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Auction versus Negotiated Sale: Evidence from Real Estate Sales

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We offer a theoretical and empirical comparison of auctions and negotiated sales. We first build a simple model to show that auctions generate a higher relative price than negotiated sales when demand for the asset is strong, when the asset is more homogeneous and when the asset attracts buyers with higher valuations. Using data from property sales in Singapore, we find support for our theoretical predictions. In addition, we find that auctions do not necessarily generate a higher price premium for foreclosed properties than for nonforeclosed properties.

Standard auctions are deemed to be the revenue-maximizing methods of sale when bidders are assumed to hold independent private valuations, are *ex ante* identical and exhibit symmetric bidding strategies (McAfee and McMillan 1988, Wang 1993, Campbell and Levin 2006, Bulow and Klemperer 2009). Auctions are favored in practice when the good sold is unique or nonstandardized, the good is infrequently traded or has a "thin" market or the good's price is not easily determined (Cassady 1967, Milgrom 1989). Examples of unique goods include rare art pieces, diamonds and vintage wine. Real estate, given its characteristics (products are heterogeneous and high-value real estate tends to be infrequently traded, leading to price uncertainty in the market), seems to be well suited to be sold through auction. Yet, the dominant selling mechanism for real estate is through brokered or negotiated sales.[1] In the U.S. real estate market, auctions are rarely carried out, except for foreclosed or distressed properties. In this instance, the auction mechanism is chosen not because of

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[1]There are a few exceptions. In Australia and New Zealand, for instance, auctions are widely used to sell properties.

its revenue-maximizing feature but for its ability to minimize the property's holding costs[2] and to expedite the recovery of the mortgage loan.

The literature tends to look at the problem of the optimality of the sales mechanism from the buyers' and sellers' perspectives and implicitly assumes the product to be homogeneous. This article looks at the same question but with an emphasis on the impact of the asset and market characteristics on the choice of sales mechanism. First, we build a simple theoretical model to compare expected revenue under auctions and negotiated sales. We then compare the performance of the two sales mechanisms empirically, using transactions data for properties sold in Singapore. Our aim is to establish whether a gap exists between the two sales mechanisms, that is, whether the same asset sells for the same price under the two mechanisms. If such a gap exists, we then investigate how it varies with the characteristics of the property and across different market conditions.

Existing literature presents mixed results regarding these two sales mechanisms.[3] The contribution of this study to the existing literature is twofold. First, we offer a simple theoretical model to study the price differential between the two sales mechanisms and how the price differential varies with the homogeneity of the asset and the market conditions. Second, we provide a detailed empirical investigation of whether the two sales mechanisms perform consistently across different property types and market conditions. The data set comprises both successful and unsuccessful auction attempts of foreclosed and nonforeclosed residential real estate in Singapore over a period of 10 years, covering three different market periods (up, down and flat markets). The range of property types covers relatively homogeneous properties (apartments) as

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[2]Quan (2002) reports that the annual holding cost for commercial property can be up to 20% of the property's appraised value. In the residential market, listed properties may take many months before being sold by an agent, whereas the auction process only requires a month.

[3]Studies by Quan (2002), Mayer (1995, 1998) and Lusht (1996) examine price differences between auction and negotiated sale mechanisms by utilizing property sales data from the United States, Australia and New Zealand, respectively. As will be described in detail in the next section, these studies arrive at different conclusions. In the literature relating to business acquisitions, the results are also mixed as to whether auctioning off a company or selling it through a sequential process is more profitable (Bulow and Klemperer 1996, 2009, Thomas and Wilson 2002, Boone and Mulherin 2007). Studying the price difference in relation to product types, Wang (1993) and Bulow and Klemperer (2009) consider auctions to generate higher revenue when the asset (bidders' values) has higher price dispersion. With regard to price differences across market conditions, Bulow and Klemperer (1996) conclude that auctions perform better when there are more bidders, Boone and Mulherin (2007) find the wealth effects for target shareholders to be comparable in auctions and negotiations, and Thomas and Wilson (2002) find prices to be higher in multilateral negotiations when the number of sellers is small.

well as more heterogeneous properties (terrace, semidetached and detached houses[4]). Overall, our results show that properties obtain a higher price when sold through auction than through negotiated sales. However, this premium is not consistent across property types and market conditions. As predicted by our theoretical model, we find that auctions enjoy a higher price premium in markets where demand is stronger and for higher valued properties. We also find that homogeneous properties have a higher price premium in an auction than heterogeneous properties. In addition, we find that auctions do not necessarily generate a higher price premium for foreclosed properties than for nonforeclosed properties.

The rest of the article is structured as follows. The next section provides a general overview of the differences between auction and negotiated sales and reviews papers that compare the performance of these two mechanisms. The third section offers a simple theoretical model to study the relative attractiveness of the two mechanisms under various parameterized market conditions. The fourth section discusses the methodology, and the fifth section describes the data. The sixth section presents the empirical results, and, finally, the seventh section offers concluding remarks.

Background and Literature Review

In the real estate market, the critical difference between auctions and negotiated sales lies in the timing and comparison of the offers. In negotiated sales, buyers go through a search process to find the "right" property, while sellers go through a search process to find the buyer who is willing to pay at least the seller's reservation price. Through the search process, the seller receives and evaluates offers sequentially. The seller has the option to solicit additional offers if initial offers are unsatisfactory. However, this process does not allow the seller to compare offers, as offers do not arrive simultaneously and expire if not accepted within a certain period of time. The auction, by contrast, acts as a centralized marketplace for the seller to solicit offers at one time, and it allows the seller to compare all the offers available at that time. If at least one bid meets the reservation price, the sale can proceed immediately.

Bulow and Klemperer (2009) identify four factors that may explain why auctions generate higher revenue for sellers than sequential mechanisms, when

[4]To map these property types to the U.S. residential market: terrace houses are a row of two-story townhouses, semidetached are two units of adjoining townhouses and detached houses are single-family dwellings. It is important to note that auctions are commonly used to sell real estate in Singapore, both for foreclosed and nonforeclosed property. This is different from the United States where auctions are typically used only to sell foreclosed properties.

entry is costly. These four factors are (1) number of potential bidders; (2) bidders' ability to make "jump bids" where their ability to make jump bids may drive buyers' profits to zero in the search market, and to the negative numbers in the auction market; (3) more dispersed bidder values for auctions; and (4) the gap between expected winning values and expected revenue. According to Bulow and Klemperer (2009), the most critical factor is that bidders' values are more dispersed for auctions, making the auction a less informationally efficient mechanism than sequential sales, which have less dispersed bidders' values. Sellers will be able to capitalize on this relative information inefficiency to earn higher revenue.

Milgrom (1987) argues that the auction is a popular selling mechanism over a wide range of circumstances because auctions lead to stable and efficient allocation outcomes. The auction, through the competitive bidding process, enables a seller in a weak bargaining position to do as well as a seller in a strong bargaining position. Arnold and Lippman (1995) prove theoretically that if a seller is selling a small number of identical items, he or she will obtain a higher per-unit return from the sequential sales mechanism. However, if a seller is selling a large number of items, the cost savings accruing from selling all items at the same time yield a better per-unit return. Thus, the value of higher negotiation or bargaining strength is small compared to the value of using competition among the bidders to drive prices up (Bulow and Klemperer 1996). Thomas and Wilson (2002) argue that a buyer's ability to credibly reveal rival offers to sellers influences the revenue obtained from two different mechanisms—multilateral negotiations and first-price auctions. If information on rival bids is not credible, the favorable negotiation position of one party may result in negotiated prices being higher than auction prices. In the experiments they conduct, Thomas and Wilson (2002) find that prices are indistinguishable between multilateral negotiations and auctions when there are four sellers, but higher in multilateral negotiations when there are two sellers. Wang (1993) compares posted-price selling against auctions and concludes that auctions are preferred to posted-price selling when the value of the object is more dispersed[5] and for items with higher value. Hence, whether auction or negotiated sales is a better mechanism varies according to the parameters of the sale, including the number of objects auctioned and the distribution of valuations.

Engelbrecht-Wiggans (1996) presents a model in which a seller of multiple units of a good sells some units noncompetitively (via any sales technique besides an auction) and some units through an auction. He argues that such a mix of auction and noncompetitive sales benefits the seller and increases

[5]For Wang (1993), dispersion refers to the variance around the mean value of the item.

market efficiency because some buyers may not participate in an auction due to high participation costs. Engelbrecht-Wiggans' (1996) insight is also applicable to the real estate market where participants are often one-off buyers and sellers, and may face high information costs related to researching the sales procedures, investigating the prevailing market values of similar properties and determining what properties are available in the market. Boone and Mulherin (2007) consider the agency costs and information costs of takeovers. They find that the wealth effects for target shareholders are comparable in auctions and negotiations.

The focus in Wang (1993) is on the circumstances in which a seller chooses to auction an object rather than selling it at a fixed price. The author finds that if there is a relatively wide dispersion in the distributions of buyers' valuations, the seller prefers to wait longer in order to have more bidders participating in the auction. Over time, the distribution of the second-highest bid shifts upward and the seller is likely to get a higher sales price. Wang (1995) compares bargaining to posted-price selling and concludes that for objects that are difficult to value (*i.e.*, when buyers' valuations are dispersed), sellers prefer bargaining to posted-price selling.

The choice of sales mechanism may also be influenced by the characteristics of the product being sold. Bajari, McMillan and Tadelis (2003) examine how building contracts are awarded in Northern California. They find that auctions perform poorly when the building design is complex. In addition, they find that the use of auctions is countercyclical. During a construction boom, few contractors are willing to bid for projects. This low participation erodes the competitive bidding advantage accruing to an auction. Helstad, Vassdal and Trondsen (2005) examine the use of auctions and negotiated sales in the sale of fish in North Norway. Their study indicates that more homogeneous lots are typically sold by auction, whereas more heterogeneous lots are typically sold by negotiated sales. They also find that frozen fish sold through auction obtain the highest sales price, although auction sales also exhibit larger monthly variation in prices. Kulger, Neeman and Vulkan (2006) find that a centralized market is more advantageous to "high-value" traders of homogeneous goods. In their study, "high-value traders" are buyers who have a high willingness to pay and sellers who have low reservation prices. Using an experimental methodology, the authors find support for their hypothesis.

