w) = 1$.

Our mixed strategy equilibrium can be seen as a cousin of Proposition 2 in Ellingsen (1997). Ellingsen also studies the trade-off between commitment and flexibility in the Nash Demand game, albeit in a single-population evolutionary model with observable strategies and zero commitment costs. His Proposition 2 considers a case in which the size of the pie is uncertain, and commitments are nominal. In that case, a bilateral commitment to " fair" demand, such as half the normal surplus, will entail conflict whenever the surplus is smaller than normal. The flexible strategy then does better than the committed fair strategy,

[6] For completeness, let us mention that, if commitment would be cheaper than remaining flexible, many other equilibria are sustainable and there are no weakly dominated strategies.

and ends up coexisting with the aggressive committed strategy. Ellingsen's result hinges crucially on the assumption that the size of the surplus is uncertain when the commitment is made, and that it is impossible to commit to a relative share of the surplus. We make neither of these assumptions.

In another closely related paper on the Nash Demand game, Güth, Ritzberger and van Damme (2004) assume that there is some small uncertainty as to the actual size of the surplus and let negotiators choose their demands either before or after the uncertainty resolves. They show that there are only two strict Nash equilibria. In each of these equilibria, one negotiator demands almost all of the surplus before the uncertainty is resolved. The other waits until the size of the pie is known and demands the remainder. In their model, as in Ellingsen's, commitment is costly because of the inability to adapt the demand perfectly to the size of the surplus. However, by only reporting asymmetric strict equilibria, they predict an efficient outcome. It is worth pointing out that the asymmetric equilibria are strict only because of the uncertain size of the surplus. With full certainty of the surplus size, Güth, Ritzberger and van Damme are back to the vast multiplicity of equilibria.

3 Uncertain commitment

In this section, we maintain the assumption that players can attempt commitment at a cost c, but relax the assumption that the commitment succeeds with probability 1. Define $q_1 = q_2 = q$ as the probability (independent of the size of commitment) of success. We only consider the case $0 < c \leq q(1-\beta_i)$ in which commitment is potentially attractive.

As a backdrop, consider first the argument of Crawford (1982, pages 620-623) that commitments are likely to be made when q is small. The idea is that efficient compatible commitment outcomes, such as $s_1 = s_2 = 1/2$, cannot be sustained in equilibrium, because the defection to $s = 1$ is too tempting. Suppose $\beta_1 = \beta_2 = 1/2$. Given that the opponent plays $s_j = 1/2$, a defection from $s_i = 1/2$ to 1 pays whenever $q(1-q) \times 1 + (1-q)/2 > 1/2$. That is, the defection pays if $q < 1/2$. Indeed, if $q < 1/2$, it is straightforward to show that in the unique equilibrium both players commit to take the whole surplus, and thus that there is conflict with probability q_2. On the other hand, if $q > 1/2$ there is always an efficient Nash equilibrium in which $s_1 = s_2 = 1/2$.

As we shall now see, the efficient equilibria that exist when $q \in (1/2, 1)$ are highly sensitive to the assumption $c = 0$. More precisely, when c is positive but sufficiently small, the efficient equilibria vanish.

Proposition 3 *(i) If $0 < c < q(1-q)(1-\beta_i)$, then for each player i only $s_i = 1$ is an iteratively strictly undominated strategy. (ii) If $0 < q(1-q)(1-\beta_i) \leq c \leq q(1-\beta_i)$, then only 1 and w are iteratively strictly undominated strategies.*

Proof. Observe first that player i strictly prefers w to any $s_i \in [0, \beta_i]$: The commitment strategy s_i yields $qs_i + (1-q)\beta_i - c < \beta_i$ when player j chooses w. It yields no more than $q^2(1-s_j) + q(1-q)s_i + (1-q)q(1-s_j) + (1-q)^2\beta_i - c < q(1-s_j) + (1-q)\beta_i$ when player j chooses a compatible commitment in $[0, 1-s_i]$, and finally it yields $q(1-q)s_i + (1-q)q(1-s_j) + (1-q)^2\beta_i - c < q(1-s_j) + (1-q)\beta_i$ when player j chooses an incompatible demand.

After these commitment strategies are eliminated, it is easy to check that strategies $s_1 \in (\beta_1, 1)$ are strictly dominated by the mixed strategy $\sigma_1 = (p_1(1) = s_1, p_1(w) = 1 - s_1)$: If player 2 plays w, player 1's payoff to a pure strategy in $s_1 \in (\beta_1, 1)$ is $qs_1 + (1-q)\beta_1 - c$; whereas under the mixed strategy σ_1 he gets $qs_1 + (1 - qs_1)\beta_1 - s_1 c$. If player 2 plays $s_2 \in (1-\beta_1, 1]$, the payoff to a pure commitment strategy in $s_1 \in (\beta_1, 1)$ is $q(1-q)s_1 + (1-q)q(1-s_2) + (1-q)^2\beta_1 - c$ whereas the payoff to the mixed strategy is $qs_1(1-q) + (1-qs_1)q(1-s_2) + (1-qs_1)(1-q)\beta_1 - s_1 c$, which is strictly greater. Likewise, player 2 strategies $s_2 \in (1-\beta_1, 1)$ are dominated by the mixed strategy $(p_2(1) = s_2, p_2(w) = 1 - s_2)$.

