Right of First Refusal (ROFR) Effects in Auctions with Reserve Price: Empirical Evidence from Taiwanese Government Land Auctions

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Abstract

The *right-of-first-refusal* (ROFR) granted by the seller to a buyer that allows the favored buyer to purchase the asset at the highest price the seller can obtain from other competing buyers is common in auctions and other economic transactions. Yet the predictions of the theory on the impact of this hybrid mechanism on auction outcomes have not been tested using real-world transaction data. Hence, our knowledge of the practical economic impact of this hybrid auction that decouples price formation and allocation on bidder behavior and ultimately expected seller revenue and profit is quite limited. This paper presents the first empirical evidence on the effects of ROFR from 1012 first-price sealed-bid auctions for the sale of government owned land in Taiwan from 2007 to 2010. The main findings are as follows. An auction with the ROFR has significant negative effect on auction success, i.e. it decreases the likelihood of asset sale. Further, we find that the presence of ROFR in an auction: (i) discourages bidder entry into auction, (ii) creates incentive for bidders to bid less aggressively, and (iii) ultimately reduces seller expected revenue and profit. Interestingly, in almost all the margins of auction outcomes we analyzed the reserve price tends to offset the effects of the ROFR, and the ROFR in turn has significant negative effect on the level of reserve price set by the seller. Overall, the weight of our empirical evidence provide support for the branch of the theory that predicts negative impact of ROFR on auction outcomes, and thus questions the wisdom of granting the ROFR.

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Key Words: auctions, right-of-first-refusal, mechanism design, reserve price, real estate

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Introduction

A recurring theme in the auction literature is how auction design itself affects the margins of auction outcomes (Vickery [1961], Myerson [1981], and Engelbrecht-Wiggans [1987]). More specifically, attention has focused on how an auction should be designed to maximize seller expected payoff. In this context, an extant issue of great interest in the economics of applied auction design centers on the *right-of-first-refusal* (ROFR), an auction policy tool that allows the holder of the right to subsequently win the auction and acquire the asset simply by matching the highest bid of the other competing bidders in the auction. Although, it is tempting to think of the ROFR clause as akin to a regular option, conceptually it is different. Unlike a true option the time to exercise the ROFR is purely at the whim of the seller (not the right holder) as determined by the receipt of a bona fide offer from a competing bidder in the auction.

Auctions with ROFR are interesting especially when compared to standard auctions where the winner of the auction is *ipso facto* the highest bidder. Unlike a standard auction an auction with ROFR does not commit the auctioneer (seller) to selling the asset to the highest bidder (or purchasing from the lowest bidder in case of procurement auctions). Essentially, auctions with ROFR decouple price discovery (the bids received) from allocation of the asset. This implies that the final winner is at the discretion of the seller and may not necessarily be the bidder with the highest valuation. At issue is how this applied auction design impacts entry into auctions, bidders' behavior and ultimately seller expected revenue and profit. These are important empirical questions whose relevance transcends the immediate confines of auctions with ROFR to include the class of applied auction design that combine the market competition of pure auction and a non-competitive arrangement to determine the ultimate auction winner.[3]

In this paper, we focus on the effects of auctions with ROFR on margins of auction outcomes. It is worth emphasizing that in this hybrid mechanism the auction itself does not determine the winner; rather the auctioneer uses the price set by the auction to exert some control over who gets to be the ultimate winner. Although an auction with a ROFR is a form of favoritism

[3] In a procurement process, Englebrecht-Wiggans and Katok (2004) examine theoretically and in laboratory setting the performance of a hybrid mechanism that combines an auction with a non-competitive sales contract. They find that this hybrid mechanism reduces the buyers cost relative to a pure standard auction. They stress that this cost reduction endures without considering the potential benefits from establish long-term relations between the buyer and the supplier.

bestowed the "favored" bidder, it is frequently found in a variety of economic transactions. It is often utilized in procurement auctions to award government contracts and by firms buying inputs, where in this case the auctioneer is seeking a low price rather than a high price[4]. Other economic transactions involving vast amount of money, for example transactions on interests in partnerships and closely held corporations[5], real estate[6], professional sports contracts[7], entertainment contracts[8], and venture capital financing are commonly consummated using the ROFR mechanism. In all these economic transactions, at least one "favored" bidder (the right holder) has distinct comparative advantage over other bidders.

