Why sellers avoid auctions: Theory and evidence

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Abstract

The theoretical literature suggests that the seller of a unique object maximises her expected revenue by running a standard auction with an optimally chosen reserve price. However, in reality, there are instances in which sellers decide to accept an offer before the auction starts and cancel the auction. This paper first theoretically investigates the rationale behind this type of behaviour and then empirically analyses evidence from real-world auctions. In particular, we suggest that, if some individuals are risk averse—in contrast to the standard auction theory models, in which all parties are risk neutral—then it is possible that accepting a price before the auction maximises the expected revenue for the seller. Finally, with data on housing market auctions, we show evidence of such behaviour and further investigate the implications of the theory.

Keywords: Auction; risk aversion; real estate.

JEL Classification: D44, D82, R32

1 Introduction

Auction theory suggests that, under the assumption of independent private values (IPV), standard auctions maximise the expected revenue for the seller of a unique, indivisible object. These mechanisms allocate the object to the buyer with the highest value for the object, with some standard payment rules[1]. However, in real-

[1] Standard auctions usually refer to high-bid, English, sealed-bid first, and sealed-bid second-price auctions.

world markets, it sometimes happens that a seller welcomes offers before the auction starts. It follows that if a buyer settles on a price with the seller before the auction, then the object is not necessarily allocated to the buyer with the highest value for the object. Because such values are private and since bidding never takes place, there is no credible method to verify that the winning buyer actually has the highest value. We argue that this kind of behaviour is in contradiction with the assumption of risk neutrality of either the seller or the buyers. In fact, the standard result of auction theory only holds when both the seller and buyers are risk neutral. Of course, this is not a universal assumption and does not necessarily apply to many real-world market situations.

According to Myerson (1981), the expected revenue-maximising auction, or the optimal auction, is a second-price auction with an appropriately chosen reserve price. While risk neutrality is crucial for this result, Maskin and Riley (1984) showed that, with risk aversion, the optimal auction could violate the optimality condition. They discussed the optimal design of an auction with risk-averse buyers. With risk aversion of buyers, the revenue equivalence of standard auctions no longer holds. Auctions are popular selling methods in many real-world markets, such as art, wine, and real estate. However, real-world auctions are not exactly the same as the optimal auction suggested by theory. Ashenfelter (1989) discussed how auctions work for art and wine as two examples of real-world auctions. Auctions have also been used to sell residential properties for centuries[2]. In fact, they are still popular in many countries as a means of selling unique and high-demand properties. One of the non-standard behaviours we observe in these markets is the before-auction arrangement. In the particular instance we will examine here, a buyer presents an interesting offer that causes the seller to call off the auction and sell the property at that offer.

In the current study, we consider a seller of a single object who does not advertise a reserve price and does not commit to any other pre-auction prices. We argue that there are equilibria such that a seller of this kind might agree to sell her object before the auction starts under two different circumstances: First, when buyers are risk averse and the seller is risk neutral; and second, when the seller is risk averse and the buyers are risk neutral. We show that it is possible that such equilibria include before-auction arrangements for both cases. Finally, with data on real estate auctions, we test the suggestion of these two theories and investigate which party (the seller or buyers), on average, would show risk-averse behaviour in these auctions.

Similar behaviour is observed in online auctions that include a buy-it-now or buyout option. The buy-it-now option includes a price that the seller would accept for

[2]Goeree and Offerman (2004) is one example of residential property auctions.

an object before the auction starts[3]. However, there are some important differences between online auctions and the auctions we are considering in this study. The most important difference is that in our case no buyout price is advertised, but pre-auction trades nevertheless take place. There is also no disclosed reserve price for these auctions. A typical example of this situation is housing market auctions. These types of auctions have been significantly understudied compared to similar markets. Unlike traditional auctions, there is a growing body of literature on online auctions to discover the rationale for sellers' use of buyout prices and why they may avoid proceeding with an auction. Mathews (2004) suggested that impatience of the buyers or the seller might justify the use of buyout prices in these auctions. Mathews and Katzman (2006) studied the effect of the seller's attitude towards risk in these auctions. They suggested that a risk-averse seller could increase the expected profit by setting a buy price that will be acceptable to some types of buyers. Reynolds and Wooders (2009) suggested that if buyers are risk averse they may accept a buy price, which is certain, rather than an outcome from an auction, which is unknown. Another possible rationale is competition among sellers and multi-unit demand, which was studied by Kirkegaard and Overgaard (2008) with two sellers and two buyers. They suggested that, if two sellers sequentially advertise their objects, the first seller can increase the expected profit with a buyout price.

