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Bargaining orders in a multi-person bargaining game ☆

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ABSTRACT

This paper studies a complete-information bargaining game with one buyer and multiple sellers of different "sizes" or bargaining strengths. The bargaining order is determined endogenously. With a finite horizon, there is a unique subgame perfect equilibrium outcome, in which the buyer purchases in order of increasing size–from the smallest to the largest. With an infinite horizon, if the sellers have sufficiently different sizes, there is a unique equilibrium outcome, which has the same bargaining order. If the sellers have similar sizes with an infinite horizon, there may be multiple equilibrium outcomes with different bargaining orders.

1. Introduction

Consider a scenario in which a real estate developer must acquire land from multiple sellers. The sellers' lots are of different sizes with a larger lot giving a higher flow of payoffs to its owner. Such situations are quite common. For example, in Chongqing, China, the construction of a retail mall required 280 properties of different residents. The project was suspended for three years because one out of the 280 owners refused to sell his property to the developer.[1] Columbia University's expansion plan in West Manhattanville is another prominent example. The 17-acre project was worth 6.3 billion dollars, and the land was acquired from 67 separate property owners. The entire negotiation lasted over a long period from years 2002 to 2010, and the negotiation on the last three properties alone took more than three years.[2] What should the buyer (developer) do when she needs to purchase land from multiple sellers who own lots of different sizes? In particular, which seller should she bargain with first, the one with a large lot or a small lot? This paper examines the corresponding non-cooperative bargaining game. We find that the buyer should bargain with the seller of the smallest lot first, especially when the sizes of the lots are quite different. This paper does not try to explain the delay in the examples above. Delays occurred even when there was only one seller remaining in the first example, perhaps due to incomplete information.[3]

While the model studied here is couched in the language of a single developer negotiating with multiple sellers, it is applicable to a variety of other bargaining scenarios. For example, consider an airline that must bargain with two separate

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[1] The negotiation began in 2004, and eventually the owner sold his property in 2007. See "In China, Fight Over Development Creates a Star," *New York Times*, March 26, 2007, or "Nail House in Chongqing Demolished," *China Daily*, April 3, 2007.

[2] See "2 Gas Stations, and a Family's Resolve, Confront Columbia Expansion Plan," *New York Times*, September 20, 2008; "Reaction to Court's Rejection of Manhattanville Eminent Domain," *News*, December 4, 2009; and "The Clever Capitalism of Nicholas Sprayregen," *CU Columbia Spectator*, September 16, 2010.

[3] See, for instance, Admati and Perry (1987) for how incomplete information can lead to delay.

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unions, pilots and flight attendants, in order to end a strike. Both unions are necessary for the airline to operate, but their outside options differ.[4] Which union should the firm negotiate with first? A similar question can be asked about the negotiation between a manufacturer and a group of upstream suppliers producing parts at different costs.[5] Our model also applies to the case in which a good, in order to reach the buyer, needs to pass a sequence of intermediaries with different transaction costs.[6] The key characteristics common to these scenarios are: the one-to-many aspect of the negotiation; the fact that an agreement with *all* sellers is necessary to reap any economic gains; and finally, the "size" differences among the sellers.

In this paper, bargaining strength is measured by the size of the inside/outside options available to a seller when bargaining with the buyer.[7] A seller with a large lot is stronger than a seller with a smaller lot in the sense that, in equilibrium, the price received by the large seller is higher than that received by the small seller. There are other notions of bargaining strength, of course. For instance, one may measure bargaining strength by how patient a seller is and different sellers may have different discount rates. Alternatively, it may be related to the likelihood of making initial offers (see, for instance, Li, 2010).

It is useful to begin with a simple example. Consider a scenario with one developer and two farmers. All parties share a discount factor of $\delta \in (0, 1)$. Farmer 1 owns a large lot of land that produces $(1-\delta)/2$ units of harvest in each period; farmer 2 owns a small lot of land that produces $(1-\delta)/10$ units of harvest in each period. The land does not produce any harvest once it is sold to the developer. The developer must purchase both lots to build a mall that produces $1-\delta$ units of profit in each period. Therefore, the present value of all harvests is $v_1 = 1/2$ for farmer 1 and $v_2 = 1/10$ for farmer 2, and the present value of the total profit of the mall is 1.