The prevalent use of the ROFR in economic transactions has spawned a burgeoning theoretical literature (which we review below) that provides predictions of the effects of this auction policy tool on the margins of auction outcomes.[9] Although the theory has been important in developing our understanding of this hybrid auction mechanism, it nevertheless offers competing predictions regarding its effects on auction outcomes. Remarkably, despite the pervasive use of ROFR in economic transactions the competing and often conflicting predictions of the theory have not been empirically tested using real-world transactions data.[10] Hence, the practical impacts of this auction policy tool on the outcomes of real-world

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[4] The National Park Service (NPS) has used the right-of-first-refusal to auction concession contracts on Federal lands sine 1965. Concession contract is big business producing gross revenue of about $2.2 billion in 1994. In 2000 the NPS withdrew the right from all incumbent concessioners grossing $500,000 and above based on several General Accounting Office reports alleging that the right has detrimental effect on competition and revenue to the federal government.

[5] It is a common feature in contracts for the eventual dissolution of business (See Brooks and Spiers, 2004)

[6] ROFR is often found in real estate transactions either in the form of contractual clause or by legal statute. For example in the District of Columbia the Tenant Opportunity to Purchase Act gives the tenant ROFR when the owner wants to sell the property. Similarly, in both Britain and France property laws protect the tenant by granting her the ROFR in the sale of the rental property. Grooskopf and Roth (2005) analyze Britain's Landlord and Tenant Act of 1987 that stipulates that tenants of flats in England and Wales have the right to purchase their flat before the landlord can offer it to a third party. They find that the specific characteristic of the right can work to disadvantage the right holder

[7] In the National Football League (NFL) the incumbent team has the right to match the best offer a player has from another team to retain the player once he becomes a restricted free agent.

[8] In 2001 Paramount Studios, the producer of the successful TV show *Frasier*, renegotiated its expired contract with NBC, where NBC, as the incumbent network at the time held the ROFR. NBS was given 10 days to match the terms offered by CBS (See Grosskopf and Roth 2009)

[9] One conventional justification offered for granting ROFR in economic transactions is that it serves to level the playing field between a weak bidder and a strong bidder that is more likely to have a high valuation for the object (Lee, 2008). Yet another explanation for ROFR is to mitigate breakdown in bargaining and exit from a market (Walker 1999).

[10] In an experimental setting, Grosskopf and Roth (2005) find that the right may disadvantage the holder. Although their findings are insightful the experiment was based on a special type ROFR (a combination of

economic transactions are still not well understood. Indeed, our knowledge of its practical economic effects is at best quite limited.

This paper contributes to the empirical auction literature by being the first to provide empirical evidence on the effects of the ROFR on auction outcomes from 1012 first-price sealed-bid auctions for the sale of government-owned lands in Taiwan conducted between 2007 and 2010. At a policy level, the motivation for our analysis is to provide empirical evidence regarding the impact of the ROFR on a rich set of auction outcomes aiming discriminate among the competing predictions highlighted by theory. Specifically, we use our unique data set to fill the empirical void by investigating the impact of auctions with ROFR on several margins of bidders' behavior and seller payoff expectations including: (1) the probability of auction success, (2) the number of bidders that enter the auctions, (3) bidding behavior within the auctions, and (4) seller expected revenue and profit. Intuitively, since the auctions we analyze also uniformly employ the *reserve price* in combination with the ROFR, we provide insights on the determinants of reserve price set by the seller; in particular we shed light on whether the ROFR influences the level of reserve price set by the seller.[11]

