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Revenue maximizing with return policy when buyers have uncertain valuations☆

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ABSTRACT

This paper examines the optimal mechanism design problem when buyers have uncertain valuations. This uncertainty can only be resolved after the actual transactions take place and upon incurring significant post-purchase cost. We focus on two different settings regarding how the seller values a returned object (salvage value). We first study the case where the salvage value is exogenously determined. We find that the revenue maximizing mechanism is deterministic and "separable". We illustrate that the optimal revenue can be implemented by a mechanism with a "no-questions-asked" return policy. In addition, we show that "linear return policies" are suboptimal when the hazard rates of initial estimates are monotone. We next examine the case where the salvage value is endogenously determined. We demonstrate that "separability" no longer holds and the "recall" of buyers is necessary in the optimal mechanism.

1. Introduction

In many auctions, buyers have uncertain valuations about the objects. These uncertainties can only be resolved after the actual transactions take place and the buyers receive the objects. For example, in online auction sites such as eBay.com, buyers' valuations are subject to after-transaction shocks, adding to their initial estimates. These shocks can result from matching tastes or styles, complementarity with other products that the consumers have already owned, the conditions of the objects upon the arrivals of the shipments, etc. Similarly, in an estate auction, bidders may not know their ultimate values of a piece of furniture for sale until they have it in the house and see how well the color of the upholstery matches the carpet and the size fits relatively to existing pieces. When firms bid for the assets of a bankrupt company, they will not know their true values until they begin integrating them into their existing concern.[1] Foals are often auctioned before they are born in Japanese racehorse industry. Similarly, livestock breeders auction embryos in Australia, Canada, and the United States. Agricultural produce is auctioned off long before it is harvested. In the UK gas industry, the National Grid auctions off the transmission capacity rights long before the realization of demand.

With these uncertainties, sellers can choose to auction off the objects in the traditional way, but more revenue may be raised by using a mechanism with terms conditioning on the new information available later on. A simple way to implement this is to run an auction, and then allow the winner to return the object after the uncertainty resolves. Indeed, many sellers in various online auction sites, such as Amazon.com, eBay.com, Johareez.com and Yahoo.com, provide return services; buyers get their transaction prices refunded after paying some restocking fees and shipping fees when returning the objects. A recent search for antique auctions in eBay.com came out 161,729 items, and 108,150 (67%) of them came with certain return policies. The percentage of art auctions offering refunds is even higher, 131,944 out of 175,329 auctions had return policies, representing 75% of the auctions. Other examples include the NHL (National Hockey League) online auctions, which provide a 7-Day, 100% Money-Back Guarantee, sellers in auctions for embryo, who guarantee

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[1] We thank a referee for providing us with the above two motivating examples.

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pregnancy, and the National Grid, which promises to buy back capacity rights.

In this paper, we aim to examine the optimal auction design problem when buyers have uncertain valuations, and illustrate how auctions with return policies can achieve optimality.[2] With a more generous return policy, on one hand, the seller may end up with the returned object and pay back the buyer more often; on the other hand, buyers will bid more aggressively. The optimal return policy balances these two effects. We perform our analysis in an environment where a seller (she) sells one indivisible object to a few buyers. A buyer's (he) valuation depends on both his initial estimate and a shock. In the beginning, buyers observe their initial estimates privately. A buyer learns his shock only after he wins, pays, and then receives the object for examination. Usually, the realization of the winner's shock is privately observed. For example, whether the clothes fit the buyer or not is privately observable only to the buyer himself. One of our results is that the seller can achieve the same revenue regardless this shock being publicly or privately observed.

Since buyers learn more information after inspecting the object, the seller may have interest to reallocate the object after new information flows in. As a result, one important issue is how the seller values the returned object (salvage value). We first study the case where there is much fluctuation in the market place, and therefore, the salvage value is exogenously determined. In the optimal mechanism, the seller first allocates the object to the buyer with the highest "modified virtual initial estimate", provided that it is higher than the seller's reservation value. She then lets the winner return the object if his *ex-post* valuation is lower than a cutoff, which depends on and only on his initial estimate. The cutoff is lower than the socially efficient one, implying excess return in the optimal mechanism. The optimal mechanism is proved to be separable. Competition among buyers only affects the selection of the winner. The return rule for when the winner should return the object depends only on the winner's initial estimate and his shock, not on the number of buyers nor the losers' types. As a result, the seller should select the return rules as if the winner were the only buyer. Therefore, the analysis of the optimal mechanism can be disaggregated into two separate issues: selecting the right winner and optimizing the return policy.