Negotiations are sequential. In any period, the developer negotiates with only one farmer. The developer first offers a price, which the farmer may accept or reject. If the offer is accepted, the developer proceeds to negotiate with the other farmer in the next period (in a standard two-player alternating offer bargaining game). If the offer is rejected, the farmer makes a counter-offer in the next period, which the developer may accept or reject. If the developer accepts this offer, she proceeds to negotiate with the other farmer. If the developer rejects the offer, she picks a farmer, who could be the same one as in the previous period, and negotiates with him in the same fashion, and so on. Which farmer should the developer bargain with first?

Notice that the developer can pick any remaining farmer to negotiate with, there is no restriction on the choice of bargaining order. However, there is a unique subgame perfect equilibrium outcome, in which the developer purchases from farmer 2 first and then from farmer 1. The equilibrium prices are explained below. The payment to the first farmer is a sunk cost to the buyer. Therefore, after farmer 2 sells his land, the surplus is $1-v_1$, which is the difference between the value of the mall and the value of farmer 1's harvests. Our result can be best illustrated with $\delta \to 1$.[8] If δ converges to 1, farmer 1 receives $\delta/(1+\delta) = 1/2$ of the surplus as in the Rubinstein bargaining game.[9] This implies that a surplus of $\frac{1}{2}(1-v_1)$ is paid to farmer 1, so he sells at a price of $v_1 + \frac{1}{2}(1-v_1)$.[10] Excluding the price for farmer 1, the remaining value of mall is $\frac{1}{2}(1-v_1)$. As a result, the total surplus for farmer 2 and the buyer is $\frac{1}{2}(1-v_1) - v_2$, which is also the difference between the remaining value of the mall and the value of farmer 2's harvests. Similarly, farmer 2 and the buyer split this surplus equally as in the Rubinstein bargaining game. Therefore, a surplus of $\frac{1}{2}\left[\frac{1}{2}(1-v_1) - v_2\right]$ is paid to farmer 2, and the buyer's payoff is $\frac{1}{2}\left[\frac{1}{2}(1-v_1) - v_2\right] = \frac{3}{40}$. In contrast, if the buyer purchases from seller 1 first instead, she would receive a payoff of $\frac{1}{2}\left[\frac{1}{2}(1-v_2) - v_1\right] = -\frac{1}{40}$.

Our model builds on the model of Cai (2000) by introducing endogenous bargaining order and asymmetric sellers. His model is the extreme case of our infinite-horizon game if the farmers do not receive harvest. The bargaining order is fixed and rotates among the sellers in his paper. He finds multiple stationary subgame perfect equilibrium outcomes, and that delay can occur in some of them. In contrast, the sellers are asymmetric and the bargaining order is endogenous in our game, resulting in a *unique* subgame perfect equilibrium outcome.

Several papers have the feature that the bargaining orders are endogenously determined, but they are determined in a restricted way. Perry and Reny (1993) allow each player to decide when to make an offer, which implicitly allows for different bargaining orders. Stole and Zwiebel (1996), Noe and Wang (2004) and Bedrey (2009) study bargaining orders in finite-horizon bargaining games. Chatterjee and Kim (2005) focus on the bargaining orders, in which the buyer does not switch to another seller before an agreement. The literature on agenda formation also discusses orders, but the orders have

[4] An outside option is the payoff that a player receives if he leaves the negotiation.

[5] Bargaining between a manufacturer and its upstream suppliers is discussed, for example, in Blanchard and Kremer (1997), and Bedrey (2009).

[6] Manea (2017) discusses this example along with others in a study of a different topic on intermediation in networks.

[7] An inside option is the payoff received by a seller while negotiations are ongoing (see, for example, Muthoo, 1999). The analysis in Sections 2 and 3 focus on inside options, but our qualitative results would not be affected if sellers had outside options instead. Section 4 discusses outside option in more details.

[8] A larger discount factor could stand for shorter periods. As δ becomes larger, the harvest within each period becomes smaller, while the present value of the harvests remains the same.

[9] See Rubinstein (1982).

[10] The equilibrium prices are calculated according to Step I in the proof of Proposition 4.