Our key findings regarding the effects of ROFR on the margins of auction outcomes emphasized by theory are as follows. First, ROFR has significant negative effect on the probability of auction success, i.e. it decreases the likelihood of asset sale. To the best of our knowledge this is the first direct empirical evidence of the negative impact of ROFR on asset sale in auctions. Second, ROFR reduces the number of actual bidders that enter the auctions, creates incentive for bidders to bid less aggressively within auctions, which we find ultimately reduces expected seller revenue and profit. These findings are the more economically important given that the vast majority of procurement auctions actually used in practice are hybrid mechanisms (like auctions with ROFR) that decouple price formation and allocation, which creates flexibility for the auctioneer to accomplish other goals such as establishing long-term relationship.

Third, and interestingly, in all the standard margins of auction outcomes we investigate, except bidders' entry into auctions, the reserve price offsets, although partially, the negative

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right of first offer and right of first refusal) and instead of an auction they used sequential negotiation format.

[11] Lee (2008) argues that the ROFR and reserve price are complementary auction policy tools for reducing asymmetry (leveling the playing field) between weak bidders and strong bidders in certain situations. Further, the two auction policy tools may exhibit counterbalancing effects in terms of impact on auction outcomes.

effects of the ROFR. Fourth, the effect of the ROFR on auction outcomes is also sensitive to market and asset characteristics such as location of the asset to be auctioned and land use type. In this regard, there are important market dynamics and asset differences that affect entry into auctions and ultimately seller expected payoff, quite apart from those emanating from the ROFR and the reserve price. Finally, on the determinants of the reserve price, we find among other factors, the ROFR reduces significantly the level of reserve price set by the seller.

The empirical results are robust after controlling for possible endogeneity of the reserve price, and the *corner solution outcome* associated with response variables (dependent variable) in successful auctions.[12] Mapping our overall results back to theory, on the substantive issue regarding the effect of ROFR on auction outcomes, we can discriminate in favor of the branch of the theory that predicts that the ROFR will have negative effect on margins of auction outcomes especially seller expected revenue and profit. Hence, the conclusion we draw from the empirical evidence is that it may not be in the best interest of the seller to grant the buyer *the-right-of-first refusal,* unless there is some upfront compensation from the right holder to the seller, or some other unstated objective such as using the mechanism to facilitate long-term relationship between the buyer and the supplier in procurement process.

Our work contributes to the empirical literature on the impact of auction design in several ways. First, we present for the first time empirical evidence from 1012 first-price sealed-bid auctions of the effects ROFR on several margins of auction outcomes that theory labelled but waiting for empirical validation. Indeed, as stated earlier there has been an upsurge of interest in theoretical work on the effect of auctions with ROFR, but this type of mechanism has not been analyzed empirically. Second, our findings indirectly evaluate the possible economic consequences of hybrid auction mechanisms where the pure auction component of the mechanism determines price, but the seller retains some control over who gets to be the eventually winner. In particular, we shed empirical light on the possible detrimental effects of such class of hybrid mechanisms most often used in practice that combine auction with non-competitive bidding where hitherto our understanding of their effects on auction outcomes is limited.

[12] For example, the optimal value for the response variable, winning bid, is zero with positive probability for some potential bidder, but is strictly positive and continues for other bidders.

Third, this paper provides empirical evidence on the possible interactive or counterbalancing effects between the ROFR and reserve price highlighted in the theoretical literature. Specifically, we provide empirical support for the proposition that depending on the degree of asymmetry between a weak bidder (who is favored) and a strong bidder, the ROFR when combined with the reserve price, would tend to offset each other's effect on auction outcomes [see Lee 2008]. Fourth, we also contribute to the growing empirical literature that investigates whether the behavior of bidders is consistent with standard auction theory. In this regard, we find empirical evidence consistent with auction theory in that higher reserve price discourages entry of bidders, but increases the winning bid and ultimately seller's expected revenue and profit. However, the reserve price is not independent of the number of bidders, contrary to prescription of theory. Further, the reserve price set by the seller correlates negatively with the ROFR. To the best of our knowledge this is the first empirical evidence of the impact of ROFR on the reserve price set by the seller.