The structure of this paper is as follows. In section 2 we describe a basic model for our analysis. Then in section 3 we discuss a situation with risk-averse buyers and a risk-neutral seller in which a pre-auction trade may take place. Then, in section 4 we analyse the case with risk-neutral buyers and a risk-averse seller. Section 5 provides an empirical analysis of the proposed theory with data on housing market auctions.

2 Basic Model

We start with a standard IPV model. Suppose the seller of a unique indivisible object faces a set of $n \geq 2$ potential buyers. Each buyer i has a private value v_i for the object, independently and identically distributed according to $F(.)$ on $[0, \bar{v}]$ with density $f < \infty$. Suppose $F(.)$ is continuous and twice differentiable and has a non-decreasing *hazard rate* function. The seller's value for the object is normalised to zero.

[3]In online auction literature, a variety of these options have been studied. Some buyout prices are active until the end of the bidding. Some are only active before the first bidder places a bid. The latter is also called a temporary buyout option.

The seller runs a second-price sealed-bid auction[4] without a publicly announced reserve price[5] to sell her object. We want to first analyse the bidders' optimal behaviour and the seller's expected payoff when all players are risk neutral.

It is well known from the auction theory literature[6] that each buyer has a weakly dominant strategy, which is to bid her value for the object. If all buyers follow the equilibrium bidding strategy b, then the payoff for bidder i who bids b_i is $v_i - max b_{j \neq i}$ if she is the highest bidder and zero otherwise. Each bidder with a value v has the following expected payment.

$$\psi = \int_0^v x(n-1)F(x)^{n-2} f(x)dx. \tag{1}$$

The seller's expected revenue is the *ex ante* expected payment multiplied by the number of bidders, that is,

$$\pi = n \int_0^{\bar{v}} x(n-1)(1-F(x))F(x)^{n-2} f(x)dx. \tag{2}$$

The question we are investigating is why some sellers decide to cancel the auction and accept an offer before the auction begins. There are two potential reasons for such behaviour. First, a potential buyer offers more than the seller expected revenue from the auction. Second, the seller accepts a price that is lower than the expected auction price to avoid the uncertain outcome of the auction. We shall analyse each case separately.

3 Risk-averse buyers

First, suppose bidders are risk averse. In this case they might pay a higher price to avoid bidding in an auction because of its risky outcome. In particular, suppose that each buyer has a von Neumann-Morgenstern utility function $u_b(x)$ with $u'(.) > 0$ and $u''(.) < 0$. We also assume that $u(0) = 0$.

[4]Real-world auctions for the relevant markets are usually traditional English auctions, but in this particular setting these two auctions are strategically equivalent; therefore, we have chosen the second-price auction for the sake of convenience.

[5]There are many reasons that a seller may prefer not to disclose a reserve price. For instance, see Rosenkranz and Schmitz (2007) and Li and Tan (2000) for two possible explanations. However, our analysis is not sensitive to the disclosure of a reserve price, and the results hold with a disclosed reserve price.

[6]Krishna (2002).

Even with risk aversion, bidding the valuation is still a weakly dominant strategy for each bidder. Therefore, the equilibrium bidding behaviour for the auction is unaffected. Suppose the seller offers a price p to each interested buyer who wants to avoid bidding in the auction. If a buyer accepts p then the buyer wins the object and pays p, and the auction is cancelled. Depending on the value of p, this bidder may be better off paying a price higher than the expectation of the second-highest bidder to avoid the risk of bidding in an auction. In particular, we are interested in the existence of a cut-off value v^*, such that bidders with value higher than v^* would prefer to accept p. If all other buyers use the same cut-off value, then the expected utility of a bidder with value $v > p$ from accepting an offer p before the auction is:

$$U_p(v, v^*) = \rho(v^*)u(v - p), \tag{3}$$

where

$$\rho(v^*) = \sum_{m=0}^{n-1} \binom{n-1}{m} \frac{1}{m+1}(1 - F(v^*))^m F(v^*)^{n-m-1}$$

is the sum of probabilities of the case that m other buyers also accept p. By assumption in this case, each bidder has equal probability of winning the object. We can reduce this term and rewrite (3) as

$$U_p(v, v^*) = \frac{1 - F(v^*)^n}{n(1 - F(v^*))} u(v - p), \tag{4}$$

The expected utility of a buyer with a value v for participation in the auction is

$$U_b(v, v^*) = \int_0^{min\{v,v^*\}} u(v - x)(n - 1)F(x)^{n-2} f(x)dx. \tag{5}$$

If $c(v)$ is defined such that we have

$$u(v - c(v)) = \int_0^v u(v - x)(n - 1)F(x)^{n-2} f(x)dx \tag{6}$$

then $c(v)$ is the certainty-equivalent payment for a buyer with value v, which makes this buyer indifferent between participating in the auction or paying $c(v)$ before the auction. If we increase the level of risk aversion, then $c(v)$ increases and the buyer is willing to pay more to avoid the uncertain outcome of the auction.

