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Social networks among auction bidders: The role of key bidders and structural properties on auction prices

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ABSTRACT

Auctions have been studied extensively as an economic marketplace. The economist's focus is on modeling final sales prices, but the processes that give rise to those outcomes are rarely studied in great detail. This research is intended to provide that complementary perspective. We show how the interactions between bidders in an auction unfold in a dynamic pattern of bids and counter-bids, and thereby over the duration of an auction, create a network structure. The auction network contributes significantly to models of price dynamics and the network predicts final sales prices better than economic (non-network) indicators alone. In addition, network analyses are useful in identifying the key bidders whose actions seem to exert disproportionate influence on other bidders and the final sales prices. Furthermore, the key bidders may be identified very early in an auction process, which has practical implications for the auction house managers and for other bidders.

Auctions are an important means of selling many types of products, from antiques to real estate to thoroughbreds. They have served as an important vehicle for commerce for hundreds of years. Sotheby's and Christie's were founded in 1744 and 1766, respectively, and they continue to thrive today, with annual sales exceeding five billion dollars each. Tokyo's famed fish market was founded in 1923, and its annual sales also exceed five billion dollars.

Newer and larger still is eBay, established in 1995, with annual revenue around $12 billion dollars. Online auctions like eBay are important because of their size, but they interest researchers particularly because they provide rich sources of relatively novel data.

In the short time since eBay's founding, the auctions literature has also grown as researchers pose numerous questions to examine this means of market exchange. The literature to date has focused on studying aspects of auction design to achieve maximum final sales prices. For example, economic theories suggest that the auctions that attract more bidders will experience more competition, therefore resulting in higher final sales prices, compared to auction items that are bid upon by few bidders.

Economic theory tests have provided a reasonable understanding of auction outcomes—final prices. Yet what is lacking in the literature is an understanding of the processes underpinning auctions that yield those resulting sales outcomes. For example, what happens between the first and final bids?, how do bidders behave?, are all bidders the same?, do prices increase steadily over the course of an auction?, if not, what is occurring amongst bidders to drive any differential effects? In this paper, we use network analyses to model interactions among bidders. Following the bidding and counter-bidding exchanges in a continuous manner over time illuminates both structural and sequential aspects of auction processes.

The remainder of this paper is organized as follows: (1) the auctions literature is briefly reviewed, along with some relevant social networks research. We show how interactions among bidders may be viewed and analyzed as a network, and derive predictions about auction structures and bidder behaviors. (2) The methods and measures used to study auction data as networks are described, and a model is presented to test predictions about the network effects. (3) Results on the bidder network are presented, including models of price dynamics and key bidder profiles. (4) A discussion follows of the results of the study and their implications.

1. Literature review and theoretical background

The question that has received the most attention in the auctions literature is, "How may we achieve the most profitable sales prices?" As a result, the research focuses on modeling auction outcomes, including the winning auctions prices and the highest bids per bidder (Lucking-Reiley, 1999). Final sales prices have been

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studied as a function of numerous design elements e.g., English (ascending) auctions tend to generate larger surpluses than second-price auctions or Dutch (descending) auctions (Milgrom and Weber, 1982; Zheng, 2012).

Auction outcomes have also been studied as a function of characteristics of the products being sold. For example, higher prices occur when bidders can observe the product quality or when there are offers with money back guarantees. Without objective information providing assurances of quality, bidders make inferences from other cues, such the sellers' reputations or price cues such as the posted reservation prices. Bajari and Hortacsu (2003) found that sellers requesting higher minimum bids created auction environments that discouraged bidders from bidding. As a result, fewer bidders participated, resulting in less competition, and yielding lower than expected profits. Analogously, Chernomaz and Levin (2012) and Kagel and Levin (2005) showed that bidding on multiple items simultaneously improves auction efficiencies particularly for sets of products with synergies or complementarities.

While many such facets of auctions have been studied with regard to their effects on sales price outcomes, we seek to generalize our understanding of auctions along two dimensions to contribute to the literature. We begin by examining the sequential nature of auctions as intricate processes that yield the sales price outcomes. We then examine the auction exchanges among bidders as a social network enterprise to understand the structure and nature of the interactions.

1.1. Longitudinal processes of auctions

Regarding the longitudinal nature of auctions, scholars have commented that there is a very real need for research that systematically looks at the processes that give rise to the auction outcomes (Bapna et al., 2008). The sequential nature of the series of bids and counterbids would seem to be intriguing theoretically and pragmatically, yet it is rarely discussed and woefully under-studied, in favor of the simpler economic focus on sales outcomes.