The remainder of the paper is organized as follows. Section 2 briefly reviews the theoretical predictions of the effects of ROFR on auction outcomes. Section 3 discusses the institutional features of Taiwan government land auctions, and presents our analytical model of bidder behavior and seller expected payoff in the auctions. Section 4 describes the data and provides descriptive statistics on various dimensions of the sample. Section 5 discusses the results of our multiple regression analysis on the impact of the ROFR and reserve price on the margins of auction outcomes. Section 6 uses the results from this study to evaluate some major economic transactions that used the ROFR to accomplish the transaction, and the final section concludes with a summary and direction for future research.

2. Theoretical Background

To be precise, theory provides competing predictions regarding the impact of the ROFR on the margins of auction outcomes we analyze in this paper. Moreover, the theory is essentially silent on whether the ROFR influences the level of reserve price set by the lender. For ease of discussion we have broadly grouped the theoretical papers into two: papers that predict granting the ROFR can increase the seller expected revenue or the joint profit of the seller and the right holder, and those that essentially predict the opposite, namely that the presence of ROFR in auctions reduces seller expected payoff or has negative effects on auction outcomes.

In a first-price procurement auction, Burget and Perry (2009) show that the expected joint surplus of the buyer and the supplier is maximized if the supplier is granted the ROFR than would be using a standard first-price auction. This result is conditional on the right being auctioned off to the highest bidder beforehand, which suggests that granting the ROFR for free never benefits the seller. Choi (2008) discusses the effect of ROFR in a modified two-bidder auction where the right-holder gets to observe the bid of the non-favored bidder before making her own. He shows that when the favored bidder wins the auction, the ROFR increases the joint profit of the seller and the favored bidder at the expense of non-favored bidder. However, the paper also finds that ROFR may at times lead to inefficient allocation or decrease social welfare because the favored bidder may win the auction even if her private valuation is less than that of the non-favored bidder.

A recent paper by Elmaghraby et al (2011) models the ROFR in a two-stage sequential auction with earlier release of information. They show that the seller can increase her revenue compared to a single auction or sequential auction executed without ROFR. However, as stressed by the authors this result hinges on information flow and the timing of its release. In a procurement setting, Lee (2008) models the effects of ROFR in a first-price sealed-bid auction with two asymmetric bidders, weak bidder and strong bidder. He shows that when the asymmetry between the weak bidder and the strong bidder is sufficiently large, granting the weak bidder the ROFR levels the playing field, thereby eliciting more aggressive bidding from the strong competitor, which maximizes the seller's expected payoff. Further, he shows that when the ROFR is combined with the reserve price the ROFR benefits the seller strictly at intermediate levels of asymmetry. And that at other levels of asymmetry the reserve price neutralizes the effects of ROFR. [13]. Rothkopf et al (2003) find that in an asymmetric auction, offering some degree of favoritism in the form of adjusted bids generally benefits the seller.

The cluster of theoretical work that predicts negative effect of ROFR on auction outcomes or seller expected payoff includes the following papers. Atozamena and Weinschelbaum (2006), assuming independent private values (IPV), conclude that no auction mechanism that includes the ROFR is capable of maximizing the joint expected surplus of the seller and right holder. Moreover, such auction design would be suboptimal. Bikhchandani et al (2004) discuss the impacts of the ROFR on auction outcome in a second-price sealed-bid auction

[13] In this context one can think of ROFR and reserve price as substitutes in terms influencing expected surplus or profit of the seller (see Lee (2008)).

where bidders observe private signal about their valuations. They conclude that the ROFR is inefficient in that the bidder with the highest value does not necessarily win and it benefits only the right holder at the expense of the seller and other competing buyers. Moreover, when bidders' valuations are correlated, the ROFR exacerbates the winner's curse. Based on their results, Bikhchandani et al caution that sellers should exercise extreme caution when considering whether or not to grant the ROFR.