Proposition 1. *For any price $p < c(\bar{v})$, there is a symmetric cut-off value $v^* \in (p, \bar{v})$, such that a buyer with value $v > v^*$ is willing to buy the object at p before the auction starts.*

Proof. It is clear that no rational buyer with a value within the defined interval would accept a price higher than $c(\bar{v})$. However, prices lower than $c(\bar{v})$ might be acceptable by some types of buyers. Given a price p, by definition of v^*, a buyer with this value is indifferent to the options of accepting p before the auction or bidding in the auction. Therefore, the cut-off value must satisfy the following:

$$U_p(v^*, v^*) = U_b(v^*, v^*),$$

and

$$\frac{1 - F(v^*)^n}{n(1 - F(v^*))} u(v^* - p) = \int_0^{v^*} u(v^* - x)(n-1)F(x)^{n-2} f(x)dx. \tag{7}$$

Thus for any given $p < c(\bar{v})$, v^* is defined implicitly by this equation. It is also possible to verify that such a cut-off value is unique. To see this, for every $v > v^*$, equation (5) may be rewritten in terms of certainty equivalence:

$$U_b(v, v^*) = F(v^*)^{n-1} u(v - c(v^*)) \tag{8}$$

Then we have

$$\frac{\partial U_p(v, v^*)}{\partial v} = \frac{1 - F(v^*)^n}{n(1 - F(v^*))} u'(v - p)$$

and

$$\frac{\partial U_b(v, v^*)}{\partial v} = F(v^*)^{n-1} u'(v - c(v^*))(1 - c'(v^*)).$$

We need to prove

$$\frac{\partial U_p(v, v^*)}{\partial v} > \frac{\partial U_b(v, v^*)}{\partial v}.$$

First, it is easy to verify that

$$\frac{1 - F(v^*)^n}{n(1 - F(v^*))} > F(v^*)^{n-1},$$

since

$$1 - F(v^*)^n - nF(v^*)^{n-1} + nF(v^*)^n > 0.$$

Then by substitution of (8) in equality (7), to satisfy the equality, we must have $u(v^*p) < u(v^* - c(v^*))$, which implies $p > c(v^*)$. Thus we have $u(v-p) < u(v-c(v^*))$ and $u'(v-p) > u'(v-c(v^*))$ because of the concavity of $u(.)$. Since the $c(.)$ function is also increasing, then $(1 - c'(v^*)) < 1$. This completes the proof for uniqueness. □

3.1 Seller's Revenue

Given the current situation, in which buyers are risk averse, there is a possibility of increasing the expected revenue for the seller by offering a before-auction arrangement. If the buyers are also risk neutral, then it is not possible to gain from such an offer. In that case, the revenue-maximising mechanism would allocate the object to the highest bidder. From Myerson (1981) we know that this mechanism is a standard auction with an optimally chosen reserve price. In fact, it is simple to argue that with risk-averse buyers, a risk-neutral seller can increase her *ex ante* expected profit by offering buyers the option of purchasing the object before the auction starts. To increase our understanding of this situation, suppose that buyer j with value v_j has the highest value among all buyers. If $v_j < v^*$, then all buyers participate in the auction, and the seller's revenue is equal to the expectation of the second-highest value. However, if $v_j > v^*$, then with positive probability, the seller sells her object at the price p. Now focus on a price that would not be accepted by risk-neutral buyers——that is, a p higher than the certainty equivalence of the highest type $\bar{v}$, which we define as $\tilde{c}(\bar{v})$. Since the certainty equivalence of a risk-averse buyer is higher, then $\tilde{c}(\bar{v}) < c(\bar{v})$. A price $\tilde{c}(\bar{v}) < p < c(\bar{v})$ would be accepted by risk-averse buyers with positive probability, which is strictly higher than the expectation of the second-highest value. Thus, the overall *ex ante* expected revenue of the seller is higher when seller accepts a before-auction arrangement.

It is important to mention that, although in many real-world auctions sellers do not disclose their reserve prices, even if the reserve price for the auction was disclosed, our results would not change. Therefore, it remains optimal for the seller to offer a before-auction arrangement to risk-averse buyers.

4 Risk-averse sellers

As we mentioned in section 2, the second potential reason for a seller to sell her property before the auction starts could be the risk aversion of the seller herself.

In this case the seller might accept a lower price than the expected auction price to avoid the uncertainty of the outcome of an auction. We continue with our basic model, except that we now assume the seller is risk averse and faces risk-neutral buyers. Suppose the seller has a utility function $u_s(x)$, which is continuous, with $u_s' > 0$ and $u_s'' < 0$.