The three papers most relevant to the current study are Quan (2002), Mayer (1995) and Gan (2013). Quan (2002) focuses on the difference in the timing of offers between the two sales mechanisms. He points out that in real estate, the transaction, search and holding costs are high. A buyer's reservation price and expected benefit from search are influenced by the search costs. Thus, a buyer with high search costs attends auctions. Conversely, a buyer with low search costs has a higher payoff in the search market. Therefore, because high-search-cost buyers attend auctions, prices are expected to be higher for properties sold at auction. On the seller's side, the cost of holding a property will influence the number of properties put up for auction. Mayer (1995) also compares the performance of real estate auctions with negotiated sales and develops a theoretical model that explains the observed discounts in auction markets and why they increase in a down market. In an auction, the buyer's valuation is based on alternatives expected to be available in the search market. When there are more vacant units available in the property market, buyers find that the search alternative offers better choices, resulting in an increase in the auction discount. The existence of more buyers, on the other hand, increases the effectiveness of the auction method and leads to a decrease in the auction discount. Gan (2013) contributes to the literature on alternative selling mechanisms in real estate by allowing sellers to be risk averse. Focusing on the seller's risk attitude and adopting a mean-variance analysis, Gan (2013) finds that there exist positive auction discounts and these auction discounts are compensated by lower risks undertaken by the seller. He concludes that more-risk-averse sellers choose to auction their properties while less-risk-averse sellers choose to sell their properties through negotiated sales. In addition, Gan (2013) also shows that more sellers will prefer auctions when the market is hot and all loss-averse sellers choose the negotiated sales.

Empirical studies using real estate data that compare property returns from negotiated sales and auctions present differing results. Ashenfelter and Genesove (1992) document that condominium units in New Jersey sold through negotiated sale after an unsuccessful auction process are sold at a 13% discount.[6] Lusht (1996) finds that properties auctioned in the Melbourne, Australia, housing market sell on average for about 8% more than properties sold through negotiated sales. Mayer (1998) finds that compared to the market price index, properties auctioned in Los Angeles sell at an estimated discount of 0–9%, while properties auctioned in Dallas sell at an estimated discount of 9–21%. Dotzour, Moorhead and Winkler (1998) find mixed results in their analysis of

[6]The results from Ashenfelter and Genesove (1992) need to be interpreted with care. Buyers of the unsold units were registered bidders from the auction. These buyers may have an informational advantage regarding the "common value" (hammered down auction price) and might have a good guess about the level of competing demand for these units. Therefore, they are probably going to use this information to their advantage in subsequent negotiations. In addition, these unsold units may be "burned"—when an advertised item is not sold, its future value will be affected (Ashenfelter 1989). Theoretically, this point will not matter if buyers hold independent valuations. However, the authors state that some of the buyers were purchasing for investment purposes; hence, the common value assumption may apply and the issue of unsold units being "burnt" may become relevant.

the housing market in Christchurch, New Zealand. Their results indicate that highly priced, unique and desirable houses achieve a 5.9–9.5% premium when sold through auction, while houses in the other two areas under study show no premium or discount between auction and private-treaty sales.

In the next section, we build a simple theoretical model to compare the expected revenue of the two sales mechanisms and how revenue relates to such factors as the number of bidders, homogeneity of the asset and the distribution of buyers' valuation of the asset.

A Simple Model

Consider a risk-neutral seller and n interested buyers of a real estate property. We consider two components of the valuations of the buyers. One is the "common value" component. For simplicity, we assume that all common value components of all the potential buyers are the same and equal to m. The second aspect is the "private value" component. We suppose that the private values of the buyers are independently and identically distributed. Private values represent personal preferences of the buyers; therefore the independence assumption is reasonable. For simplicity, we further assume that the seller's valuation for the house is equal to m, which is assumed to be common knowledge. In this model, there is one-sided incomplete information. Buyers do not know each other's private valuations, and they compete with each other (and a possible reserve price) in order to buy the house. Because market value m is the same for all buyers and the seller, we can normalize it to zero. We consider the private values of the buyers to be distributed over $[\underline{\omega}, \bar{\omega}]$ according to a continuous distribution F, where $\bar{\omega} > \underline{\omega} \geq 0$. We assume that F is regular in the sense of Myerson (1981): the *virtual value function* is given by the equation

$$\psi(x) = x - \frac{1 - F(x)}{f(x)}, \tag{1}$$

where $f(x) = F'(x)$; and the virtual value function is assumed to be increasing in x.

We compare two different selling mechanisms. The first mechanism, auctions, involves gathering all interested buyers and running a standard (say, second-price, or first-price) auction with a reserve price. In the second mechanism, negotiated sales, the seller approaches interested buyers one by one, and make each buyer a take-it-or-leave-it offer.[7] We first calculate expected *observed selling prices*. We then compare the expected prices under the two mechanisms.

[7]Although in the real world the negotiation is more likely to be a bargaining process (with offers back and forth between the buyer and the seller), for simplicity, we assume a take-it-or-leave-it offer process.

Auction

Consider a standard auction in which the highest bidder is awarded the property. Given the regularity assumption, standard results of auction theory (see Krishna 2002, section 5) obtain that the revenue is maximized by setting the optimal reserve price $r^* = \psi^{-1}(0)$. In this case, the expected selling price is given by:

$$R^A = \int_{r^*}^{\bar{\omega}} \psi(x)\, g(x)\, dx,$$

where $g(x) = nF(x)^{n-1} f(x)$ and ψ is defined in (1). However, in the empirical analysis, the selling price is observed only when the sale takes place. For this reason, we also consider the expected selling price, which is given by:

$$\begin{aligned} P^A &= \frac{R^A}{1 - (F(r^*))^n}, \\ &= \frac{\int_{r^*}^{\bar{\omega}} \psi(x)\, g(x)\, dx}{1 - (F(r^*))^n}. \end{aligned} \qquad (2)$$

Note that the property is sold, except for the case when all bidders have values smaller than the optimal reserve price, r^*, with a probability of $1 - (F(r^*))^n$.

Negotiated Sales

Suppose that the seller first makes a take-it-or-leave-it offer to buyer n. If the offer is rejected, the seller makes an offer to buyer $n - 1$, and if the offer is still rejected, continues to make an offer to buyer $n - 2$, and so on. Let $p_n, \ldots, p_1$ represent optimal offers. We solve for a subgame perfect equilibrium of this game. At the last stage of the game, the seller makes a take-it-or-leave-it offer to buyer 1. Let

$$V_1 = \max_p p(1 - F(p))$$

and

$$p_1 = \arg\max_p p(1 - F(p)).$$

We obtain the following result:

$$p_1 = r^* = \psi^{-1}(0)$$

and

$$V_1 = r^* \left(1 - F\left(r^*\right)\right).$$

Going backwards, we have the following for buyer 2:

$$V_2 = \max_p p\,(1 - F\,(p)) + F\,(p)\,V_1$$

and

$$p_2 = \arg\max_p p\,(1 - F\,(p)) + F\,(p)\,V_1.$$

To generalize,[8] for $k = 2, \ldots, n$, we have:

$$V_k = \max_p p\,(1 - F\,(p)) + F\,(p)\,V_{k-1}$$

and

$$p_k = \arg\max_p p\,(1 - F\,(p)) + F\,(p)\,V_{k-1}.$$

The expected revenue generated by negotiated sales is then given by:

$$R^{NS} = p_n\,(1-F\,(p_n)) + \sum_{k=1}^{k=n-1} p_{n-k}\,(1-F\,(p_{n-k}))\left(\prod_{l=0}^{l=k-1} F\,(p_{n-l})\right) = V_n.$$

The expected observed selling price is given by:

$$\begin{aligned} P^{NS} &= \frac{R^{NS}}{1 - \prod_{k=1}^{k=n} F\,(p_l)} \\ &= \frac{V_n}{1 - \prod_{k=1}^{k=n} F\,(p_l)}. \end{aligned} \tag{3}$$

Note that the property is sold, except for the case where each bidder l has a value that is less than p_l, with a probability of $1 - \prod_{k=1}^{k=n} F\,(p_l)$.

[8]We do not consider discounting between offers to buyers. The conclusions would not change qualitatively as discounting is considered.

Comparison of Expected Selling Prices

We compare the two sales mechanisms by examining the expected selling price ratio between auction and negotiated sales. Given any number of players n, and the value distribution of players F, let us define the ratio of the expected observed selling price of auction to that of negotiated sales:

$$r(F, n) = \frac{P^A}{P^{NS}},$$

where P^A and P^{NS} are defined earlier in Equations (2) and (3), respectively.

The first question that we consider is how the reserve price ratio, r, changes with different number of players, n. To answer this question, we focus on uniform value distributions. In our data, the number of bidders is usually between two to three bidders, and in rare occasions, increases to five to six bidders. Thus, we consider uniform value distributions for n ranging from two to six.

Uniform Distribution: $F(x) = x$, $n = 2, \ldots, 6$.

Assuming a uniform distribution, we obtain the value function:

$$\psi(x) = 2x - 1.$$

Using this value function, we calculate the prices for the two sales mechanisms and the ratio of the two prices, for two to six buyers:

From Table 1 (Panel A), we note that observed prices from auctions perform better when there are more buyers (this situation alludes to an upmarket versus a down market comparison). From these calculations, we propose the following prediction:

***Hypothesis 1**: When the demand in the market is stronger,* i.e., *when the number of bidders/buyers in the market is larger, the expected selling price under the auction mechanism becomes relatively higher than under the negotiated sale mechanism.*

The second question that we consider is how the ratio, r, changes with different value ranges of properties, F. More specifically, we compare the r of F to the r of $\tilde{F}$. $\tilde{F}$ represents the distribution for the higher end properties, whereas F represents the distribution for the lower end properties, and $\tilde{F}$ has a higher

Table 1 ■ A simulated price comparison between two mechanisms.

Panel A: Comparisons between Two Expected Prices, Assuming a Uniform Distribution					
	$n = 2$	$n = 3$	$n = 4$	$n = 5$	$n = 6$
P^A	0.55556	0.60714	0.65333	0.69355	0.72789
P^{NS}	0.56818	0.61767	0.65587	0.68651	0.71177
$r(x, n)$	0.97779	0.98295	0.99613	1.0103	1.0226

Panel B: Comparisons between Two Expected Prices, Assuming a Distribution with a Higher Mean					
	$n = 2$	$n = 3$	$n = 4$	$n = 5$	$n = 6$
P^A	0.65774	0.72351	0.77418	0.81214	0.84051
P^{NS}	0.66029	0.71441	0.75294	0.78195	0.80465
$r(x^2,n)$	0.99614	1.0127	1.0282	1.0386	1.0446

Panel C: Comparisons between Two Expected Prices, Assuming a Distribution with a Lower Variance					
	$n = 2$	$n = 3$	$n = 4$	$n = 5$	$n = 6$
P^A	0.50870	0.56169	0.60738	0.64555	0.67688
P^{NS}	0.51921	0.56729	0.6034	0.63181	0.65487
$r\left(\frac{x-0.1}{0.8}, n\right)$	0.97976	0.99013	1.0066	1.0217	1.0336

mean than F. For this purpose, we consider that $\tilde{F}(x) = x^2$, which first-order stochastically dominates $F(x) = x$.

A Distribution with a Higher Mean: $\tilde{F}(x) = x^2$, $n = 2, \ldots, 6$.