In a paper prompted by the decision of U.S. National Park Service (NPS) to eliminate the ROFR in some of its concession contracts, Chouinard (2005) plausibly concludes that the NSP is indeed better off without the ROFR in its concession contract auctions. Specifically, Chouinard shows that the expected value to the seller of a standard auction without ROFR exceeds that of an auction with ROFR. Kahan et al (2012) discuss the ROFR in a multiple-buyer sequential bargaining setting (not auctions). They find that the right not only transfers benefits from the other buyers to the right-holder, but may also force the seller to make suboptimal offers. Overall, this latter theoretical group predicts that the ROFR will negatively impact auction outcomes such as entry and ultimately seller expected revenue and profit.

The fact the theory is conflicting regarding the impact of ROFR as a policy tool in auctions makes the question of who wins versus who loses in auctions with ROFR an empirical one. We contribute to the auction literature by providing credible empirical evidence of the causal effects of ROFR on the margins of bidder behavior and seller expected payoff, and in the process discriminate among the competing predictions of the theory. Additionally, the theory stresses the interaction between the ROFR and the reserve price as auction policy tools for leveling the playing field between asymmetric bidders (see Lee, 2008). We shed light on the nature of this possible interaction between the two auction policy tools as well as whether the ROFR influences the level of reserve price set by the seller.

3.0 Institutional Auction Background, Models of Bidder Behavior and Seller Expected Value

In this section, we first provide a description of the institutional setting of Taiwan auctions for sale of government-owned lands. Auctions have been used to sell several millions of square meters of government-owned land involving vast amounts of money. We use the knowledge gained to model bidder strategy and seller expected payoff in subsequent auctions aiming to capture the key institutional features of the auction design. In particular, the models of bidder strategy and seller expected revenue reflect the role of the two auction policy tools, ROFR and reserve price, on auction outcomes.

3.1 Institutional Background of Taiwan Land Auctions

Since 2002, auctions have been used to sell government-owned lands in Taiwan. The auction mechanism used is a first-price sealed-bid auction. An interesting feature of these auctions is that the ROFR is granted to some potential buyers of the property to be auctioned. As stated earlier this right allows the right-holder the opportunity to buy the property being auctioned simply by matching the highest price obtained by the government from a third party in the auction. In addition to the ROFR, another applied auction design uniformly found in the auctions is the *reserve price*, the price below which the government will not sell the real estate asset.

The Taiwanese ROFR is granted by legal statute as contained in various articles of the Land Act of 1930.[14] As prescribed by the relevant articles of the Act, the ROFR is invoked in the sale or disposition of shares of government-owned lands, ownership of co-owned real estate, leased land or building, leased farmland, and lands where private property rights have become vested in the government as a result of non-compliance with applicable provisions of the land law. For example, article 104 of the Land Act (page 29) that governs the sale or disposition of leased land or building states:

> *"When the building site is offered for sale, the lessee shall have preference right* (ROFR, emphasis ours) *to purchase it on the same terms as are offered to any other person, and when the house on the leased site is offered for sale, the owner of the site shall have preferential right to purchase it on the same terms as are offered to any other person"*

Branch offices of the National Property Administration (NPA) of the Taiwan Ministry of Finance, from time to time, conduct public auctions for the sale of government-owned real

[14] The Taiwan Land Act is a broad statute that inter alia governs all manner of property rights, restrictions on property rights, circumstances under which private land becomes vested in the government, land use type, situations that give rise to right-of-first-refusal in the sale or disposition of property rights, etc. Articles 34-1, 73-1, 104, and 107, respectively deal with right-of-first-refusal in connection with the sale of land or building under co-ownership, government owned land or land whereof private ownership is extinguished and vested in the government, leased land or building, and leased farm. The Act was first promulgated on June 30, 1930 and became enforceable on March 1, 1936. In nearly a century of its existence the Act has been amended ten times; the latest amendment occurred on June 15, 2011.

estate for non-public use. Potential bidders must submit bids in prescribed form accompanied by a deposit (10% of the reserve price) in the form of money order or bank draft.[15] This payment allows bidders to determine their private valuation of the property being auctioned based on the information released by the administrative office and their own private information. The information released by a branch office includes reserve price, the presence or absence of the ROFR on the asset to be auctioned, location of the land, land area in square meters, floor area if there is a building on the land, and the date for the auction.