Since in this scenario the buyers are risk neutral, the seller needs to offer a price that is low enough to be accepted by a buyer before the auction starts. But first, we need to determine the conditions in which a buyer will accept such a price. We are looking for a cut-off value $v^\dagger$, such that buyers with value $v > v^\dagger$ accept a price $\tilde{p}$ before the auction starts. If all other buyers follow $v^\dagger$, then a buyer with value $v > v^\dagger$ receives the following expected payoff by accepting a price $\tilde{p}$ offered by the seller before the auction starts.

$$\tilde{U}_p(v, v^\dagger) = \sum_{m=0}^{n-1} \binom{n-1}{m} \frac{1}{m+1} (1 - F(v^\dagger))^m F(v^\dagger)^{n-m-1} (v - \tilde{p}) \tag{9}$$

which is equal to

$$\tilde{U}_p(v, v^\dagger) = \frac{1 - F(v^\dagger)^n}{n(1 - F(v^\dagger))} (v - \tilde{p}) \tag{10}$$

If there is more than one buyer with value higher than $v^\dagger$, then one of them wins the object randomly. The expected payoff for a buyer who bids in the auction is

$$\tilde{U}_b(v, v^\dagger) = \int_0^{min\{v, v^\dagger\}} (v - x)(n-1)F(x)^{n-2} f(x) dx \tag{11}$$

Proposition 2. *There is a symmetric equilibrium with a cut-off value $v^\dagger$ that defines the before-auction price $\tilde{p}$ as follows:*

$$\tilde{p} = v^\dagger - \frac{n(1 - F(v^\dagger))}{1 - F(v^\dagger)^n} \int_0^{v^\dagger} F(x)^n dx,$$

such that all buyers with values higher than $v^\dagger$ are willing to accept this price before the auction starts.

Proof. By definition, a buyer with value $v^\dagger$ is indifferent between accepting $\tilde{p}$ or participating in auction. Thus we have,

$$\frac{1 - F(v^\dagger)^n}{n(1 - F(v^\dagger))}(v^\dagger - \tilde{p}) = \int_0^{v^\dagger} (v^\dagger - x)(n-1)F(x)^{n-2}f(x)dx. \tag{12}$$

Integrating in part the right-hand side would result in

$$\frac{1 - F(v^\dagger)^n}{n(1 - F(v^\dagger))}(v^\dagger - \tilde{p}) = \int_0^{v^\dagger} F(x)^{n-1}dx. \tag{13}$$

After rearrangement, we have

$$\tilde{p} = v^\dagger - \frac{n(1 - F(v^\dagger))}{1 - F(v^\dagger)^n} \int_0^{v^\dagger} F(x)^{n-1}dx. \tag{14}$$

Since both $\tilde{U}_b(v, v^\dagger)$ and $\tilde{U}_p(v, v^\dagger)$ are strictly increasing in v, if we show that for every $v > v^\dagger$ it is the case that

$$\frac{\partial \tilde{U}_p(v, v^\dagger)}{\partial v} > \frac{\partial \tilde{U}_b(v, v^\dagger)}{\partial v},$$

then buyers with value higher than $v^\dagger$ would be willing to accept $\tilde{p}$. For every $v > v^\dagger$, we have

$$\frac{\partial \tilde{U}_p(v, v^\dagger)}{\partial v} = \frac{1 - F(v^\dagger)^n}{n(1 - F(v^\dagger))} \tag{15}$$

and

$$\frac{\partial \tilde{U}_b(v, v^\dagger)}{\partial v} = F(v^\dagger)^{n-1}. \tag{16}$$

Since $\frac{1-F(v^\dagger)^n}{n(1-F(v^\dagger))} - F(v^\dagger)^{n-1} > 0$, the proof is completed. □

4.1 Seller's utility

We have characterised buyers' equilibrium behaviour given the situation with a seller who offers a before-auction price to buyers. However, we have not yet discussed the effect of the seller's attitude towards risk on this kind of offer. If the seller is risk neutral, then according to Myerson (1981) we know that a before-auction price cannot increase the seller's profit. In fact, in that case, the seller sets a price that is higher than acceptable by any buyer. However, if the seller is risk averse, she might set a price that is low enough to be accepted by some risk-neutral buyers. According to buyers' equilibrium behaviour, the seller's expected utility is

$$U_s(v^\dagger) = \int_0^{v^\dagger} \Big(\int_0^{x} (n-1)u(y)F(y)^{n-2}f(y)dy \Big) nf(x)dx + \int_{v^\dagger}^{\bar{v}} u(\tilde{p}(v^\dagger))f(x)dx. \quad (17)$$