For $\tilde{F}(x) = x^2$, we obtain the value function:

$$\tilde{\psi}(x) = x - \frac{1 - x^2}{2x} = \frac{3x^2 - 1}{2x}.$$

Using this value function, we calculate the prices for the two sales mechanisms and the ratio of the two prices, for two to six buyers.

When we compare the results in Table 1 (Panel A) with Panel B, we observe that $r(x^2, n) > r(x, n)$ for all values of n. These results imply that auctions perform relatively better in a market with a higher mean. We propose the following prediction:

Hypothesis 2: *When the expected property values are higher, or equivalent, for properties in the higher segment of the property market, the expected selling price under the auction mechanism is relatively higher than under the negotiated sale mechanism.*

The final question that we consider is how the ratio, *r*, changes for distributions with lower variances. We consider a uniform distribution over the range [0.1, 0.9], $\hat{F}(x) = \frac{x-0.1}{0.8}$. This distribution has the same mean as $F(x) = x$, but with a lower variance.

A Distribution with a Lower Variance: $\hat{F}(x) = \frac{x-0.1}{0.8}$, $n = 2, \ldots, 6$.

For $\hat{F}(x) = \frac{x-0.1}{0.8}$, we obtain the value function:

$$\hat{\psi}(x) = x - \frac{1 - \frac{x-0.1}{0.8}}{\frac{1}{0.8}} = 2x - 0.9.$$

Using this value function, we calculate the prices for the two sales mechanisms and the ratio of the two prices, for two to six buyers.

When we compare the results in Table 1 (Panel A) with Panel C, we observe that $r\left(\frac{x-0.1}{0.8}, n\right) > r(x, n)$ for all values of *n*. These results imply that auctions perform relatively better in a market with more homogenous assets. We propose the following prediction:

Hypothesis 3: *The ratio of the expected price from an auction to that of a negotiated sale is higher for more homogenous assets.*

It is worth noting that we have performed the above analysis under the assumption that the number of (potential) buyers under the two mechanisms is the same. It is possible, for instance, that one mechanism attracts more buyers than the other mechanism for higher value or for more homogenous assets. Unfortunately, we do not have data on the number of potential buyers under the two mechanisms. The challenge with addressing this issue theoretically is that any value we assign to the difference in the number of buyers under the two mechanisms will be an arbitrary value. We already know from the model, for instance, that a higher number of buyers would increase the expected price under both mechanisms. Thus, increasing the number of buyers for one mechanism (*vis-à-vis* the other mechanism) will increase the relative attractiveness of that mechanism and will eventually make that mechanism more attractive than the other mechanism. Allowing different number of buyers under the two mechanisms would make it difficult to compare the performance of the two mechanisms with respect to homogeneity of the asset, expected value of the asset and a change in the market demand. That is why we have performed our analysis with equal number of buyers under the two mechanisms.

In the rest of the article we offer empirical evidence for the three hypotheses suggested by the simple theory developed in this section. We next discuss our empirical methodology and the data set.

Methodology

A question of primary interest in this article is whether there is a price premium or discount if the same property is sold through auction versus negotiated sale. Any comparison of the two sales mechanisms has to account for sample selectivity bias; otherwise, the results obtained may be biased due to specification error of an omitted variable.

In the residential real estate market, even though buyers and sellers predominantly sell their properties through negotiated sales, in reality, both auction and negotiated sales are used to dispose of residential properties. In the United States, auctions are used almost exclusively for distressed properties. However, in Australia, New Zealand and Singapore, auctions are widely accepted and are used to sell both desirable as well as distressed properties. The choice made by the seller between the two sale mechanisms represents the trade-off between an expedient sale[9] and waiting for an offer that will meet or even exceed the seller's reservation. The rational seller will choose the method that maximizes the expected returns. The choice made by the buyer between the two sale mechanisms also represents the trade-off between an expedient sale with a transparent price determination process (auction) or a long search process ending with a potentially uneven bargaining platform (buyers' vs. sellers' market, seller under pressure to sell, buyer in urgent need to buy, *etc*.). In the real estate market, a seller can put up a property for sale through either auction or negotiated sale, and a buyer can purchase a property either through auction or negotiated sale. These choices imply that the sample of properties sold through different sales mechanisms is not random. However, we are not able to observe the choices, or the unsuccessful attempts by sellers and buyers to purchase property through either of the two sales mechanism, we can only

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[9]Han and Strange (2014), using data from the National Association of Realtors, find that time-on-the-market is between 6 to 12 weeks for the period 2003 to 2006, and between 10 to 17 weeks for the period 2007 to 2010. An auction sale typically takes between 4 to 6 weeks.

observe the outcome: whether the property is sold through auction or negotiated sale. Thus, we need to check for and, if needed, correct for sample selection bias.[10] If this bias is not accounted for in the empirical model, the estimates for the house price coefficients and the subsequent price predictions will not be consistent.

Following the structure of the empirical model of Lee (1978), we use the two-step estimation procedure suggested by Heckman (1976, 1979) to estimate our price equations for the two sales mechanisms. We can think of the two-step estimation as a two-part model—the first part is a binary outcome selection equation that models the sales mechanism that the property was sold by, the second part is a regression model that estimates the house price conditional on the choice of sales mechanism. The selection equation that models the type of sales mechanism is estimated using a probit model:

$$I_i^* = \gamma_0 + \gamma_1 X_i' + \gamma_2 M_i' + \gamma_3 Z_i' + \varepsilon^*, \tag{4}$$

where I_i^* represents the latent endogenous variable, and $I_i = 1$ if the property is sold through negotiated sale and $I_i = 0$ if the property is sold through auction. The variables X_i and M_i are observable exogenous variables. X_i is a vector that consists of different property characteristics—property types, geographical location, property tenure (to be explained shortly), floor area and a dummy vector that indicates whether the property is foreclosed. M_i is a vector of property market conditions and includes the property price index as well as three binary dummy variables that indicate the states of the property—up, down and stable. Z_i is a vector of qualitative variables that proxy for factors that influence the seller's choice of sales mechanism. The two variables in vector Z_i are: number of prior unsuccessful auction attempts, and whether the property was sold through repeated auction attempts. In the context of sample-selection modeling, the vector Z_i is considered to be a set of exclusion restrictions and will be discussed in detail in the next section of the article.

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[10]The significance of selectivity bias is illustrated by Quan (2002). Using U.S. data, Quan (2002) finds that if the choice of sales mechanism is not treated as an endogenous variable, property prices will decrease if sold by auction. However, when the endogenous explanatory variable problem is accounted for, property prices increase by 30% if sold by auction. Lusht (1996), using Australian data, did not find evidence of sample selection bias between auction sales and negotiated sales. These studies suggest that it is important to check whether properties or sellers with certain characteristics are more prone to choose one sales mechanism over the other.

From the probit model, we derive the inverse Mills ratio to determine whether selectivity bias is present. Thus, the pricing equations conditional on the chosen sales mechanism[11] are:

$$lnprice_{nsi} = \theta_{ns0} + X_{nsi}\theta_{ns1} + M_{nsi}\theta_{ns2} + \sigma_{nsi\varepsilon}\left(-\frac{f(\Psi_i)}{F(\Psi_\text{i})}\right) + \eta_{ns}, \quad (5)$$

$$lnprice_{ai} = \theta_{a0} + X_{ai}\theta_{a1} + M_{ai}\theta_{a2} + \sigma_{ai\varepsilon}\left(\frac{f(\Psi_i)}{1 - F(\Psi_\text{i})}\right) + \eta_{a}, \quad (6)$$

where $E(\eta_{ns}|I_i = 1) = 0$ and $E(\eta_a|I_i = 0) = 0$, $lnprice_{nsi}$ is the natural logarithm of the transacted price when property i is sold through a negotiated sale auction, and $lnprice_{ai}$ is the natural logarithm of the transacted price when property i is sold through an auction. Following the definition given for I_i earlier, we observe $price_{nsi}$ when $I_i = 1$ and $price_{ai}$ when $I_i = 0$.

Using these estimated pricing equations conditional on the sales mechanisms, we further obtain the estimated price difference for the same property when sold through auction and negotiated sale. For property i, the estimated auction price and estimated negotiated sale price[12] are:

$$\hat{\mu}_{ai} = \hat{\theta}_{a0} + X_{ai}\hat{\theta}_{a1} + M_{ai}\hat{\theta}_{a2}, \quad (7)$$

$$\hat{\mu}_{nsi} = \hat{\theta}_{ns0} + X_{nsi}\hat{\theta}_{ns1} + M_{nsi}\hat{\theta}_{ns2}. \quad (8)$$

We calculate the estimated percentage price differential for property i sold under auction versus negotiated sale as:

$$EstPrDiff_i = \frac{EstPrice_{ai} - EstPrice_{nsi}}{EstPrice_{nsi}}, \quad (9)$$

where $EstPrice_{ai}$ is the estimated auction price for property i derived from Equation (7), and $EstPrice_{nsi}$ is the estimated negotiated sale price for property i derived from Equation (8).

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[11] In our article, vectors X_{ai} and X_{nsi} (similarly, M_{ai} and M_{nsi}) include the same set of variables. However, we adopted these notations to differentiate between the negotiated sales and auction pricing equations.

[12] Our estimated prices are in levels, hence, we need to retransform the estimated prices. We follow the computation suggested in Cameron and Trivedi (2009). Thus, our prediction functions to obtain the estimated prices are:

$$\widehat{price}_{nsi} = exp\left(\theta_{ns0} + X_{nsi}\theta_{ns1} + M_{nsi}\theta_{ns2} + \sigma_{ns}^2/2\right)$$
$$\times \left\{1 - \Phi\left(-\left(\gamma_0 + \gamma_1 X_i' + \gamma_2 M_i' + \gamma_3 Z_i'\right) - \sigma_{probitns}^2\right)\right\}$$
$$\widehat{price}_{ai} = exp\left(\theta_{a0} + X_{ai}\theta_{a1} + M_{ai}\theta_{a2} + \sigma_a^2/2\right)$$
$$\times \left\{1 - \Phi\left(-\left(\gamma_0 + \gamma_1 X_i' + \gamma_2 M_i' + \gamma_3 Z_i'\right) - \sigma_{probita}^2\right)\right\},$$

where $\sigma^2, \sigma_{ns}^2, \sigma_a^2, \sigma_{probitns}^2$ and $\sigma_{probita}^2$ are the variance and covariance parameters.

In this article, we are also interested in whether this estimated percentage price differential between the two sales mechanisms is constant across different price segments. We subdivide our data into three groups using the ratio 0.3, 0.4 and 0.3. The lowest 30th centile corresponds to the low-end property market, the highest 30th centile corresponds to the high-end property market and the middle 40th centile corresponds to the middle-priced property market. To further examine the estimated percentage price differential between the two sales mechanisms, we run the following regression:

$$EstPrDiff_i = \beta_0 + \beta_1 VR_i + \beta_2 SM_i + \beta_3 FC_i + \varepsilon, \tag{10}$$

where VR_i is a vector consisting of two variables: price variance of the transacted price of property *i* that measures the deviation of the transacted price of property *i* from typical price levels in the sample,[13] and the atypicality of property *i* that measures the deviation of the property characteristics of property *i* from a typical property in the sample. SM_i is a vector of property market conditions that includes changes in the property price index from the base period, and three binary dummy variables that indicate the states of the property market—up, down and stable. FC_i is a vector of variables that includes a dummy variable indicating whether property *i* was sold as a foreclosed property, and interaction dummy variables for the property being a foreclosed property sold during different states of the property market.

