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Bargaining with random implementation: An experimental study

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ABSTRACT

We use a laboratory experiment to study bargaining with *random implementation*. We modify the standard Nash demand game so that incompatible demands do not necessarily lead to the disagreement outcome. Rather, with exogenous probability q, one bargainer receives his/her demand, with the other getting the remainder. We use an asymmetric bargaining set (favouring one bargainer) and disagreement payoffs of zero, and we vary q over several values.

Our results mostly support game theory's directional predictions. As with conventional arbitration, we observe a strong *chilling effect* on bargaining for q near one: extreme demands and low agreement rates. Increasing q reinforces the game's built-in asymmetry – giving the favoured player an increasingly large share of payoffs – but also raising efficiency. These effects are non-uniform: over sizable ranges, increases in q have minimal effect, but for some q, small additional increases lead to sharp changes in results.

1. Introduction

Many economic transactions involve a decentralised element, with the price (and perhaps other attributes) set by a single buyer and a single seller, each with some degree of market power. Well-known examples of at least partly decentralised markets include those for houses, new cars and used cars in most countries, as well as labour markets in many professions. In such a market, associated with any potential transaction is a relation-specific surplus for the parties involved: for example, if a painting is worth $50,000 to its current owner and $80,000 to a potential buyer, then a surplus of $30,000 is available to the two parties. The fundamental role of bargaining in determining how surpluses are divided (and indeed, whether they are even realised) in decentralised markets has long been recognised, with work in this area going back at least to the late nineteenth century (Edgeworth, 1881). However, until the 1950s, bilateral bargaining situations were deemed by economists to lack a clear predicted outcome.[2] The only quasi-prediction was that the division of the surplus would depend on the two parties' relative bargaining power.

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[2] For example, as Roth (1979) points out, von Neumann and Morgenstern's (1944) bargaining solution coincides with the set of all efficient outcomes that both bargainers prefer to disagreement.

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Nash (1950) approached this indeterminacy problem by proposing a set of four axioms that the outcome of bargaining ought to follow, and proving that together, these axioms entail a unique solution to any bargaining situation that satisfies a few weak conditions, giving rise to the *Nash bargaining solution*.[3] Nash (1953) followed up this axiomatic approach by introducing a very simple non-cooperative game, now known as the *Nash Demand Game* (which we abbreviate as NDG). In the simplest version of the NDG, there is a fixed sum of money (a "cake") available to the two bargainers, and each simultaneously makes a single, irrevocable demand. If the demands are compatible (their sum does not exceed the size of the cake), then there is "agreement", and each bargainer receives the amount he/she demanded. If not, then a predetermined "disagreement" outcome is imposed. By introducing the NDG, which was meant to capture the key aspects of real bargaining, Nash established a new research agenda, now called the "Nash program" (e.g., Binmore, 1998). This program uses non-cooperative game theory to provide a foundation for axiomatic (cooperative) bargaining solution concepts like the Nash solution.

The simplicity of the Nash Demand Game is a great virtue, but as a model of real bargaining it has two major disadvantages: one theoretical and one practical. Its theoretical disadvantage is that most versions of the NDG have a large number of Nash equilibria. In particular, every efficient, individually rational division of the surplus corresponds to a Nash equilibrium. (There are also inefficient Nash equilibria.) This multiplicity of equilibria – and resulting lack of predictive power – clearly limits the usefulness of the NDG for analysing real bargaining.

The practical shortcoming of the NDG concerns the implication of incompatible demands. In this case, the disagreement outcome is imposed, resulting in a severe punishment to the bargainers, with no chance of avoiding it (e.g., through renegotiation). The fact that failure to agree immediately leads to irrevocable disagreement – irrespective of how close to being compatible the two demands were – flies in the face of most people's intuitive understanding of how bargaining works. Despite this seeming deficiency, some researchers have defended the NDG as at least capturing the most important features of real bargaining. Binmore (2007) points out that when bargainers can commit to demands, but neither has the ability to commit before the other, the NDG is the limiting case where both bargainers "rush to get a take-it-or-leave-it demand on the table first" (p. 496), resulting in simultaneous irrevocable demands. Moreover, Skyrms (1996) argues that in modelling the bargaining process, "[o]ne might imagine some initial haggling... but in the end each of us has a bottom line" (p. 4); focusing on these bottom lines results in the NDG. However, experimental evidence suggests that there are indeed systematic differences in behaviour between the NDG and less structured bargaining settings – both in the likelihood of reaching agreement and in how the resulting surplus is divided (Feltovich and Swierzbinski, 2011) – suggesting that some important features of real bargaining are lost by modelling it with the NDG. In particular, subjects in NDG experiments tend to leave more money "on the table", hedging against the game's strategic uncertainty by reducing demands, compared to less structured settings.

Nash (1953) himself provided the first attempt to rectify these problems with the NDG, using a "smoothing" approach. Under smoothing, incompatible pairs of demands do not necessarily lead to zero payoffs; rather, the probability of a pair of demands being accepted decreases continuously from one (at the boundary of the original bargaining set) to zero based on a smoothing function.[4] Clearly, such a modification treats incompatible demands differently according to how close to being compatible they were. Less obviously, when an appropriate smoothing function is used, it results in the set of Nash equilibria shrinking to a unique equilibrium corresponding to the Nash bargaining solution. Although this smoothing attempt was the first to provide non-cooperative foundations for the Nash solution, it has typically not been deemed reasonable by game theorists since that time.[5]

A more recent attempt is that by Anbarci and Boyd (2011), whose "probabilistic simultaneous procedure" (p. 18) modified the NDG so that bargainers submitting incompatible demands do not necessarily receive their disagreement payoffs; instead, this happens only with exogenous probability $1 - q$, where $q \in [0, 1]$. With the remaining probability q (conditional on incompatible demands), a fair coin toss determines which of the two bargainers receives his/her demand, with the remainder going to the other bargainer. Anbarci and Boyd's game can be thought of as tacking a (stylised) element of arbitration onto the standard NDG. If demands made in the first stage are incompatible, with probability q the bargainers move to a second stage where they undergo final-offer arbitration, and where these final offers are just the bargainers' demands from the first stage.[6] This mechanism differs from many models of final-offer arbitration in that the arbitrator

[3] Formally, a two-person bargaining problem is described by a pair (S, d) where $S \subset \mathbf{R}^2$ is the *set of feasible agreements* with a *disagreement point* $d = (d_1, d_2) \in S$ being the allocation that results if no agreement is reached. Nash's solution requires only that S is compact and convex, and that it contains some (x_1, x_2) with $x_1 > d_1$ and $x_2 > d_2$ (that is, gains from agreement are available); these conditions will be satisfied for the bargaining problems considered in this paper.

[4] See Binmore et al. (1993) for an experiment using a "smoothed" bargaining set.

[5] For example, Luce and Raiffa (1957) write that "Nash offers an ingenious and mathematically sound argument for [resolving the indeterminacy problem], but we fail to see why it is relevant" (p. 141) and go on to call smoothing "completely artificial" (p. 142). Schelling (1960) was more sympathetic, but even so, stated that smoothing was "in no sense logically necessary" (p. 283) and that while it provided a way of selecting one of the multiplicity of equilibria, the same argument "equally supports any other procedure that produces a candidate for election among the infinitely many potential [solutions]" (p. 284).

[6] Since the outcome imposed in the second stage is binding on the bargainers, the mechanism is more similar to arbitration than to *mediation*, where the second-stage result is not binding on the bargainers and thus must be agreeable to both of them.