The first part of this equation represents the expectation of the case in which no buyer is able to accept the before-auction price. The second part is the expected utility of selling the object at price $\tilde{p}$ before the auction starts. We can rewrite the seller's expected utility as follows.

$$\begin{aligned} U_s(v^\dagger) = & \int_0^{v^\dagger} n(n-1)u(y)F(y)^{n-2}\big(F(v^\dagger) - F(y)\big)f(y)dy \\ & + u(\tilde{p}(v^\dagger))\big(1 - F(v^\dagger)^n\big) \end{aligned} \quad (18)$$

Proposition 3. *A risk-averse seller maximises her expected utility by setting a price $\tilde{p}^*$ that is low enough to be accepted by some risk-neutral buyers, with positive probability.*

Proof.

According to (14), any buyer with a value higher than $v^\dagger$ would accept $\tilde{p}$ before the auction starts. If we show that the seller maximises profit by setting a $\tilde{p}^*$ such that the cut-off value is low enough, that is, $v^\dagger < \bar{v}$, then any risk-neutral buyer with a type $v^\dagger < v \leq \bar{v}$ would be certain to accept $\tilde{p}^*$. First, we differentiate (18) as follows:

$$\begin{aligned} \frac{\partial U_s(v^\dagger)}{\partial v^\dagger} = & \int_0^{v^\dagger} n(n-1)u(y)F(y)^{n-2}f(v^\dagger)f(y)dy \\ & + u'(\tilde{p}(v^\dagger))\frac{\partial p(v^\dagger)}{\partial v^\dagger}\big(1 - F(v^\dagger)^n\big) \\ & - nu(\tilde{p}(v^\dagger))F(v^\dagger)^{n-1}f(v^\dagger) \end{aligned} \quad (19)$$

If we evaluate this differentiation at the point $v^\dagger = \bar{v}$, we have

$$\begin{aligned} \frac{\partial U_s(v^\dagger)}{\partial v^\dagger} \mid_{v^\dagger=\bar{v}} = & \int_0^{\bar{v}} n(n-1)u(y)F(y)^{n-2}f(\bar{v})f(y)dy \\ & - nu(\tilde{p}(\bar{v}))F(\bar{v})^{n-1}f(\bar{v}) \\ & = nf(\bar{v})\Big(\int_0^{\bar{v}}(n-1)u(y)F(y)^{n-2}f(y)dy - u(\tilde{p}(\bar{v}))\Big) \\ & = nf(\bar{v})\Big(u(\bar{v}) - \int_0^{\bar{v}} u'(y)F(y)^{n-1}dy - u(\tilde{p}(\bar{v}))\Big) \end{aligned} \tag{20}$$

Since $lim_{v^\dagger \to 0} \frac{n(1-F(v^\dagger))}{1-F(v^\dagger)^n} = 1$, we can substitute $\tilde{p}$ and rewrite the differentiation as

$$\frac{\partial U_s(v^\dagger)}{\partial v^\dagger} \mid_{v^\dagger=\bar{v}} = nf(\bar{v})\Big[u(\bar{v}) - \int_0^{\bar{v}} u'(y)F(y)^{n-1}dy - u\big(\bar{v} - \int_0^{\bar{v}} F(x)^{n-1}dx\big)\Big] \tag{21}$$

Let's call the term in the big brackets M. If we show that M is negative, the proof is completed. To focus on the lower bound of the two integrals, if the lower bounds become equal to $\bar{v}$, then M becomes zero. If we show that M is strictly increasing in the lower bounds, then it must be negative when the lower bounds are zero. To show this, the lower bound may be substituted with a and the term in brackets differentiated. We then have

$$\frac{\partial M}{\partial a} = u'(a)F(a)^{n-1} - u'\big(\bar{v} - \int_a^{\bar{v}} F(x)^{n-1}dx\big)F(a)^{n-1} \tag{22}$$

This is the point at which the concavity of $u(.)$ is necessary for the proof. Since $u'(.) > 0$ and $u''(.) < 0$, then as long as $\bar{v} - \int_a^{\bar{v}} F(x)^{n-1}dx > a$, the aforementioned term is positive. We complete the proof by showing that

$\int_a^{\bar{v}}(1 - F(x)^{n-1})dx > 0 \Rightarrow \bar{v} - a - \int_a^{\bar{v}} F(x)^{n-1}dx > 0 \Rightarrow \bar{v} - \int_a^{\bar{v}} F(x)^{n-1}dx > a$ $\square$

5 Empirical Analysis

In sections 3 and 4 we discussed two major theoretical rationales for those sellers and buyers who decide to settle on a price before the auction starts. The main findings of the theoretical models are, first, that with risk-averse buyers, there is a symmetric equilibrium in which some types of buyers will accept a price higher than the expected price of the auction to avoid a risky outcome. Second, if the seller is risk averse, there is an equilibrium in which the seller has an incentive to accept a price lower than the expected price of the auction to avoid the risky outcome of the auction. In this empirical section, we will seek to determine, using data on real estate auctions, whether either of these two behaviours can be supported. Therefore, we will test whether sellers or buyers on average show risk-averse behaviours.