[13]We adopt the Mahalanobis approach to measure the covariance-adjusted differences in the estimated prices of property *i* from typical price levels in the data sample. Our price variable is computed as follows:

$$DPVar^2_{homo,il} = \left(PVar_{homo,il} - \overline{PVar}_{homo,il}\right)' C_w^{-}1 \left(PVar_{homo,il} - \overline{PVar}_{homo,il}\right)$$
$$DPVar^2_{hetero,jl} = \left(PVar_{hetero,jl} - \overline{PVar}_{hetero,jl}\right)' C_w^{-1} \left(PVar_{hetero,jl} - \overline{PVar}_{hetero,jl}\right)$$

where $DPVar^2_{homo,il}$ measures the squared covariance-adjusted distance to the group mean of the estimated prices of homogeneous properties located in planning region *l*. $DPVar^2_{hetero,jl}$ measures the squared covariance-adjusted distance to the group mean of the estimated prices of heterogeneous properties located in planning region *l*. $PVar_{homo,il}$ refers to the vector of estimated sales prices (auction and negotiated sales prices) for homogeneous property *i* located in region *l*. $PVar_{hetero,jl}$ refers to the vector of estimated sales prices for property *j* located in region *l*. $\overline{PVar}_{homo,il}$ refers to the group mean of the vector of estimated sale prices for homogeneous properties located in planning region *l*. $\overline{PVar}_{hetero,jl}$ refers to the group mean of the vector of estimated sale prices for heterogeneous properties located in planning region *l*. C_W^{-1} refers to the inverse of the pooled within-group covariance matrix of the vector of estimated sale prices *PVar*. The Mahalanobis distance is calculated by setting $DPVar^2_{homo,il} = DPVar^2_{hetero,jl}$ and then solving for *PVar*. The same methodology is applied to calculate the atypicality of the property.

Data

The data that were compiled by the Singapore Institute of Surveyors and Valuers (SISV) consisted of data on properties that were put up for auction between 1995Q3 and 2006Q4. The data can be viewed as a panel data that tracked the sales status of only the aforementioned properties.[14] The data collected included information like the auction date, property address, whether the auction is a distressed sale, the type of property, floor area, tenure, the auction house, auction sale (hammered down) price and whether the property was sold on the date auctioned. Subsequently, for properties that were not sold through auction in the first instance, the seller has two choices: (1) put up the property for auction again at a later date or (2) list the property with a broker and sell through negotiated sale (property is sold through a bargaining process between the seller and buyer, and brokered by a real estate broker). If the seller decided to put the property up for auction again, SISV would continue to document this follow-up auction attempt. If the seller decided to list the property with a broker, and the property was subsequently sold through negotiated sale, SISV would note that the property was sold through negotiated sale and collect additional information like the transaction date and transaction price; thereafter, the property would not be tracked further. However, SISV would not be able to capture the information that the property was listed with a broker. Thus, a deficiency of these data is that it had records of the number of auction attempts for a particular property, but it did not have records of the number of listing attempts for a particular property. The data used in the empirical models consist of 3,022 successful sales transactions,[15] of which 777 observations are auction sales and the remaining 2,245 observations are negotiated sales. Table 2 lists the variables used in the empirical models.

The variables used to proxy for the property characteristics are property type, geographical location, property tenure, floor area and a dummy variable indicating whether the property is under foreclosure. There are four main property types: apartments (*dum_apt*), terrace (*dum_ter*), semidetached (*dum_sd*) and

[14] At first glance, it would seem that the data originated from properties that were first put up for auction and, subsequently, through the negotiated sales mechanism. This process would seem contrary to the assumption made in the theoretical model. However, there is no conflict in the data-generating process of house prices determined through auction or through negotiated sales. Prior to the auction sale, we have no way to prove or disprove whether the property had gone through the multiple listing process. In Singapore, there are many property consultancies, with no centralized multiple listing services.

[15] Since the research question is focused on the impact of sales mechanism on property prices, only successful sales transactions were used as observations in the data set. The main reason for not using the data from unsuccessful sales is that we do not have data on properties that were not successfully sold through negotiated sales. Hence, only using data on properties that were not successfully sold through auction may lead to biased/truncated estimates in the probit model of choice of sales mechanism.

Table 2 ■ Definition of variables in the empirical models.

Variable	Description
alnprice	Natural logarithm of the selling price of properties sold through auction.
nslnprice	Natural logarithm of the selling price of properties sold through negotiated sale.
dum_apt *dum_ter* *dum_sd* *dum_det*	Binary dummy variable indicating the type of property sold. The dummy variable is one if the property is: *dum_apt*: apartments or condominium units *dum_ter*: terrace houses *dum_sd*: semidetached houses *dum_det*: detached houses
dum_pr1 *dum_pr2* *dum_pr3* *dum_pr4* *dum_pr5*	Binary dummy variable indicating the geographic location of the property. The location is organized by planning regions as demarcated in the Singapore Masterplan. The dummy variable is one if the property is located in: *dum_pr1*: Central region *dum_pr2*: East region *dum_pr3*: North-East region *dum_pr4*: North region *dum_pr5*: West region
tenuretype	Binary dummy variable indicating the land tenure of the property. The dummy variable has a value of 1 if the land tenure has a remaining land lease of more 99 years or more and zero otherwise.
lnarea	Natural logarithm of floor area of the property, measured in square feet.
lnarea2	The square of *lnarea.*
ppi	A quarterly property price index that tracks the movement of property prices in Singapore.
forcedsale	Binary dummy variable indicating whether the property is a foreclosed property. The dummy variable is one if the property is foreclosed.
aucattempts	Number of times that the particular property was put on auction before it was sold.
multiauction	Binary dummy variable of one that indicates the property was sold through auction, but not on the first auction attempt.
salemtd	Binary dummy variable indicating whether the property was sold by auction or by negotiated sale. The dummy variable is one if the property was sold by auction.
dum_up *dum_down* *dum_flat*	Binary dummy variable indicating the three phases of the property market over the period 1995–2008.

Figure 1 ■ Geographical map of the five planning regions in Singapore.

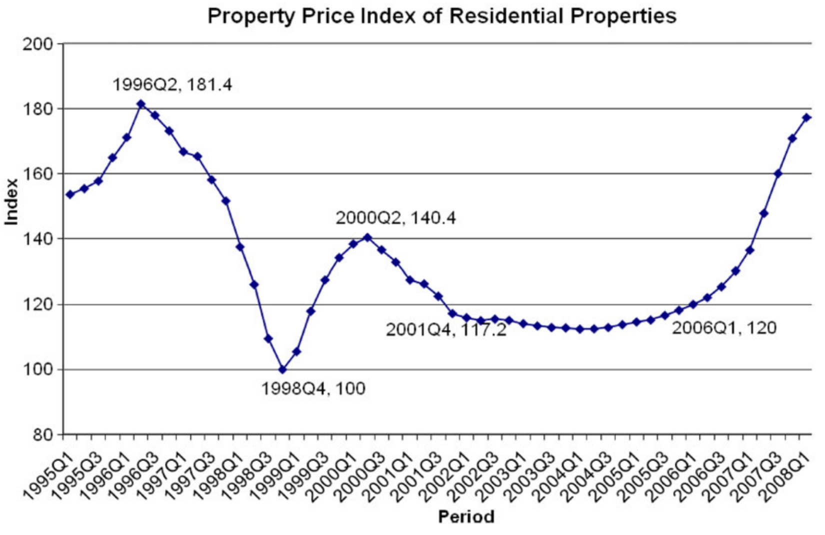
Source: URA website: http://www.ura.gov.sg/ppd/mp2003/index.jsp.

detached houses (*dum_det*). The geographical location is assigned according to the planning regions as set out in the MasterPlan for Singapore. A geographical map is shown in Figure 1. There are five planning regions: Central (*dum_pr1*), East (*dum_pr2*), North-East (*dum_pr3*), North (*dum_pr4*) and West (*dum_pr5*). These five planning regions are heavily populated; the whole island is widely serviced by an efficient public transportation system that comprises the subway, light rail and buses. Out of the five planning regions, land values are highest in the central region because the central business district, downtown core and high-income residential districts are located there. The geographical location proxies should also pick up any information (*e.g.*, location near the sea, location near the central business district, high or low crime rate[16] in the area) pertaining to that particular planning region that may contribute to variations in the house prices.

The data do not contain information about the age of the property. The best alternative is to use the variable "property tenure." In Singapore, there are two categories of property tenure: freehold and leasehold. An owner of a freehold property, depending on the sale terms, may own the property for perpetuity, for 999 years or for 9,999 years. For leasehold properties, the 99-year lease starts from the moment a developer purchases the land for development. Upon

[16]Singapore has a low crime rate; on average, there were 724 cases per 100,000 population for the period 2005–2010. (Source: Yearbook of Statistics, Singapore, 2011.) In Singapore, property prices are very high (for instance, median price for apartment in 1995Q3 is S$757 psf; 2006Q4 is S$688 psf; 2012Q1 is S$1,075 psf; Source: Urban Redevelopment Authority); correspondingly, there are no big pockets of urban decay.

Figure 2 ■ Property price index of residential properties.



Source: Urban Redevelopment Authority.

building (usually one to two years later), the developer sells the completed properties to interested buyers. Hence, an owner of a leasehold property in effect only owns the property for less than 99 years. Given these circumstances, the data distribution for property tenure seems better suited as a discrete variable than as a continuous variable. Consequently, in our article, properties with a remaining lease of 99 years or more are classified as freehold (*tenuretype* = 1). Properties with a remaining lease of less than 99 years are classified as leasehold (*tenuretype* = 0).

The floor area of the property is measured in square feet. Unfortunately, the data collected by SISV do not contain further property characteristics like number of bedrooms, number of bathrooms or the condition of the property. However, based on the information available, the independent variables in the pricing equations explain around 72–81% of the variations in the property prices; hence, the explanatory power of these variables is substantial.

