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Bidding and performance in multiple unit combinatorial fishery quota auctions: Role of information feedbacks

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ABSTRACT

This article explores the role of market information and learning in multiple unit combinatorial markets for fishing quota. Combinatorial auctions allow trading of packages of different types of quotas (for example for different regions or industry) in the same auction market. Bidders can submit package bids which would allow them to enjoy synergy benefits. However, to realize the full benefit bidders require comprehensive understanding of the market. This article focuses on the impact of varying levels of information feedback on performance in multiple unit forward combinatorial auctions using laboratory experiments. In a general context of trade in fishery quota, it was asked whether (a) providing additional market information and (b) learning through time helps in more efficient outcomes. It is found that much of the benefits of information are derived from structural effects, like repeated rounds and package valuations. Providing additional market information does not improve auction performances to a large extent. These results will be useful in designing more efficient combinatorial markets for fisheries quota.

1. Introduction

In many situations there are significant benefits from holding joint or packages of items. This question is explored in the general context of fishing quota. In the case of multispecies fishing, for example, complementarity in production would imply presence of significant scope economies in joint catch [14]. Similarly, fishers could enjoy significant cost synergies from acquiring quotas for multiple regions in close proximity. A recent study by Innes et al. [26] provides evidence that fishers engage in package quota trading in the Australian Coral Reef Fin-Fish Fishery on the Great Barrier Reef. The fishers potentially benefit from reduced transaction costs and perception of low risk of failure of package offers. Such presence of package trading behavior indicates the need for more formal mechanisms to facilitate package quota trading. Currently there is a lack of information on appropriate mechanism designs which would allow fishers to enjoy benefits of economies of scope through submitting package bids [33,34].

Combinatorial auctions allow trade in different types of quotas (for different regions, industry or species for example) in the same auction market. Bidders can submit bids on combinations of individual quotas which would allow them to enjoy synergy benefits. Many studies have shown that combinatorial auctions achieve high allocative efficiency with traders having economies of scope [4]. Combinatorial auctions have been successfully applied to spectrum auctions [27], the procurement of goods and services [16,20], transportation services, and school meals distribution [17]. It has also been tested in a wide range of markets such as airport slot allocation [30], emission trading schemes [29] and environmental payment services [24].

Economies of scope in commercial fisheries arise from the fact that fishers are often catching different species at the same time or on the same voyage. Nevertheless, combinatorial auctions have been only recently tested in the sector. Stoneham, et al. [33] suggested using combinatorial auctions for allocating multiple aquaculture sites. In 2007, the Department of Primary Industries in Victoria, Australia used combinatorial auctions for fisheries site allocation [13]. Under this auction multiple (18) sites were sold

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simultaneously where bidders could submit package bids on combination of sites. Bidders responded positively to such opportunities and around 40% of the submitted bids were package bids. In a follow-up mail survey it was found that the majority of the bidders (10 out of 14) were happy with the experience [13].

Recently, Iftekhar and Tisdell [25] studied a multiple region fishery quota market and compared a simultaneous ascending auction design with an iterative combinatorial auction design using agent based simulations. They observed that in a low synergy environment, simultaneous auction design performed better than the combinatorial auction design, and conversely in high synergy environments combinatorial market design was more efficient. Later, Tisdell and Iftekhar [34] extended the work and studied the performance of the designs using laboratory experiments. They observed that the aggregate performance of combinatorial auction is best when all human bidders are package bidders. On the other hand, simultaneous auction performed best when half of the human bidders are package bidders and half item bidders.

This article contributes to this growing body of literature on the application of combinatorial design. While interest in the application of combinatorial auction designs has increased in recent years there is still a lot to understand. The role of market information in influencing bidders' behavior in multiple unit combinatorial auctions, for example, is not clear. Combinatorial markets often suffer from threshold problems and computational complexity. A threshold problem occurs when bidders with interests in only a sub-set of items fail to coordinate their bids and fail to win their desired set of items. Moreover, because of the wide strategy space involved in a combinatorial auction, bidders often suffer from computational complexities in expressing their preferences [12]. Bidders' choices in combinatorial auctions involve the selection of the 'right' package and the 'right' price. They can also attempt and need to consider others trying to influence the competition by strategically selecting packages and prices. Chen and Takeuchi [9] suggested that dominant strategies may not be transparent to the bidders and that bidders may have to resort to a trial and error learning process to adjust their behavior. Similarly, Scheffel et al. [31] observed bidders often pre-selecting a few packages early in the auction on which they continued to bid. These experimental studies demonstrated the importance of understanding the role of information feedback in strategy selection in multiple unit combinatorial auctions.