Suppose now that $c < q(1-q)(1-\beta_i)$. Since all other strategies are eliminated, it is easy to check that $s_i = 1$ dominates w: If the opponent waits, $s_i = 1$ gives $q + (1-q)\beta_i - c$ and w gives β_i. Commitment is the better strategy, since

$q(1-\beta_i) > q(1-q)(1-\beta_i) > c$. If the opponent plays $s_j = 1$, playing $s_i = 1$ yields $q(1-q)+(1-q)(1-q)\beta_i - c$ while w yields $(1-q)\beta_i$. Since $c < q(1-q)(1-\beta_i)$, commitment is again better. Thus, part (i) is established. On the other hand, if $c \geq q(1-q)(1-\beta_i)$, $s_i = w$ is a best response to $s_j = 1$ but $s_i = 1$ is a best response to $s_j = w$. This establishes part (ii). ■

The most remarkable feature of the result is that, when c is sufficiently small, conflict occurs with probability q^2 in a unique equilibrium even as q is arbitrarily close to 1. While the probability of conflict in the best equilibrium based on Crawford's analysis is at most $(1/2)^2 = 1/4$, in the perturbed game the best equilibrium may instead have conflict with almost full certainty.

Since we normalize the size of the total surplus to 1, another way to interpret the result is that conflict becomes increasingly likely as the size of the surplus increases. It is the ratio of the commitment cost to the size of the surplus that matters. Therefore, our model explains why some issues may be regarded as too small to fight about, whereas big issues invite conflict.

From a technical point of view, making commitment somewhat uncertain does not affect the first two iterations in Lemma 1. Yet, it changes the strategic aspects of the remaining 2×2 game. With certain commitment, this was a game of Chicken, with uncertain commitment and low cost of attempting, it becomes a Prisoners' Dilemma: Attempting commitment is a strictly dominant strategy.[7]

Finally, let us again consider the role of equilibrium refinement in the limit case $c = 0$.

Proposition 4 *Suppose $c = 0$. Then, for each player i, only $s_i = 1$ is an iteratively weakly undominated strategy.*

Proof. Step(i). Any first stage commitment $s_i \leq \beta_i$ is weakly dominated by w. The commitment strategy yields $qs_i + (1-q)\beta_i \leq \beta_i$ when player j chooses w. It yields at most $q^2(1-s_j) + q(1-q)s_i + (1-q)q(1-s_j) + (1-q)^2\beta_i \leq$

[7] This result bears a relation to Young's (1993) insight that a small chance of meeting a bargainer from one's own population destabilizes asymmetric stable states. Here the small uncertainty of failure of commitment plays a similar role as the probability of meeting a player from the own population.

$q(1-s_j)+(1-q)\beta_i$ when player j chooses a compatible commitment, and finally it yields $q(1-q)s_i+(1-q)q(1-s_j)+(1-q)^2\beta_i < q(1-s_j)+(1-q)\beta_i$ when player j chooses an incompatible commitment. Step (ii). After opponent strategies $s_j \leq \beta_j$ are likewise eliminated, any commitment strategy $s_i \in (\beta_i, 1)$ is now weakly dominated by 1, since 1 earns the same as s_i for all weakly undominated opponent strategies except w; in the latter case 1 earns more. Finally, when all but $s_i = 1$ and $s_i = w$ are eliminated, the former dominates the latter: if $s_j = 1$, then $s_i = 1$ yields $q(1-q)+(1-q)^2\beta_i$ whereas $s_i = w$ yields $(1-q)\beta_i$, which is less. ∎

4 Final remarks

We have re-examined the problem of observable commitments in bargaining, first studied by Schelling (1956) and later formalized by Crawford (1982). Our benchmark is the special case of Crawford's model in which commitment sticks with probability q and is freely revokable with probability $1-q$. We show that either a slight perturbation of the model (the introduction of a positive cost of commitment) or a strengthening of the solution concept suffice to greatly alter the results. The new results potentially shed light on two types of phenomena.

The first phenomenon is the infrequency of side-payments. Although we lack systematic evidence, it seems to us that side-payments are less frequent than suggested by the compromise outcomes favored by most other bargaining models. Consider for example the case in which an unpleasant job can be carried out either by person A or by person B, but not by both of them (say, the job of being department chairperson). The compromise solution is that whoever takes on the job ought to be compensated by the other through a side-payment. Our model, like Schelling's intuitive analysis, implies that such side-payments should not occur unless commitment costs are prohibitively high.

The second phenomenon is conflicts. If it is cheap to make commitments but impossible to make such commitments stick with probability 1, the model predicts that there is stalemate due to conflicting commitments. Thus, we here have a simple explanation of conflict that invokes neither asymmetric information nor exogenous constraints on side-payments. If anything, the model produces incompatible commitments all too readily.

Our analysis leaves out several considerations that may be important in practice. For example, the model allows commitments to be made in a single period only. Allowing more time periods as well as (random) delays in the communication of commitments are two natural avenues along which the analysis may be profitably extended. After more than fifty years, formal game theory is still catching up on Schelling's analysis of commitment tactics in bargaining.

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