The variable *ppi* represents the property price index. This variable is extracted from ReaLink and is compiled by the Urban Redevelopment Authority (URA). In the data, we correlate the date of sale with the property price index for that quarter. Thus, *ppi*, as used in our data, helps to capture the state of the real estate market during the time of sale. Figure 2 graphs the movement of the property price index for the period 1995 to 2008, where the base year is 1998. The Singapore property market experienced two peaks (2Q1996 and 2Q2000), a valley (4Q1998) and a relatively long period of flat sales. Based on the shape of the property price index graph, the data are divided into three periods: up market (3Q1995 to 2Q1996, 1Q1999 to 2Q2002 and 1Q2006 to 1Q2008), down market (3Q1996 to 4Q1998 and 3Q2000 to 4Q2001) and flat market (1Q2002 to 4Q2005). Results from the Chow tests for stability in the coefficients show significant differences in the coefficients in the three market periods. Thus, we have to use dummy variables to account for differences in the slopes during different market phases.

Table 3 presents a summary of the descriptive statistics for the data. Panels A, B and C present the summary statistics for the full sample, negotiated sales and auction sales, respectively; Panel D tests for differences in property characteristics between the two sales mechanisms through a comparison of their mean and median values. Overall, we note that the standard deviation for the variables are high, indicating that the data points spread over a large range of values. We also note that the median values are generally lower than the mean values in each of the subsample. Consequently, we conduct four tests in Panel D: (1) a two-sample mean-comparison test, (2) a Skewness and Kurtosis test for normality, (3) a Wilcoxon rank-sum test and (4) a nonparametric *K*-sample test for equality of medians.

As shown in Table 3, auctioned sales on average obtain a statistically significant higher price than negotiated sales; auctioned sales obtain a higher price on average (mean = S$1.171 million, median = S$0.88 million) when compared to the overall sample (mean = S$1.156, median = $0.79 million) and negotiated sales (mean = S$1.151 million, median = S$0.76 million). Tests in Panel D indicate that the differences are statistically significant, giving *prima facie* evidence that there exists a potential premium/discount between the two sales mechanisms.

Next, we look for differences in the properties sold under the two mechanisms, through the property types (apartments, terrace, semidetached, detached), tenure (freehold vs. nonfreehold), floor area and location variables (five planning regions). Panel D shows mixed results. If we assume the variables are normally distributed (*t*-test), or if we adopt a nonparametric comparison between two independent samples (Wilcoxon rank-sum test), the results indicate that: more terrace housing are sold through auction sales; more freehold properties are sold through auction sales; more properties located in planning region 1 (Central region) are sold through auction sales; contrastingly more properties located in planning regions 2 (East region) and 5 (West region) are sold through negotiated sales. However, the tests for equality of medians

Table 3 ■ Descriptive statistics and correlation matrix.

Panel A: Full Sample

Variables	Obs.	Median	Mean	Std. Dev.	Min.	Max.
price ('000)	3,022	791	1,157	1,279	135	18,000
price psf	3,022	395	434	218	12	4,941
dum_apt	3,022	1	0.59	0.49	0	1
dum_ter	3,022	0	0.14	0.35	0	1
dum_sd	3,022	0	0.16	0.36	0	1
dum_det	3,022	0	0.11	0.32	0	1
tenuretype	3,022	1	0.73	0.44	0	1
dum_pr1	3,022	1	0.52	0.80	0	1
dum_pr2	3,022	0	0.13	0.34	0	1
dum_pr3	3,022	0	0.17	0.37	0	1
dum_pr4	3,022	0	0.06	0.23	0	1
dum_pr5	3,022	0	0.13	0.34	0	1
area	3,022	1,776	3,058	8,586	409	439,781
ppi	3,022	115.2	119.4	13.3	100	181.4
forcedsale	3,022	1	0.71	0.45	0	1
dum_up	3,022	0	0.36	0.48	0	1
dum_down	3,022	0	0.09	0.29	0	1
dum_stable	3,022	1	0.55	0.50	0	1
aucattempts	3,022	1	1.96	1.83	1	25
multiauction	3,022	0	0.07	0.26	0	1

Panel B: Negotiated Sales Properties

Variables	Obs.	Median	Mean	Std. Dev.	Min.	Max.
price ('000)	2,245	761	1,152	1,302	135	18,000
price psf	2,245	390	424	174	12	3,136
dum_apt	2,245	1	0.60	0.49	0	1
dum_ter	2,245	0	0.13	0.34	0	1
dum_sd	2,245	0	0.15	0.36	0	1
dum_det	2,245	0	0.12	0.32	0	1
tenuretype	2,245	1	0.72	0.45	0	1
dum_pr1	2,245	0	0.50	0.50	0	1
dum_pr2	2,245	0	0.14	0.35	0	1
dum_pr3	2,245	0	0.16	0.37	0	1
dum_pr4	2,245	0	0.06	0.23	0	1
dum_pr5	2,245	0	0.14	0.35	0	1
area	2,245	1,733	3,142	9,835	409	439,781
ppi	2,245	115.2	119.9	13.8	100	181.4
forcedsale	2,245	1	0.68	0.47	0	1
dum_up	2,245	1	0.34	0.47	0	1
dum_down	2,245	1	0.34	0.47	0	1
dum_stable	2,245	1	0.57	0.49	0	1
aucattempts	2,245	1	2.10	1.96	1	25
multiauction	2,245	0	4.5E-04	0.02	0	1

Table 3 ■ Continued

Panel C: Auction Properties

Variables	**Obs.**	**Median**	**Mean**	**Std. Dev.**	**Min.**	**Max.**
price (‘000)	777	880	1,171	1,211	200	17,800
price psf	777	410	463	311	75	4,941
dum_apt	777	1	0.57	0.49	0	1
dum_ter	777	0	0.16	0.37	0	1
dum_sd	777	0	0.16	0.37	0	1
dum_det	777	0	0.10	0.30	0	1
tenuretype	777	1	0.77	0.42	0	1
dum_pr1	777	1	0.58	0.49	0	1
dum_pr2	777	0	0.10	0.30	0	1
dum_pr3	777	0	0.17	0.37	0	1
dum_pr4	777	0	0.06	0.23	0	1
dum_pr5	777	0	0.10	0.30	0	1
area	777	1,864	2,818	2,687	463	27,796
ppi	777	115.5	118.1	11.7	100	181.4
forcedsale	777	1	0.80	0.40	0	1
dum_up	777	0	0.40	0.49	0	1
dum_down	777	0	0.10	0.31	0	1
dum_stable	777	0	0.50	0.50	0	1
aucattempts	777	1	1.57	1.34	1	16
multiauction	777	0	0.29	0.45	0	1

Panel D: Comparisons between Negotiated Sales and Auction Properties

Variables	***t*-Test**	**Normality Test**	**Ranksum Test**	**Medium Test**
price (‘000)	-4.3889^{**}	No	-3.346^{**}	17.3244^{**}
price psf	-4.3889^{**}	No	-3.346^{**}	13.4160^{**}
dum_apt	1.1179	–	1.118	2.3759
dum_ter	-2.2432^{**}	–	-2.242^{**}	0.0008
dum_sd	−0.6467	–	−0.647	0.1326
dum_det	1.4722	–	1.472	1.1135
tenuretype	-2.3775^{**}	–	-2.376^{**}	0.1788
dum_pr1	-3.7217^{**}	–	-3.714^{**}	1.9898
dum_pr2	3.0460^{**}	–	3.042^{**}	0.0006
dum_pr3	−0.2445	–	−0.245	0.3651
dum_pr4	0.0819	–	0.082	0.2285
dum_pr5	2.7016^{**}	–	2.699^{**}	2.1326
area	0.9055	No	-1.663^{*}	4.0010^{**}
ppi	3.3060^{**}	No	0.94	1.6307
forcedsale	-6.5013^{**}	–	-6.457^{**}	12.9179^{**}

Table 3 ■ Continued

Panel D: Comparisons between Negotiated Sales and Auction Properties

Variables	***t*-Test**	**Normality Test**	**Ranksum Test**	**Medium Test**
dum_up	−2.8507**	–	−2.847**	3.4724*
dum_down	−1.6899*	–	−1.689*	0.0204
dum_stable	3.7224**	–	3.715**	0.2334
aucattempts	6.9161**	No	8.647**	16.5083**

Notes: Panel A presents the descriptive statistics and comprises of four panels. Panels A to C present the summary statistics for the full sample, properties sold through negotiated sales and properties sold through auction. Panel D compares the mean and median statistics between the negotiated sales and auction samples. We run four tests in Panel D: (1) a two-sample mean-comparison test (assuming the two groups are normally distributed) that performs the *t*-test for equality of means between the two groups; (2) skewness and kurtosis test for normality; (3) Wilcoxon rank-sum test with the hypothesis that the two groups are from populations with the same distribution; and (4) a nonparametric *K*-sample test for equality of medians between the two groups. Besides reporting the results for the usual *t*-tests, we further ran the skewness and kurtosis test and the Wilcoxon rank-sum test because we note that the data may have a nonnormal distribution. We run the nonparametric *K*-sample test because we note, from the summary statistics in Panels B and C, that the median values seem different from the mean values. ** and * indicate a 5% and 10% level of significance, respectively.

indicate that there are no statistically significant differences in the medians of property characteristics for properties sold under the two mechanisms. For the variable, floor area, both tests (ranksum test and the test for equality of medians) indicate that properties with larger floor areas tend to be sold through auction. To recapitulate, these results seem to indicate that "better" properties (centrally located, bigger floor area and with a freehold tenure) tend to be sold through auction. Thus, we will need to control for these variables in our subsequent regression analysis.

Finally, we look for differences related to the conditions of sale (the state of the property market and whether the property is a distressed property). Results from Panel C indicate that more distress properties are sold through auction. This result is in line with the perception that due to time and holding costs constraints, auction is the predominant method of disposal for distressed properties. From the states of the property market (up, down, stable), the results indicate that more properties are sold through auction when the market is booming and when the market is depressed. When the market is stable, more properties tend to be sold through negotiated sales. Intuitively, this result makes sense. When markets are volatile (boom and bust), sellers and buyers would prefer a quick transaction, and thus auction sales are more efficient than brokered sales.

However, when markets are stable, buyers can afford to search for the "right" property, and thus sellers can afford to wait for the offer that matches or is higher than their reservation price.

Because distressed properties are closely related to the sales mechanism, we create interaction terms with the variable *forcedsale* and include two sets of interaction regressors. One set relates to state of the market: *forcedsale* × *dum_up*, *forcedsale* × *dum_down* and *forcedsale* × *dum_stable*. The other set relates to geographic location: *forcedsale* × *dum_pr* (1–5).

Overall, the data set seems balanced: (1) Property types—60% of the data are apartment sales, the balance is landed property sales; (2) Market conditions—55% of the properties are sold during a stable market, 45% of the properties are sold when the market is on an uptrend or downtrend; (3) Geographical location—52% of the transactions occurred in the central region, 48% occurred in the rest of the island. The major point of contention rests with the fact that 71% of the data set consists of distressed sales. This point will be important if distressed sale properties are associated with poorly maintained and poor quality properties. However, in Singapore, this is not the case. Aside from property condition considerations, the other factor to consider is that sellers of distressed properties are pressed to sell. However, our data indicate that on average, there were 1.5 to 2 prior auction attempts before the property was sold. In addition, mortgages in Singapore are recourse mortgages, and foreclosed properties can be rented out by banks for rental income until they are sold. In fact, our summary statistics indicate that auctioned properties have a higher price, on average, than negotiated sale properties.