Based on the premise that market information in principle should overcome threshold problems and computational complexity [3,6] combinatorial auctions are often run iteratively, where bidders can learn about their relative standings in the market during intermediate rounds. Iterative formats are less cognitively demanding as bidders can solve their preference elicitation problem in a distributed manner. To facilitate bidding, market information is processed based on provisional allocations for the current round [19,31]. As a result, the nature and type of information released to the bidders plays a crucial role in influencing bidding strategies in repeated auction settings.

A related question then is how bidders' capacity to learn and assimilate the market information influences auction outcomes.[2] To explore the impact learning has on the performance of combinatorial fisheries quota markets, robots with pre-determining learning strategies were included in this study. In previous experimental studies with artificial agents, robots used a pre-defined bidding strategy (such as random, sincere or Nash equilibrium bidding) and did not allow them to learn from the market [8,9]. In this study an agent based learning algorithm was employed. Having robot traders with defined learning algorithms allows for a more systematic analysis of behavior in complex multiple-unit combinatorial markets and leads to better evaluation of how humans react to controlled behavior in an experimental setting.

In essence, the role of market information and learning in bidders' behavior in multiple unit combinatorial auctions for fisheries quota allocation has yet to be fully explored. This research in part fills this gap by reporting results from a series of experiments on repeated forward combinatorial auctions involving a market of 4 humans and 4 robots in an independent private value setting. Bidder behavior was studied in three information treatments. In the basic feedback treatment, the human bidders received information on market prices and status of their own bids. In the second treatment, they received additional information on winning bids. In the third treatment, they observed all bids and their respective status from previous round. The main contribution of this article is in formally testing the role of market information on bidders' behavior in a multiple unit forward combinatorial auction games under controlled experimental conditions.

In order to test the effect of market information and learning the following questions were asked: (1) Does additional information help human bidders find socially optimal packages? (2) Does additional information facilitate human bidders to bid closer to their induced values? and (3) Does additional information allow advantages to human bidders over robots with a fixed learning model and access to a limited set of information? Answering these questions will be valuable to design more efficient markets for fisheries quota.

2. The auction model

The role of information and learning is explored in a repeated multiple unit forward combinatorial auction design. The notion behind iterative bidding is that after bids are placed, the bidders are given information about the provisional allocation and prices, and have the opportunity to revise their bids through rounds. In the first round of the auction, bidders place price-quantity bids indicating their willingness to purchase a number of quota units. The auctioneer then solves an optimization algorithm (known as the winner determination problem) to select winning bids with the objective of maximizing revenue from selling the targeted number of quotas. The auctioneer also calculates feedback prices based on submitted bids. Bidders use this information to revise their bids in the following round in a series of single shot games. The process continues until the maximum number of rounds is reached. The winner determination problem and the feedback price calculation procedure are formally presented below.

In the auction model, the auctioneer targets to sell a set of items, where u_k represents the number of quotas for item k ($k = 1 \ldots K$) for sell. Bidder i's bid j is represented by $\left\langle \lambda_{ij}^{k}, b_{ij} \right\rangle$ where $\lambda_{ij}^{k} \geq 0$ is the number of quotas for item k asked and b_{ij} is respective bid price. The auctioneer's winner determination problem is to maximize the sum of all bid prices (in other words, maximize total revenue or Z) subject to the number of quotas for sale. Formally:

[2] In a repeated first price auction game, such as the one implemented in this article, a bidder does not earn any rent from bidding her true value even if she is selected. Therefore, the dominant strategy is to bid as little as possible while still winning the item. It is considered such strategic behavior as part of their learning.