During the bid-tender period the administrative office conducting the auction is not permitted to open bids and is explicitly forbidden from revealing bid information. Bids are opened publicly on the day of the auction to determine the winning bid. The winning bid is the highest bid among all bids submitted. If there is more than one bid with the highest price, the winner is awarded by lottery. Then if someone holds the ROFR on the property to be auctioned the process enters its second stage where the holder of the right gets to observe the winning bid. If the right holder matches the winning bid she acquires the property at the winning bid. If not the non-favored bidder with the highest bid acquires the property and pays the winning bid price since this is a first-price sealed-bid auction.

The typical bidder or buyer in such auctions is a property developer buying the real estate for subsequent conversion into residential, commercial or mixed use and not for resale of the land acquired. Given the absence of resale motive *independent private value* (IPV) seems appropriate as paradigm governing the auctions for the sale of government land in Taiwan. Moreover, from an economic perspective, it is likely that ex ante bidders are asymmetric in terms of value proposition, expertise, and production efficiencies, relating to the ultimate *highest and best use* for the acquired real estate, further justifying the IPV assumption. Based on these arguments we consider asymmetric IPV in modeling bidder strategy and expected seller payoff in auctions with and without ROFR, where the seller imposes also the reserve price.

3.2 Modeling Bidder Strategy and Seller Expected Value

As the basis for our analytical model, we want to capture the essential institutional features of the setting for the Taiwan government first-price sealed-bid auction in which potential

[15] The deposit is refunded to losing bidders. The price paid by winning bidders is the winning bid minus the deposit. Consequently the real cost of participating in the auction is the opportunity cost of the deposit (or the interest forgone) and other associated cost of preparing bids and entering the auction. We do not model these costs.

bidders know that at least one of the bidders is favored in some of the auctions. Specifically, we first model an equilibrium bidding strategy in which a favored bidder(s) is granted the ROFR by statute which gives her an opportunity to win the auction by matching the highest bid of a competing non-favored bidder. This setting implies that the favored bidder has the advantage of knowing the private bid of the non-favored competitor at some stage in the auction process. We then model and contrast this with the bidding strategy in a standard first-price sealed bid auction with no ROFR. From the equilibrium strategies we sketch out the seller's expected value under the auction with ROFR and under a standard first-price sealed bid auction with no ROFR. We then deduce which of the two auction designs result in higher payoff to the seller.

Our approach in modeling the bidder's strategy follows Chouinard (2005), Choi (2009) and Lee (2008). There are three risk-neutral profit maximizing players, a favored buyer (B_F) with a statutory granted ROFR, a non-favored buyer (B_{NF}) with no ROFR, and the government, the seller (S), who wants to sell an indivisible real estate asset. Each bidder has a private value v drawn independently and uniformly from a common distribution $F(\cdot)$ with density function $f(\cdot)$ and support [0, 1]. This information is common knowledge among the players. However, each bidder's value depends on the bidder's private information that is not known by the competing bidders.

A strategy for a bidder that maps her true value v to a non-negative bid b is a function $s(v)=b$. We make the following two assumptions about the bidder's strategy: (1) $s(\cdot)$ is a differentiable function that is strictly increasing, such that two bidders with different values will have different bids, and (2) $s(v) \leq v$ for all v, so that bidders can shade down their bids, but will never bid above their true values. Upon payment of a deposit both the favored bidder, B_F, and the non-favored, B_{NF}, learn their private valuations, v_f, v_{nf}, respectively. Prior to the start of the auction a reserve price or minimum bid, b_m, is announced by the auctioneer, and no bid below this minimum bid will be accepted. If there is no bid $\geq b_m$ the auction fails and the government retains the asset for a later auction.