As mentioned earlier, we use exclusion restrictions in our empirical model. These exclusion restrictions work on the same principles as instrumental variables for the endogenous explanatory variable problem. The exclusion restrictions should affect the selection variable (choice of auction or negotiated sale) but should not directly affect the outcome variable (house price). We consider three sets of exclusion variables: (1) variables relating to the conditions of sale for the property: the number of auction attempts (*aucattempts*), whether there are bidders in the previous auction attempt (*biddersprev*), number of days since the last auction attempt (*tbla*) and whether the property was sold through auction but with repeated auction attempts (*multiauction*); (2) variables relating to the conditions in the real estate market: interest rate changes over a three-month period (*irchanges*) and changes in the property price index over a period of six months (*ppi_6m*), nine months (*ppi_9m*) and one year (*ppi_12m*); and (3) variables relating to the size of the property (*logarea*) and the interaction of the size of the property with market conditions (*area* × *up*, *area* × *down*, *area* × *stable*).

Table 4 shows the correlation matrix for these variables. Overall, except for *multiauction* and *aucatt*, the rest of the candidates for the exclusion restrictions do not seem to meet the requirements. Both *multiauction* and *aucatt* are correlated with the selection variable, *salemethod*, and neither of the two affects the outcome variable *logtprice* directly. Consequently, we will adopt *multiauction* and *aucatt* as the exclusion restrictions in our empirical model.

Empirical Results for Choice of Sales Mechanism

Estimated Price Equations

Table 5 shows the results of the probit model and estimated price equations. We first focus on the outcome (price) equations, and then we discuss the selection equations. We estimate separate equations for property prices sold through negotiated sales (Equation (5)) and auction (Equation (6)). The price equations are estimated with four variations: (1) Ordinary Least Squares (Model 1), (2) Heckman Two-Step Consistent Estimator (Model 2), (3) Heckman Maximum Likelihood Estimates (MLE) with no exclusion restrictions (Model 3) and (4) Heckman MLE with exclusion restrictions.

For the auction price estimations, we observe that the coefficients (except Model 3) are similar across the models. Model 1 provides a base comparison with the other models; the set of regressors explains about 73% of the variation in auction prices. We find that the coefficients for Models 2 and 4 are similar, except that the standard errors are smaller in Model 4. Using the two-step consistent estimation, we find that the inverse Mills ratio is statistically significant for both the auction and negotiated sales estimation. This indicates that if we had not corrected for selectivity bias, we would have overestimated the auction price and underestimated the negotiated sale price. In addition, we note that the estimations for Models 3 and 4 generate different coefficients for the auction sale. For the negotiated sale estimation, the results are similar across the four models. Thus, these results provide support for the use of exclusion restrictions in our estimation. For the interpretation of the results, we will use Model 4 as it has a greater log pseudo likelihood value.

For the auction price equation, the signs of the various estimated coefficients are generally as expected. A freehold property obtains a higher sales price than a leasehold property and contributes to an approximate 34.2% increase in sales price. Compared to properties located in the central region, properties located in the other regions command a lower sales price, and this discount ranges approximately from 13.8% to 20.3%. An increase in the floor area increases property prices, at an increasing rate, though the impact is not statistically significant in auction sales. When the property price index moves up one index

Table 4 ■ Correlation matrix for potential exclusion restriction variables and price equation regressors.

Variables	*biddersprev*	*Aucattempts*	*multiauction*	*tbla*	*irchanges*	*ppi_6m*	*ppi_9m*	*ppi_12m*	*lnarea*	*area × up*	*area × down*	*area × stable*
salemethod	−0.0630	−0.1249	0.4781	−0.2623	−0.0823	0.0565	0.0244	−0.0290	0.0081	0.0496	0.0287	−0.0641
lntprice	0.0996	−0.1302	−0.0073	0.1217	−0.1144	0.0563	0.0365	0.0058	0.8522	0.2089	0.1495	−0.1369
residual	0.0829	−0.0882	0.0220	0.1389	−0.0998	0.0450	0.0210	−0.0022	0.9605	0.2342	0.1688	−0.1533
dum_apt	−0.0655	0.0699	−0.0215	−0.0821	0.0901	0.0251	0.0586	0.0844	−0.6865	−0.1091	−0.1632	0.0779
dum_ter	0.0084	−0.0448	−0.0055	−0.0246	−0.0269	−0.0012	−0.0147	−0.0255	0.0078	0.0265	0.0276	−0.0409
dum_sd	0.0496	−0.0495	0.0383	0.0560	−0.0746	−0.0406	−0.0698	−0.0922	0.3414	0.0471	0.1533	−0.0747
dum_det	0.0357	−0.0026	−0.0045	0.0907	0.0090	0.0090	0.0051	0.0027	0.6682	0.0866	0.0475	0.0097
tenuretype	0.0595	−0.0566	−0.0016	0.0651	−0.0195	−0.0195	−0.0502	−0.0731	0.3130	0.0598	0.1067	−0.0646
dum_pr1	0.0145	−0.0713	0.0094	0.0035	−0.0363	0.0044	−0.0028	−0.0147	−0.0026	0.0080	0.0181	−0.0191
dum_pr2	−0.0253	0.0276	−0.0225	−0.0177	0.0078	−0.0343	−0.0248	−0.0126	−0.0323	−0.0254	0.0064	0.0151
dum_pr3	0.0243	0.0245	0.0199	0.0319	−0.0164	0.0013	−0.0080	−0.0197	0.1400	0.0253	0.0500	−0.0288
dum_pr4	0.0034	0.0112	−0.0084	−0.0069	0.0215	0.0142	0.0149	0.0128	0.0271	−0.0167	−0.0299	0.0391
dum_pr5	−0.0256	0.0437	−0.0077	−0.0182	0.0496	0.0166	0.0276	0.0475	−0.1373	−0.0033	−0.0681	0.0185
Lnarea	0.0816	−0.0518	0.0220	0.1113	−0.0782	−0.0113	−0.0366	−0.0585	1.0000	0.1255	0.1394	−0.0222
lnarea2	0.0811	−0.0508	0.0213	0.1112	−0.0757	−0.0103	−0.0342	−0.0543	0.9976	0.1237	0.1344	−0.0179

Table 4 ■ Continued

Variables	*biddersprev*	*Aucattempts*	*multiauction*	*tbla*	*irchanges*	*ppi_6m*	*ppi_9m*	*ppi_12m*	*lnarea*	*area* × *up*	*area* × *down*	*area* × *stable*
Ppi	0.0180	−0.0440	−0.0676	0.1960	−0.0394	0.2645	0.4014	0.5034	0.0587	0.3979	0.0600	−0.4136
forcedsale	−0.0036	0.1146	0.0814	−0.1594	−0.0031	−0.0419	−0.0249	−0.0148	−0.0351	−0.1367	−0.0978	0.1856
dum_up	−0.0040	−0.1055	−0.0105	0.1439	−0.0737	0.6894	0.5610	0.4141	0.0564	0.9934	−0.2330	−0.8226
dum_down	0.0501	−0.1164	0.0378	0.0296	−0.2001	−0.6916	−0.7290	−0.6871	0.1148	−0.2324	0.9961	−0.3450
dum_stable	−0.0248	0.1685	0.0668	−0.1558	0.1858	−0.2680	−0.1227	−0.0051	−0.1202	−0.8246	−0.3468	0.9911

Notes: This table is a correlation matrix that displays the correlation between potential exclusion restriction variables and (1) *salemethod*; (2) natural logarithm of the transacted house price; (3) residuals from the estimated house price equation; and (4) regressors from the estimated house price equation. Twelve variables are considered for the exclusion restriction variables. *biddersprev* is a binary indicator with value one to indicate interested bidders in the previous auction attempt. *aucattempts* is a variable that indicates the number of unsuccessful auction attempts before the property was sold, either through negotiated sale or auction. *tbla* is the number of days since the last auction attempt. *irchanges* measures the percentage change in the three-month SIBOR (Singapore Interbank Offer Rate) over a three-month period. *ppi_6m* measures the percentage change in the property price index over two quarters. *ppi_9m* measures the percentage change in the property price index over three quarters. *ppi_12m* measures the percentage change in the property price index over four quarters. *lnarea* is the natural logarithm of the floor area of the property, measured in square feet. *area* × *up* is the interaction term between *lnarea* and *dum_up* that is a binary variable indicating up market conditions. *area* × *down* is the interaction term between *lnarea* and *dum_down* that is a binary variable indicating down market conditions. *area* × *stable* is the interaction term between *lnarea* and *dum_stable* that is a binary variable indicating stable market conditions. *multiauction* is a binary variable with a value of one to indicate that the property was not sold on the first auction attempt but on subsequent auction attempts. The residual calculated in this correlation matrix table is based on the following housing price equation: $lntprice = f$(property characteristics X_i, property market conditions M_i, *forcedsale*, *salemethod*). *forcedsale* is a binary variable that indicates whether the property is a distress property. *salemethod* is a binary variable that indicates with a value of one if the property was sold by auction, and a value of zero if the property was sold through negotiated sale.

Table 5 ■ Estimated price equations conditional on method-of-sale and probit model for selection equation.

