Bilateral trading in divisible double auctions✩

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Abstract

Existing models of divisible double auctions typically require three or more traders—when there are two traders, the usual linear equilibria imply market breakdowns unless the traders’ values are negatively correlated. This paper characterizes a family of nonlinear ex post equilibria in a divisible double auction with only two traders, who have interdependent values and submit demand schedules. The equilibrium trading volume is positive but less than the first best. Closed-form solutions are obtained in special cases. Moreover, no nonlinear ex post equilibria exist if: (i) there are \( n \geq 4 \) symmetric traders or (ii) there are 3 symmetric traders with pure private values. Overall, our nonlinear equilibria fill the “\( n = 2 \)” gap in the divisible-auction literature and could be a building block for analyzing strategic bilateral trading in decentralized markets. © 2016 Elsevier Inc. All rights reserved.

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1. Introduction

Trading with demand schedules, in the form of double auctions, is common in many financial and commodity markets. In a typical model of divisible double auctions, traders simultaneously
submit linear demand schedules (i.e., a set of limit orders, or price-quantity pairs), and trading occurs at the market-clearing price. A large literature is devoted to characterizing the trading behavior in this mechanism as well as the associated price discovery and allocative efficiency (see, for example, Kyle, 1989; Vayanos, 1999; Vives, 2011; Rostek and Weretka, 2012, and Du and Zhu, 2016, among others). These models of double auctions typically require at least three traders for the existence of linear equilibria.

When there are exactly two traders, the existing theory predicts a market breakdown (no trade) unless traders’ values are negatively correlated. While the $n \geq 3$ assumption is relatively innocuous for centralized markets, it is restrictive for decentralized, over-the-counter (OTC) markets, where trades are conducted bilaterally. Active OTC markets for divisible assets include those for corporate bonds, municipal bonds, structured products, interbank loans, repurchase agreements, and security lending arrangements, as well as spot and forward transactions in commodities and foreign currencies.

In this paper, we fill this gap by studying bilateral trading in divisible double auctions, which is largely unexplored in the previous literature. In our model, each trader receives a one-dimensional private signal about the asset and values the asset at a weighted average of his and the other trader’s signals. That is, values are interdependent. In addition, the trader’s marginal value for owning the asset declines linearly in quantity. Moreover, the traders can be asymmetric, in the sense that their values can have different weights on each other’s signal, and that their marginal values can decline at different rates.

We characterize a family of nonlinear equilibria in this model. These equilibria can be ranked by their realized allocative efficiency, suggesting that efficiency is a natural equilibrium selection criterion. In an equilibrium, each trader’s demand schedule is implicitly given by a solution to a nonlinear algebraic equation. We show that each equilibrium leads to a trading quantity that is positive and strictly lower (in absolute values) than the first best (efficient quantity). This behavior is consistent with the “demand reduction” property commonly seen in multi-unit auctions (see, for example, Ausubel et al., 2014). Moreover, the equilibria that we characterize are ex post equilibria; that is, the equilibrium strategies remain optimal even if each trader would observe the private information of the other trader. In the special case of constant marginal values, we obtain a trader’s equilibrium demand schedule in closed form: it is simply a constant multiple of a power function of the difference between the trader’s signal and the price, where the exponent is decreasing in the weight a trader assigns on his own signal.

Do these nonlinear ex post equilibria also exist in markets with at least three traders? We show that no nonlinear ex post equilibria exist if: (i) there are at least four symmetric traders or (ii) there are three symmetric traders who have pure private values. Thus, under fairly general conditions the only ex post equilibrium is the linear one identified in previous models. Not only does this result provide a justification for the widespread use of the linear equilibrium in the existing literature, it also suggests that bilateral double auctions behave qualitatively differently from multilateral ones, and hence merit further investigation.

An interesting and useful direction of further exploration is to use our bilateral double auction result as a strategic building block for analyzing dynamic trading in large OTC markets. So far, in the most widely used class of OTC market models that start from Duffie et al. (2005), the two agents in a pairwise meeting observe, by assumption, each other’s valuation of the asset or continuation value, and trading happens by Nash bargaining (a split of total surplus by fixed portions). In contrast, the bilateral double auction in our model endogenously reveals asymmetric information to both counterparties through their fully strategic interactions. Thus, our model provides a strategic microfoundation for bilateral information transmission.
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