3.2.1: Bidder Strategy in Auctions with ROFR

We envisage a two-stage first-price sealed-bid auction as follows: (1) B_{NF}, the non-favored bidder, bids b_{nf}; (2) the favored bidder observes b_{nf} and decides whether or not to match b_{nf}; and (3) B_F matches b_{nf} and acquires the asset at b_{nf}, otherwise B_{NF} acquires the asset at b_{nf}. In this setting, B_{NF} realizes that the only way she can win the auction is if her bid, b_{nf}, is greater than the valuation of the favored bidder, v_f. Otherwise the favored bidder will always win the auction by exercising her ROFR and matching b_{nf}. Then the expected profit of the non-favored bidder is $E(\pi_{nf}) = (v_{nf} - s(b_{nf}))P(b_{nf} > v_f)$, where $v_{nf} - s(b_{nf})$, is the surplus or profit from the auction and $P(b_{nf} > v_f)$ is the probability of winning the auction. In this regard the non-favored bidder's probability of winning in the interval [0, 1] is exactly b_{nf}. Now if B_{NF} does win, she receives a payoff of $v_{nf} - s(b_{nf})$. Taking all of these into account, the expected payoff for the non-favored bidder can be written as:

$$g(v_{nf}) = (v_{nf} - s(b_{nf})b_{nf} \qquad (1)$$

From equation (1) the non-favored bidder's maximization problem is

$$\frac{\max}{b_{nf}}[v_{nf} - s(b_{nf})]b_{nf} \qquad (2)$$

Maximizing (2) subject to b_{nf} the first order condition is

$$v_{nf} - 2b_{nf} = 0 \qquad (3)$$

From equation (3) the solution for the optimal bid yields $b_{nf} = 1/2v_{nf}$. Thus the optimal strategy for the non-favored bidder knowing that she is competing with a favored bidder with private value drawn uniformly at random from the interval [0,1], is to bid half her true value, if the favored bidder is expected to do so as well. The non-favored bidder's complete optimal strategy, therefore is

$$s_{nf}(v_{nf}, b_f, b_m) = \begin{cases} v_{nf}/2 & if\ b_m \leq v_{nf}/2 \\ b_m & if\ v_{nf}/2 \leq b_m \leq v_{nf} \\ 0 & otherwise \end{cases} \qquad (4)$$

The favored bidder, B_F, will maximize the expected value of winning in stage two of the process.[16] At this point the favored bidder knows b_{nf} and her own private value signal, v_f. The favored bidder will exercise the ROFR if conditional on her own value (v_f) and the non-favored bidder's bid (b_{nf}), her expected valuation is larger than the non-favored bidder's bid. Hence, the favored bidder's equilibrium optimal strategy is,

[16] At this stage in the process the highest bid submitted by the non-favored bidder, b_{nf}, effectively becomes the reserve price faced by the favored bidder.

$$s_f(v_f, b_{nf}, b_m) = \begin{cases} b_{nf} & if\ b_m \le b_{nf} < v_f \\ b_{nf} & if\ b_{nf} \le v_f \le v_{nf} \\ 0 & otherwise \end{cases} \qquad (5)$$

Note that if the non-favored bidder bids an amount larger than the favored bidder's value, the favored bidder will not match; the non-favored bidder wins and the game is over. However, because the favored bidder simply has to match the non-favored bidder's bid she can win even with lower valuation as shown in the complete strategy of the favored bidder above. Since the favored bidder can win despite her lower valuation the ROFR creates inefficiency in allocating the asset to her, the size of which is given by $\int_{v_{nf}} \int_{v_f = b_{nf}(v_{nf})}^{vnf} (v_{nf} - v_f) f(v_f, v_{nf}) dv_f dv_{nf}$ (see Choi, 2009).