	Auction Sales				Negotiated Sales				Selection Equation	
Independent Variables	Model 1 (OLS)	Model 2 (Two-Step with ERs)	Model 3 (MLE)	Model 4 (MLE with ERs)	Model 1 (OLS)	Model 2 (Two-Step with ERs)	Model 3 (MLE)	Model 4 (MLE with ERs)	Probit Model	Marginal Effects
constant	8.5171**	8.4813**	6.1145**	8.4633**	4.8550**	4.9919**	4.8544**	5.0234**	6.5634*	
	(4.42)	(5.50)	(3.48)	(5.48)	(2.99)	(8.76)	(8.52)	(8.79)	(1.95)	
dum_ter	−0.0037	−0.0036	0.0219	−0.0036	0.0917**	0.0878**	0.0917**	0.0872**	−0.0574	−0.0178
	−(0.08)	−(0.09)	(0.48)	−(0.09)	(3.95)	(3.98)	(4.16)	(3.95)	−(0.62)	−(0.60)
dum_sd	−0.0192	−0.0192	−0.0218	−0.0188	0.0515*	0.0554**	0.0515**	0.0563**	0.1118	0.0332
	−(0.36)	−(0.40)	−(0.39)	−(0.39)	(1.82)	(2.10)	(1.96)	(2.12)	(0.94)	(0.98)
dum_det	−0.0242	−0.0299	−0.0492	−0.0288	0.2135**	0.2217**	0.2134**	0.2229**	0.0123	0.0038
	−(0.28)	−(0.41)	−(0.59)	−(0.39)	(4.31)	(6.18)	(5.94)	(6.19)	(0.07)	(0.07)
tenuretype	0.2961**	0.2937**	0.3137**	0.2938**	0.1604**	0.1567**	0.1604**	0.1565**	−0.0681	−0.0206
	(8.50)	(9.11)	(8.53)	(9.12)	(10.33)	(9.65)	(9.94)	(9.61)	−(0.89)	−(0.88)
dum_pr2	−0.1881**	−0.1786*	−0.2054**	−0.1791*	−0.1657**	−0.1571**	−0.1658**	−0.1567**	0.1364	0.0402
	−(2.77)	−(1.94)	−(2.04)	−(1.94)	−(5.46)	−(4.28)	−(4.55)	−(4.25)	(0.68)	(0.69)
dum_pr3	−0.2197**	−0.2275**	−0.2481**	−0.2277**	−0.2879**	−0.2835**	−0.2879**	−0.2830**	0.0830	0.0249
	−(3.55)	−(2.60)	−(2.59)	−(2.60)	−(10.20)	−(8.32)	−(8.49)	−(8.28)	(0.49)	(0.50)
dum_pr4	−0.1677	−0.1687	−0.0997	−0.1690	−0.2444**	−0.2537**	−0.2443**	−0.2548**	−0.4364*	−0.1500
	−(1.62)	−(1.40)	−(0.72)	−(1.41)	−(6.47)	−(4.07)	−(3.93)	−(4.08)	−(1.80)	−(1.64)
dum_pr5	−0.1425*	−0.1487	−0.2589**	−0.1481	−0.1293**	−0.1163**	−0.1294**	−0.1157**	0.3001	0.0840*
	−(1.66)	−(1.56)	−(2.50)	−(1.55)	−(4.09)	−(3.48)	−(3.79)	−(3.45)	(1.59)	(1.66)
lnarea	0.4583	0.4589	1.0088**	0.4643	1.3392**	1.2910**	1.3395**	1.2829**	−1.8656**	−0.5706**
	(0.88)	(1.17)	(2.27)	(1.18)	(3.22)	(9.27)	(9.48)	(9.18)	−(2.24)	−(2.22)
lnarea2	0.0196	0.0198	−0.0145	0.0194	−0.0376	−0.0347**	−0.0376**	−0.0342**	0.1175**	0.0359**
	(0.58)	(0.79)	−(0.51)	(0.78)	−(1.42)	−(4.09)	−(4.38)	−(4.02)	(2.27)	(2.23)
ppi	0.0029**	0.0026**	0.0001	0.0026**	0.0058**	0.0061**	0.0058**	0.0061**	0.0050**	0.0015*
	(2.14)	(2.27)	(0.09)	(2.27)	(10.48)	(11.15)	(10.02)	(11.15)	(1.98)	(1.95)
forcedsale	−0.0638	−0.0560	−0.0490	−0.0559	−0.0686**	−0.0655**	−0.0686**	−0.0667**	−0.0521	−0.0158
	−(1.26)	−(1.12)	−(0.87)	−(1.11)	−(2.39)	−(2.65)	−(2.79)	−(2.69)	−(0.41)	−(0.42)

Table 5 ■ Continued

Independent Variables	Auction Sales Model 1 (OLS)	Auction Sales Model 2 (Two-Step with ERs)	Auction Sales Model 3 (MLE)	Auction Sales Model 4 (MLE with ERs)	Negotiated Sales Model 1 (OLS)	Negotiated Sales Model 2 (Two-Step with ERs)	Negotiated Sales Model 3 (MLE)	Negotiated Sales Model 4 (MLE with ERs)	Selection Equation Probit Model	Selection Equation Marginal Effects
dum_up	0.1531	0.1368**	0.1075	0.1374**	0.0758**	0.0767**	0.0758**	0.0762**	0.1775	0.0532
	(2.86)	(2.32)	(1.64)	(2.33)	(2.72)	(2.90)	(2.86)	(2.88)	(1.28)	(1.23)
dum_down	0.1838*	0.1455	0.0068	0.1476	0.1089**	0.1203**	0.1088**	0.1205**	0.7162**	0.1694**
	(1.65)	(1.22)	(0.05)	(1.24)	(2.87)	(3.23)	(2.80)	(3.23)	(3.24)	(3.23)
fs × *dumpr2*	0.1350	0.1165	0.0442	0.1167	0.0461	0.0501	0.0460	0.0515	0.1606	0.0467
	(1.50)	(1.13)	(0.39)	(1.13)	(1.26)	(1.16)	(1.05)	(1.19)	(0.70)	(0.74)
fs × *dumpr3*	0.0273	0.0365	0.0340	0.0363	0.0949**	0.0988**	0.0949**	0.0997**	0.0640	0.0192
	(0.41)	(0.39)	(0.33)	(0.39)	(2.75)	(2.44)	(2.37)	(2.46)	(0.33)	(0.33)
fs × *dumpr4*	−0.0034	−0.0024	−0.1146	−0.0026	0.0541	0.0725	0.0540	0.0749	0.5365*	0.1332**
	−(0.03)	−(0.02)	−(0.74)	−(0.02)	(1.22)	(1.03)	(0.77)	(1.07)	(1.90)	(2.36)
fs × *dumpr5*	0.0309	0.0308	0.0819	0.0299	0.0638*	0.0595	0.0638	0.0605	−0.0889	−0.0279
	(0.31)	(0.29)	(0.71)	(0.28)	(1.66)	(1.45)	(1.57)	(1.47)	−(0.40)	−(0.39)
fs × *dumup*	0.0246	0.0447	0.1927**	0.0443	−0.0482	−0.0722**	−0.0480	−0.0733**	−0.7001**	−0.2384**
	(0.40)	(0.69)	(2.61)	(0.68)	−(1.50)	−(2.31)	−(1.35)	−(2.35)	−(4.48)	−(3.60)
fs × *dumdown*	−0.1797	−0.1343	0.1690	−0.1366	−0.0398	−0.0845−	−0.0395	−0.0874*	−1.2469**	−0.4612**
	−(1.48)	−(1.05)	(1.21)	−(1.07)	−(0.84)	−(1.64)	−(0.65)	−(1.70)	−(4.98)	−(5.00)
aucattempts									0.8740**	0.2673**
									(2.80)	(2.28)
multiauction									−9.7974*	−0.9272**
									−(1.89)	−(25.64)

Table 5 ■ Continued

Independent Variables	Auction Sales Model 1 (OLS)	Auction Sales Model 2 (Two-Step with ERs)	Auction Sales Model 3 (MLE)	Auction Sales Model 4 (MLE with ERs)	Negotiated Sales Model 1 (OLS)	Negotiated Sales Model 2 (Two-Step with ERs)	Negotiated Sales Model 3 (MLE)	Negotiated Sales Model 4 (MLE with ERs)	Selection Equation Probit Model	Selection Equation Marginal Effects
Inv MR		0.0601**	0.3962**	0.0588		0.1079**	−0.0005	0.1162		
		(2.59)	(33.88)	−(37.98)		(4.60)	(0.00)	−(21.34)		
No. of Obs.	777	777	777	777	2,245	2,245	2,245	2,245	3,022	
F-Stat.	129.65				532.29					
R^2	0.7255				0.8118					
Root MSE	0.3464				0.3046					
Wald ChiSq		2,064.15	1,672.02	2,064.57		9,513.49	9,678.72	9,459.43	139.12	
Pseudo R^2									0.356	
Log Likelihood			−1,890.161	−1,396.524			−2,145.055	−1,626.162	−1,109.406	

Notes: This table displays the results for the negotiated sale price equation (Equation (5)), the auction price equation (Equation (6)) and the probit model for the selection equation (Equation (4)). In the auction price equation, the dependent variable is the natural logarithm of the price of the property sold through auction. In the negotiated sale price equation, the dependent variable is the natural logarithm of the price of the property sold through negotiated sale. We have four estimations for the outcome (price) equations. Model 1 is estimated using ordinary least squares (OLS) regression with heteroskedastic-robust Huebner/White standard errors. Model 2 is estimated using the Heckman Two-Step Consistent Estimator, with two exclusion restrictions in the selection model. Model 3 is estimated using the Heckman Maximum Likelihood Estimates (MLE) with no exclusion restrictions in the selection model. Model 4 is estimated using the Heckman MLE with two exclusion restrictions in the selection model. The variables *aucattempts* and *multiauction* are used as the exclusion restrictions. In the selection equation, the dependent variable is a binary variable with a value of one to indicate that the property was sold through negotiated sale and a value of zero to indicate that the property was sold through auction. For both the selection and price equations, the t-statistics are reported in parentheses below the coefficients.

** and * indicate significance at the 5% and 10% levels, respectively.

However, for the inverse Mills ratio estimated using MLE, the chi-square values of the Wald test of independent equations are reported in parenthesis below.

point, property prices in the sample increase by 0.26%. A foreclosed property will obtain a price discount of 5.4%, but this factor is not statistically significant in auction sales. This may relate back to the argument that an auction provides a more level pricing ground than negotiated sale. Unlike in the negotiated sale, the seller is not in a disadvantaged bargaining position. The auction price is determined by the number of bidders, not the bargaining position of the seller.

Compared to a flat market, property prices are higher in an up market by 14.7%, and higher in a down market by 15.9%. The finding that property prices are higher in a down market than a flat market may seem surprising. The explanation for this result can be seen in Figure 2, where we observe that the property price index is higher in down market phases (3Q1996 to 4Q1998 and 3Q2000 to 4Q2001) than the flat market phase (1Q2002 to 4Q2005). We note that property type is not significant in explaining the variations in price for auction sales.

For the negotiated sale price estimations, we observe that the coefficients are similar across all four models. Again, Model 1 provides a base comparison with the other models; the set of regressors explains about 81% of the variation in negotiated sales prices. In general, the signs of the various estimated coefficients are again as expected. Furthermore, most of the independent variables are highly significant in explaining variations in negotiated sale prices. A freehold property obtains a higher sales price than a leasehold property and contributes to an approximate 16.9% increase in sales price. Compared to properties located in the central region, properties located in the other regions command a lower sales price, and this discount ranges from 10.9% to 24.6%. A larger floor area contributes to the house price, but at a decreasing rate. When the property price index moves up one index point, property prices in the sample increase by 0.61%. A foreclosed property will obtain a price discount of 6.5%. We note that whether the property is foreclosed is now statistically significant in explaining the price variations. This result further supports the intuition that bargaining positions matter more in a negotiated sale than in an auction. Compared to a flat market, property prices are higher in an up market by 7.9%, and higher in a down market by 12.8%. A distressed property located in the North-East region will sell for 10.5% higher; a distressed property sold during an up market will have a price discount of 7.1%; and a distressed property sold during a down market will have a price discount of 8.4%.

Next, we focus on the selection equation. The probit model indicates the west region location, floor area, a down market, interactions between distressed sales and state of the market, the number of auction attempts, and whether the property sold through auction was sold after repeated auction attempts, are important factors in the choice of the sales method.