Certainly some process information has been studied, e.g., revealing that sales prices are affected by the order of the items bid upon, and the number of bidders in the auction. In addition, some sequential analyses have been used to show, e.g., that bidders seem to be strategic in planning for future bids for items to be sold subsequently. Bidders seem sensitive to the sequential auction environment, and place demonstrably greater price increases at the beginning and end of auctions, especially for expensive items (Reddy and Dass, 2006). Furthermore, as bids unfold, real time forecasting has been shown to accurately predict and even maximize final sales prices (Dass et al., 2011).

The call to study more longitudinal aspects of auctions is echoed in many disciplines, including the social networks literature. De Nooy (2011) argues that part of the reason for the increased interest in longitudinal networks is that such data are increasingly available that capture when ties form and are modified. Thus, research questions of interpersonal and group dynamics are no longer merely theoretical inquiries, but rather may be addressed empirically. In addition, when new forms of data become available, researchers begin to pose altogether new classes of research questions.

For example, Spiro et al. (2013) write about brokeraging, which is a mediative process in which the broker facilitates interactions between two parties. They maintain that a brokerage is best understood as a process that unfolds via actor interactions within networks. While this current research is not about brokers, it similarly highlights the importance of both the interpersonal structures, and their changing form over time.

Brandes et al. (2012) also acknowledge the growth in longitudinal network data and heightened interest in studying such dynamics. They focused on offering means of visualizing the representation of the development of connections. They also urge researchers to incorporate the sequential nature of the network interactions into predictive stochastic actor models. This paper contains several visual representations of the network dynamics, and the focus of the paper is indeed a statistical model to test predictions about network structures and the roles of various actors.

Stochastic models are also useful in forecasting temporal patterns. Hasan (2012) considered relational connectivity as temporal trajectories, in that actors who occupy different structural positions are likely to proceed following different paths. These trajectories comprise an element of our modeling as well. We seek to build on the auctions outcomes literature by explicitly analyzing bids to understand price development, and to do so, in part we will model the velocity and acceleration of bidding patterns as they converge toward the ultimate auction sales prices.

1.2. Relational connectivity of auctions

In addition to the longitudinal nature of bidding, in this paper, social networks techniques are shown to discern structural elements of the bidding that nicely complement the traditional linear and economic foci on outcomes. To study the dynamics of auctions requires that we model the interactions among bidders in the form of their bid-counterbid actions and responses.

Bidders track their own behavior over time, as well as the actions and reactions of the parties against whom they are bidding. Subsequent bids are placed directly in response to those competitive bidders, and those bids provide signaling information (Cheema, 2008; Lavi and Oren, 2012). That is, bidders do not rationally post multiple bids simultaneously for the same item, and in many auctions are precluded from doing so (Malmendier and Lee, 2011). Rather, a bidder posts a subsequent bid only in response to a competitor having posted a dominating bid. Bidders respond to bids in the developing sequences, and therefore to other bidders, even if the other bidders are strangers (as is true in many game theory formulations). The fact that bids are submitted contingent upon other bids by other bidders indicates that bidders' behaviors are interdependent.

Understanding how bidders compete against each other and interact with each other in auctions is frequently pointed to as an area of research that is both very important and understudied (Milgrom and Weber, 1982; Roth and Ockenfels, 2002). In this paper, we analyze the details of bidders' interconnections, and this greater depth of knowledge illuminates auctions in ways they have not been considered to date, offering both new views on auctions and new phenomena as elements of auctions, including but not limited to final sales prices.

The notion that a bidder responds to other bidders may be easier to understand in a traditional in-person auction (e.g., Christie's), in which bidders identify each other in the audience by face or by a paddle number. Yet online auctions are less anonymous than one might think. Bidders become familiar with other bidders by their online auction usernames, and the actions they take, such as the other objects they are bidding on and the frequency of their bidding (Konrad and Kovenock, 2009). The comparison between online and offline phenomena is not unusual, given the still relative novelty of many online activities. For example, in their comparison of interpersonal connections within organizations, Johnson et al. (2012) found that offline (or, "in real life"), social networks are affected by actor attributes such as gender, tenure, and positions in organizational hierarchies, whereas online social networks were less affected by these individual characteristics.

To seek validation in this regard—that online auctions may resemble social networks, we conducted a small pilot study, in which we interviewed eight managers of major art auction houses and four known art collectors. We also conducted an online survey