We then illustrate that the optimal revenue can be implemented by a mechanism with "no-questions-asked" return policy, which does not require the seller to observe the winner's realized shock. In reality, return policies can take different forms, such as refund contracts, option contracts, and cancelation fees. Our results rationalize the wide adoption of return policies by sellers in worldwide. Furthermore, we find that linear return policies widely observed in online auctions are often suboptimal. In a linear return policy, the seller charges a fixed fee plus a percentage fee (of the transaction price) for any return. Full refund policies, proportional restocking fees and flat cancelation fees are all examples of linear return policies.

We second examine the case where the group of buyers is stable and ready to interact again, and therefore, the salvage value is endogenously determined. In a stylized symmetric two-player environment, the seller first allocates the object to the winner, who is the buyer with the higher initial estimate. If his *ex-post* valuation is lower than a certain cutoff, which depends on the other buyer's (the loser's) initial estimate, he returns the object, and then the seller allocates the object to the loser. In this case, if the loser's *ex-post* valuation is lower than another cutoff, the loser returns the object, and the seller allocates the object to the winner again. Those features illustrate that the optimal mechanism is no longer separable and recalls are important in the mechanism.

[2] Wang and Zhang (2010) consider a different type of uncertainty. They illustrate how return policies can be used to mitigate the winner's curse in common value auctions. In another paper, Wang and Zhang (2011) consider return policies under an informed principal setup.

The rest of the paper is organized as follows. In Section 2, we review the literature. In Section 3, we describe the model. In Section 4, we examine the optimal mechanism with exogenous salvage value. In Section 5, we characterize the optimal mechanism with endogenous salvage value. And in Section 6, we conclude. All proofs are relegated to an Appendix A.

2. Related literature

Our basic setup how buyers gain information after buying is borrowed from a series of papers by Haile (2000, 2001, 2003) who uses this setup to motivate auctions with resale. Whereas Haile assumes that buyers have the option to re-auction the object, we consider the environment that gives buyers an option to return it to the original seller who may then resell among the other buyers, but do not allow buyers to resell on their own.

The most closely related paper is Courty and Li (2000) on dynamic price discrimination which is motivated by the sale of airline tickets. There, an airline sells a ticket with the option to return the ticket with some costs prior to the flight. Airlines sell personalized tickets which cannot be traded by the buyer. Therefore, it is assured that buyers do not have the option to resell on their own. The return option allows the airline to extract surplus that arises in the event when the customer has downgraded his valuation. They provide a well executed general model of dynamic price discrimination, beyond the motivating but very fitting airline ticket pricing example. In their paper, airlines have production functions with constant marginal costs and can serve the entire market. Therefore, there is no competition among consumers. Introducing competition among consumers to Courty and Li (2000) makes it difficult to analyze the direct mechanisms.

Our result that buyers cannot gain any informational rents for their private information that is realized after the contract is signed has been obtained in different environments. Our model setup is closest to Eso and Szentes (2007a) who consider the situation where a seller faces buyers with initial estimates of the object and can control as well as costlessly release additional private signals correlated to the buyers' valuations. Because the release of information is costless to the seller, she releases all information to all buyers. In our model, learning is costly, and it is usually not optimal to have all of the buyers learning their shocks. We are interested in the optimal sequence of buyers learning their shocks and the role of return policy in the optimal mechanism. Crémer et al. (2009) construct an ingenious sequential selling mechanism, assuming buyers face a significant cost of drawing their valuations. However, in their paper potential buyers draw their valuations when they are offered to buy, whereas in our paper the buyer observes his valuation only after he has purchased. They find that the seller extracts all the surplus by inducing the efficient allocation since bidders do not have private information prior to signing the contract. In contrast, our optimal mechanism generally does not induce an efficient allocation, since the buyers possess some private information before signing the contracts. In Eso and Szentes (2007b), a consultant can reveal signals that affect her client's valuation and can make the payment rule conditional upon the client's actions. In their paper, it is the third party, the consultant, who controls the signal revelation.

This paper is related to the literature on return policies and money back guarantees. Che (1996) considers consumers' risk aversions and obtains intuitive results. In his paper, a return policy provides insurance for a consumer's *ex-post* loss. Since the buyer is risk averse and the seller is risk neutral, the seller earns the risk premium. However, to induce the seller to provide return policies, consumers must be highly risk averse. Furthermore, providing a return policy can never be optimal when buyers are risk neutral. In our paper, the seller is better off by providing return policies, even if she is facing risk neutral buyers. Davis et al. (1995) consider risk neutral buyers and find that when the salvage value of a product is relatively large, the seller gains from return policies. This is consistent with our findings. Both Che (1996) and Davis et al.