In Table 6, we compare the predicted prices from the estimated price equations with the actual prices. The predicted prices have been transformed (see Footnote 12) and are reported in levels. The predicted prices are −4% to −18% off from the actual prices. From the table, we also note that predicted mean in the probit model is similar to the average mean in the actual distribution of sale mechanisms.

Comparison of Price Differences between Auction and Negotiated Sales

Table 7 presents the regression results for Equation (10), where we regress the estimated percentage price differential between the two sales mechanisms on differences in property characteristics, price variance, fluctuations in the market, state of the market, whether the property is a distressed property, the interaction effects of a distressed property and proxies for time-on-the market effects. The rationale behind this regression is to see how the above-listed factors impact variations in the price spread between the two sales mechanisms.

The first column shows the results using the full data sample. The subsequent three columns separate the data into three subgroups in terms of price range. "Low 30th" represents the lowest-price properties and comprises the bottom 30th transacted price subgroup, "Mid 40" represents the midprice properties and comprises the middle 31st–70th transacted price subgroup and "Top 30th" represents the highest-price properties and comprises the top 30th transacted price subgroup. Our objective in dividing the data into three subgroups is to verify whether the slopes of the regression coefficients change as property values increase.

The dependent variable is the estimated percentage price differential for property *i* when sold through auction versus negotiated sale, based on Equation (10). It can be interpreted as the percentage price spread between the two sales mechanisms—a positive number indicating a higher price for auction sales and a negative number indicating a lower price for auction sales. From our regressions based on the full sample, we find that as a property gets more atypical, the price spread between the two sales mechanisms decreases, at an increasing rate. Higher variation in property prices in a region also decreases the price spread between the two sales mechanisms at an increasing rate. Both of these results provide support for Hypothesis 3, which argues that the ratio of the expected price from an auction to that of negotiated sale is higher for more homogenous units. More volatile changes in the property market decrease the price spread by −0.004%. A distressed sale decreases the price spread by 0.01%. Up market conditions increase the price spread by 0.06% and down market conditions increase the price spread by 0.04%. This result supports our theoretical prediction stated in Hypothesis 1. Hypothesis 1 proposes that when

Table 6 ■ Predictive power of price equations and probit model.

	Obs.	Mean	Median	Std. Dev.	Min.	Max.	Change from Actual (%)
Auction							
apriceheck	777	1,124,379	858,661	847,535	283,409	7,557,136	−4
aprice	777	1,171,383	880,000	1,210,879	200,000	17,800,000	
Negotiated Sale							
nspriceheck	2,245	939,774	614,844	1,014,660	0	24,700,000	−18
nsprice	2,245	1,151,552	760,838	1,302,086	135,000	18,000,000	
Predictions from Probit Model							
Probit Est.	3,022	0.7451	0.7846	0.2538	0	1	
Actual	3,022	0.7429	1.0000	0.4371	0	1	

Notes: This table compares the predicted prices from the estimated price equations (Equations (7) and (8)) with the actual transacted prices. The predicted prices are estimated in natural logarithm and have been transformed to levels. We follow the computation suggested in Cameron and Trivedi (2009). *apriceheck* is the estimated auction price in levels; *aprice* is the actual transacted price for the property sold through auction. *nspriceheck* is the estimated negotiated sale price in levels; *nsprice* is the actual transacted price for the property sold through negotiated sale. Table 6 also compares the predictions of the probit/selection (Equation (4)) model with actual data. The dependent variable in the probit model is a binary variable with the value of one to indicate a sale by negotiated sale, and a value of zero to indicate a sale by auction.

Table 7 ■ Regression estimation explaining for price spread between auction and negotiated sale.

Independent Var.	Full Sample	Low 30th Subgroup	Mid 40 Subgroup	Top 30th Subgroup
Constant	0.1980**	0.1388**	0.1357**	0.2448**
	(7.25)	(9.92)	(13.15)	(7.12)
mdistpc	−0.1019**	0.0116	−0.0142	−0.1762**
	−(2.98)	(0.74)	−(0.94)	−(4.25)
mdistpc2	0.0352**	−0.0061	0.0010	0.0513**
	(2.55)	−(0.88)	(0.14)	(3.48)
mdistprice	−0.0948**	−0.1054**	−0.0719**	−0.0302
	−(5.83)	−(7.67)	−(6.50)	−(1.50)
mdistprice2	0.0280**	0.0262**	0.0171**	0.0159**
	(5.22)	(5.12)	(4.20)	(2.36)
Mktmovt	−0.0039**	−0.0043**	−0.0038**	−0.0043**
	−(25.46)	−(9.44)	−(17.07)	−(21.67)
Forcedsale	−0.0139**	−0.0070	−0.0045	−0.0102
	−(2.75)	−(1.00)	−(0.80)	−(1.07)
dum_up	0.0647**	0.0605**	0.0648**	0.0404**
	(10.09)	(4.65)	(6.58)	(3.99)
dum_down	0.0369**	0.0467**	0.0477**	0.0046
	(3.69)	(2.19)	(4.65)	(0.28)
fs × *dumup*	0.1393**	0.1238**	0.1443	0.1381**
	(17.49)	(8.03)	(12.94)	(10.58)
fs × *dumdown*	−0.0562**	−0.0698**	−0.0712**	−0.0345*
	−(4.94)	−(2.97)	−(5.79)	−(1.83)
No. of Obs.	3022	915	1214	893
F-Stat.	230.72	47.95	111.39	156.63
R^2	0.5628	0.3837	0.5359	0.7419
Root MSE	0.0868	0.0836	0.07427	0.0862

Notes: This table presents the regression (see Equation (10)) that examines the price spread between the auction and negotiated sale mechanisms. In this regression, we are analyzing the price differential with property characteristics, price fluctuations, market movements and foreclosure sales. The dependent variable is the estimated percentage price differential between auction and negotiated sale (see Equation (9)). The regressors *mdistpc* and *mdistprice* are derived using the Mahalanobis approach to measure the covariance-adjusted differences in the transacted prices and property characteristics of property i from typical price levels and property characteristics in the data sample. *mdistpc2* is *mdistpc* × *mdistpc*, and *mdistprice2* is *mdistprice* × *mdistprice*. *mktmovt* measures the difference in property price index from the base price index. *forcedsale* is a dummy variable with the value one to indicate a distressed property. *dum_up* and *dum_down* are dummy variables representing the state of the market. *fs* × *dumup* and *fs* × *dumdown* are interaction terms that captures both *forcedsale* and market effects. The t-statistics are reported in parentheses below the coefficients and are estimated with heteroskedasticity-robust Huebner/White standard errors.
** and * indicate significance levels of 5% and 10%, respectively.

Table 8 ■ Estimated price differentials.

	Obs.	Median	Mean	Std. Dev.	Min.	Max.
Pricediffhat: Overall Sample						
pricediffhat	3,022	0.06	0.06	0.13	−0.28	3.84
Pricediffhat by Property Type						
dum_apt	1,786	0.08	0.07	0.11	−0.25	0.41
Non dum_apt	1,236	0.01	0.03	0.16	−0.28	3.84
dum_ter	425	0.00	0.02	0.10	−0.26	0.33
dum_sd	472	0.05	0.06	0.11	−0.24	0.67
dum_det	339	−0.05	−0.01	0.24	−0.28	3.84
Pricediffhat: Low 30th Subgroup						
Pricediffhat	915	0.01	0.03	0.11	−0.25	0.36
Pricediffhat: Mid 40 Subgroup						
Pricediffhat	1,214	0.05	0.05	0.11	−0.28	0.41
Pricediffhat: Top 30th Subgroup						
Pricediffhat	893	0.08	0.09	0.17	−0.26	3.84

Notes: This table summarizes estimated price differentials based on Equation (9). It presents estimated price differentials for the overall sample, the low 30th subgroup, the mid 40 subgroup and the top 30th subgroup.

demand in the market is stronger, that is, when the number of bidders/buyers in the market is larger, the expected selling price under the auction mechanism becomes relatively higher than under the negotiated sale mechanism. Finally, a distressed property sold during an up market increases the price spread by 0.14%.

We find some differences across the three subgroups. Differences in property characteristics are statistically significant in explaining the variations in the price spread for the top 30th subgroup but not for the low 30th subgroup and the mid 40 subgroup. On the other hand, higher variation in property prices are statistically significant in explaining variations in the price spread between the two sales mechanisms for the low 30th and mid 40 subgroups, but not for the top 30th subgroup. Whether the property is a distressed property is not statistically significant in any of the three subgroups, but is statistically significant in the full sample. In Singapore, auctions do not necessarily generate a higher premium for foreclosed properties. In an up market, the price spread is higher in the low 30th and mid 40 subgroups than in the top 30th subgroup. In a down market, the price spread increases by 0.04% for the first two subgroups, but is statistically insignificant. The interaction effect of a distressed property and different market conditions is statistically significant and contributes to a wider price spread during up market conditions and to a narrower price spread in down market conditions.

Table 8 displays a summary of the estimated price differentials based on Equation (9). It summarizes the average estimated percentage price differentials when property i is sold through auction versus sold through negotiated sale. On average, we find that auction sales are 6% higher than negotiated sales, and this premium increases as we move from the low 30th (3%), to the mid 40 (5%) and the top 30th (9%) subgroups. This result supports our theoretical prediction stated in Hypothesis 2. Hypothesis 2 predicts that the ratio of the expected price from an auction to that of negotiated sale is highest in the upper subgroup of the market, followed by the middle and lower subgroups of the market. If we examine the price spread by property types (homogenous—apartments vs. heterogeneous—nonapartments), we find that the auction premium is 7% for apartments and 3% for nonapartments. This result provides further support for the theoretical prediction of Hypothesis 3 that the ratio of the expected price from an auction to that of negotiated sale is higher for more homogenous units.

Conclusion

In this article, we started with a simple question: "Does the same property sell for the same price under different sales mechanisms, specifically, auction versus negotiated sales?" Although this is not a new question in the literature, the answers provided in previous studies vary widely. Lusht (1996) and Quan (2002) find that auctioned properties obtain a price premium, while Mayer (1998) finds that auctioned properties suffer a price discount compared to negotiated sales properties. In our article, we find that the answer to this research question depends on property type and market conditions. Homogenous properties (apartments) obtain higher price premiums than heterogeneous properties (terrace, semidetached and detached houses) when they are sold through auction. Auctions also generate a higher price premium in up markets and for higher end properties.

In comparing the performance of auction sales and negotiated sales, prior research has focused on such factors as transaction costs and also holding costs in the analysis. Our article extends this line of research by considering the impact of product heterogeneity, market conditions and market segmentation. Our results illustrate that in deciding whether to sell or buy a property through auction or negotiated sale, a market participant should consider not only holding costs, transaction costs and value of the property, but also the property characteristics, price segment of the property and market conditions.

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