5.1 Data

We will focus here on properties advertised for sale via auction in the Sydney region, Australia. The data for the current study include 6,153 properties which were advertised between June 2010 and December 2011 for sale via auction. Auctions in the Australian real estate market are traditional English auctions, with an auctioneer who manages the bidding. When only one bidder is left and no higher bids are offered, the highest bidder wins and pays the auction price. Usually the auction is set for a date a few weeks after the initial advertisement. However, sometimes the seller of a property will sell to an interested buyer before the auction starts. Specifically, in our data set, 405 homes were sold before the auction and bidding was cancelled before the auction date.

In the sections 3 and 4 we provided two possible theoretical explanations for pre-auction sales. In the empirical analysis of this study, we will try to determine which of these two theoretical models, on average, is closer to behaviour in the real world. To address this issue properly, we first controlled for heterogeneity between properties. For each property we observed the exact address, type of property (that is, whether it was a house or an apartment[7]), property characteristics, neighbourhood characteristics in the same suburb, final transaction price, and whether the home was sold under the hammer or before the auction. Table 1 shows the summary statistics for the current data. We also divided the region into eight subregions to control for geographical differences between properties. The regional division is as follows: Region 1 includes the Sydney city area, region 2 includes the eastern

[7] The terms "apartment" and "unit" have a similar meaning and refer to the same category.

Table 1: Summary Statistics

Variables	Mean	Median	Max.	Min.	St. Dev.
Transaction price (AU $)	859,561	740,000	12,000,000	103,100	529,718
Home characteristics					
Property type (House = 1, Unit = 0)	0.71	1	1	0	0.45
Number of bedrooms	2.92	3	12	0	1.13
Number of bathrooms	1.59	1	8	1	0.76
Number of car parks	1.39	1	15	0	0.97
Has study	0.13	0	1	0	0.33
Has pool	0.06	0	1	0	0.24
Has fireplace	0.10	0	1	0	0.30
Neighbourhood characteristics					
Mean household income (AU$)	68,992	64,173	176,396	40,726	22,674
Median weekly rent	407.07	400	780	175	80.06
Population	22,396	20,944	95,041	1,573	13,555
Median Age	36.08	36	53	27	3.07
Sold at auction	5,748				
Sold prior to auction	405				
Total number of observations	6,153				

suburbs, region 3 includes the inner west suburbs, region 4 includes the north shore suburbs, region 5 includes the suburbs in the northern beaches, region 6 includes the northwestern suburbs, region 7 includes the western and southwestern suburbs, and region 8 includes the southern suburbs.

5.2 Estimation strategy

Our method of testing for risk aversion of each party was based on the final transaction prices of properties. As our theory suggested, if sellers are risk averse, then on average, we would observe lower transaction prices for sellers who accepted prices before the auction. However, if buyers are risk averse, the opposite is suggested, that is, sellers would, on average, receive higher prices for before-auction settlements.

To test this theory, we ran several different log linear hedonic regressions. Since we used the sales method as a dummy variable, selectivity bias may have occurred. Thus, to avoid selectivity bias, we used the method suggested by Heckman (1979). The method constitutes a two-stage regression; in the first stage, a probit model is estimated with the sales method as a dependent variable over property and neigh-

Table 2: Parameter estimates, two-stage regression. Dep. var. Log of transaction price.

	Model 1		Model 2		Model 3	
Constant	10.69	(0.192)***	10.43	(0.193)***	2.06	(0.279)***
Sales method†	-0.014	(0.009)*	-0.016	(0.009)**	-0.004	(0.015)
Property type (House = 1)	0.115	(0.014)***	0.067	(0.015)***	0.107	(0.025)***
Number of bedrooms	0.039	(0.003)***	0.034	(0.003)***	0.093	(0.005)***
Number of bathrooms	0.035	(0.005)***	0.043	(0.005)***	0.139	(0.008)***
Number of car parks	0.025	(0.002)***	0.022	(0.002)***	0.048	(0.004)***
Has study	0.021	(0.007)***	0.016	(0.007)**	0.010	(0.011)
Has pool	0.004	(0.009)	0.008	(0.009)	0.064	(0.016)***
Has fireplace	0.041	(0.008)***	0.027	(0.008)***	0.046	(0.014)***
Log(Mean income)	0.207	(0.019)***	0.249	(0.020)***	0.844	(0.031)***
Log(Median rent)	0.033	(0.019)*	0.053	(0.020)***	0.521	(0.031)***
Log(Population)	-0.021	(0.004)***	-0.022	(0.004)***	-0.075	(0.007)***
Log(Median Age)	-0.056	(0.036)	-0.127	(0.035)***	-0.358	(0.055)***
Quartile 2	0.306	(0.006)***	0.314	(0.006)***		
Quartile 3	0.537	(0.008)***	0.548	(0.007)***		
Quartile 4	0.948	(0.010)***	0.958	(0.010)***		
Region 1	0.010	(0.015)				
Region 2	0.038	(0.010)***				
Region 3	-0.002	(0.010)				
Region 4	-0.055	(0.013)***				
Region 5	-0.035	(0.013)***				
Region 6	-0.026	(0.011)**				
Region 7	-0.028	(0.008)***				
Inverse Mills ratio	0.223	(0.094)**	-0.010	(0.097)	-1.388	(0.156)***
Adj. R-square	0.867		0.864		0.641	
Total number of observations	6,153		6,153		6,153	

† Equal to 1 for properties that sold at auction and 0 for those sold before auction.
*** significant at 1%, ** significant at 5%, * significant at 10%.

bourhood characteristics and regional or quartile dummies[8]. Then the outcome from the first regression is used to build the inverse of the Mills ratio. The second stage of the estimation is a log linear hedonic regression in which the logarithm of the transaction price is used as the dependent variable over property characteristics and regional dummies. We also used the inverse of the Mills ratio in the second stage of regression to account for potential selectivity bias. We then ran the same two-stage

[8]Quartile dummies are based on the quartile in which the transaction price of the properties lies. Specifically, quartile one includes properties with transaction prices lower than 540,000 Australian Dollar (AUD). Quartile two indicates properties with transaction prices higher than 540,000 AUD and less than 749,000 AUD. Quartile three includes properties with prices between 750,000 AUD and 1,000,000 AUD. Quartile four includes properties with transaction prices above 1 million dollars.

regression for three different models. Model one included property characteristics, neighbourhood characteristics quartile, and regional dummies (where the quartile dummies were three dummies based on the four quartiles of the transaction prices of properties). In model two we eliminated regional dummies, and in model three we eliminated both regional and quartile dummies.

Table 3: Parameter estimates, single stage regression. Dep. var. Log(transaction price)

	Model 1		Model 2		Model 3	
Constant	10.52	(0.178)***	10.44	(0.151)***	4.08	(0.225)***
Sales method†	-0.015	(0.009)*	-0.016	(0.009)*	-0.004	(0.015)
Property type (House = 1)	0.086	(0.006)***	0.069	(0.006)***	0.316	(0.010)***
Number of bedrooms	0.037	(0.003)***	0.034	(0.003)***	0.114	(0.005)***
Number of bathrooms	0.042	(0.004)***	0.034	(0.003)***	0.096	(0.006)***
Number of car parks	0.026	(0.002)***	0.022	(0.002)***	0.048	(0.004)***
Has study	0.016	(0.007)**	0.017	(0.006)**	0.044	(0.011)***
Has pool	0.011	(0.009)	0.008	(0.009)	0.020	(0.015)
Has fireplace	0.032	(0.007)***	0.027	(0.007)***	0.110	(0.012)***
Log(Mean income)	0.229	(0.017)***	0.247	(0.015)***	0.663	(0.023)***
Log(Median rent)	0.042	(0.019)**	0.052	(0.019)***	0.439	(0.030)***
Log(Population)	-0.021	(0.004)***	-0.022	(0.004)***	-0.069	(0.007)***
Log(Median Age)	-0.076	(0.035)	-0.125	(0.032)***	-0.183	(0.052)***
Quartile 2	0.303	(0.006)***	0.314	(0.006)***		
Quartile 3	0.531	(0.007)***	0.548	(0.007)***		
Quartile 4	0.938	(0.009)***	0.958	(0.009)***		
Region 1	0.032	(0.012)**				
Region 2	0.042	(0.010)***				
Region 3	0.002	(0.010)				
Region 4	-0.048	(0.013)***				
Region 5	-0.020	(0.012)*				
Region 6	-0.023	(0.010)**				
Region 7	-0.033	(0.008)***				
Adj. R-square	0.867		0.865		0.637	
Total number of observations	6,153		6,153		6,153	

† Equal to 1 for properties sold at auction and 0 for those sold before auction.
*** significant at 1%, ** significant at 5%, * significant at 10%.

Table 2 shows the results of these two-stage regressions for all three models. As shown in the table, for all three models we observed a negative coefficient for the variable sales method. These results suggest that, on average, properties that were sold before the auction had higher prices and therefore benefited the sellers. In all three models, we observed highly significant coefficients for most variables. All coefficients displayed the expected sign. For instance, all property characteristics had positive signs, and the log of population had a negative sign. However, the results for the first two models were more reliable[9]. Table 3 shows the results of the three models but without the control for selectivity bias and with single ordinary least-squares regression. Although some variables showed different coefficients, the most important variable (the sales method) still showed negative coefficients in all three models. However, the two-stage models that included controls for the selectivity bias had more significant coefficients.

5.3 Robustness checks

To this point, we have seen strong results which indicate that sellers, on average, accepted higher prices when they settled with a buyer prior to the upcoming auction. Now we will focus on those sellers who agreed to sell their properties before the auction to evaluate the further significance of the results. For this analysis, we first ran a log linear hedonic regression over all characteristics and dummies for the whole sample to construct predictions for the price of each property. We then used these predictions as expected transaction prices of properties for both sellers and interested buyers. For each property with a settlement before the auction, we calculated the difference between the transaction price and the predicted or expected price.

Figure 1 shows a graph of the sorted observations based on this difference. In almost half of the cases, the expected price was higher than the transaction price. This is because the graph intersects the horizontal axis at number 200. However, the more important point is the higher slope on the right-hand side of observation 200. In fact, for the last fifty observations, sellers made a significant profit versus the expected price of their properties. Therefore, we can conclude that, on average, sellers received more profit with respect to the price at which they expected to sell their properties. Since we controlled for all important aspects of the properties and our hedonic regression had a very high significance and a high r-square value[10], these results demonstrate the validity of the previous results.

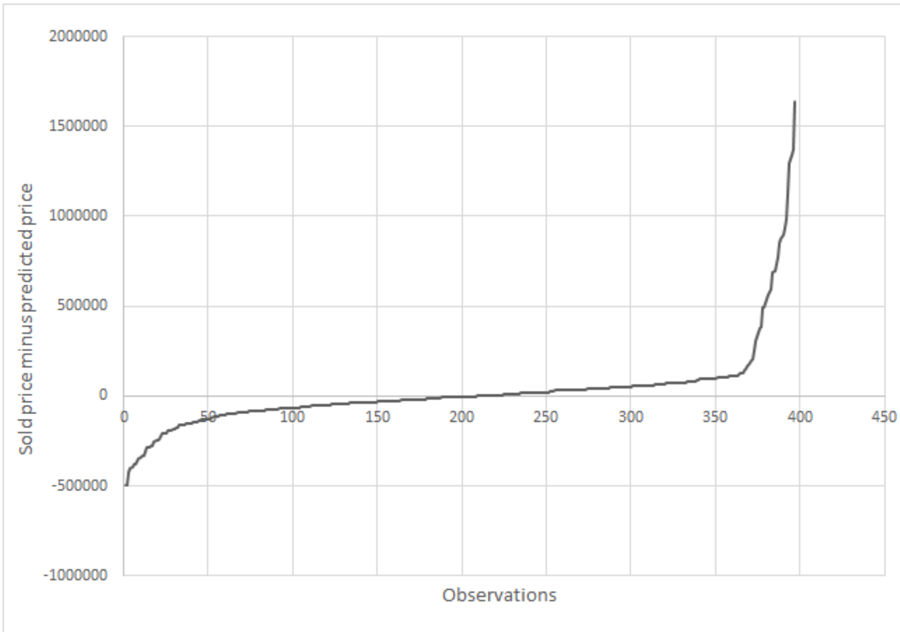
6 Conclusion

Here we investigated two theoretical rationales for a seller of a single object who may decide to avoid auctioning the object among all interested buyers and instead sell it to a buyer before the auction. Risk aversion of either sellers or buyers could

[9] We also ran these models with dummies that specified the quarter in which the auction took place but found no significant difference versus the current results.

[10] The r-square for the hedonic regression is 0.87.

Figure 1: The difference between the expected and transaction prices of properties.



result in an equilibrium that rationalises this behaviour. Our theory adds to the literature on auction theory by explaining why some sellers would avoid an auction when it has been suggested that an auction is expected to maximise revenue. There are several real-world applications for the current theory. Specifically, our data on real estate auctions show that, in more than 6% of cases, the sale of a property was finalised by pre-auction arrangement. We also investigated which party, on average, benefited from this arrangement and found strong evidence of an advantage for sellers in pre-auction settlements.

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