3.2.2: Bidder Strategy in Auctions without ROFR

In auctions without ROFR the bidders are somewhat symmetric as far as the auction design and we now assume that bids are submitted at the same time. It is well known in the auction literature that in a first-price sealed-bid auction with IPV and *n* bidders, the optimal strategy is to bid $s(v_i)=(n-1)/n \cdot v$, where v is the private valuation of the asset randomly drawn from the probability distribution function (see Milgrom (1987,1989), Milgrom and Weber (1982), McAfee and McMillin (1987), and Wofstetter (1996)). Hence, it is optimal for each bidder to shade her bid down by a factor of $(n-1)/n$, given that everyone else does the same. Under this circumstance the optimal bidding strategy for both bidders in our two-bidder scenario without ROFR translates to $s(v) = v/2$, i.e. each bidder should bid half her private valuation. Consequently, the complete bidding strategy for both bidders is

$$s_i(v_i, b_i, b_m) = \begin{cases} v_i / 2 & if\ b_m \le v_i / 2 \\ b_m & if\ v_i / 2 \le b_m \le v_i \\ 0 & otherwise \end{cases} \qquad (6)$$

Note that this equilibrium bidding strategy is the same as that of the non-favored bidder in the case of an auction with ROFR and a reserve price described above. So the non-favored bidder's bid is the same as when confronted with a favored bidder with ROFR.

3.2.3: Seller Expected Value under both auctions

In the context of a first-price sealed-bid auction with ROFR the seller expected revenue depends entirely on the highest bid which in turn depends on highest value. Then the price received by the seller is always the non-favored bidder's bid (whether the favored bidder matches or not) and the expected revenue of the seller is solely dependent on the bid function of the non-favored bidder. And given that the highest bid represents how much the non-favored bidder is willing to pay for the asset, the expected value, *E* (V_S), of the auction with ROFR to the seller can be written as[17]

$$E(V_S | ROFR) = \left[(v_{nf}/2)P(b_m \le v_{nf}/2) + (b_m)P(v_{nf}/2 \le b_m \le v_{nf})\right]P(b_{nf} > v_f) + \{ (b_{nf})P(b_m \le b_{nf} < v_f) + (b_m) \}P(b_{nf} < v_f), \quad (7)$$

where, *P* is probability.

In contrast, in the first-price sealed-bid auction without ROFR the expected value to the seller is equal to the sum of the bids of the favored bidder and the non-favored bidder.

$$E(V_S | no\ ROFR) = \left[(v_{nf}/2)P(b_m \le v_{nf}/2) + (b_m)P(v_{nf}/2 \le b_m \le v_{nf})\right]P(v_{nf} > v_f) + \{(v_f/2)P(b_m \le v_f/2) + (b_m)P(v_f/2 \le b_m \le v_f) \}P(v_{nf} < v_f \quad (8)$$

Careful inspection of equations (7) and (8) will show that the expected value to the seller under the first-price sealed-bid auction with ROFR is less than under a standard auction with no ROFR.

Given the results in (7) and (8) we expect the impact of ROFR on auction outcomes such as probability of auction success, entry of bidders, expected seller revenue and profit to be negative. Further, we note that the apparent reduction in the seller expected payoff engendered by the ROFR is most likely captured by the favored bidder if she matches. That is the favored bidder gains at the expense of at least the seller and possibly both the seller and non-favored bidder.

[17] More compactly and to the point, since the price the seller will receive is always the non-favored highest bid, paid either by the holder of ROFR if she exercised the right and matched the bid or by the non-favored bidder if she declined to match, the expected price paid to the seller (government) is solely determined by the non-favored bidder's bid function.

As previously modelled another feature of Taiwan government land auctions is the *reserve price,* which is made public before the commencement of an auction. Lee (2008) discussed above finds that when the seller grants the ROFR and simultaneously imposes a reserve price, the reserve price improves the expected profit or surplus of the seller from the auction and also counterbalances the effects of the ROFR, especially at high degrees of asymmetry between a weak bidder and a strong bidder. Hence, the combination of ROFR and reserve price in the auctions may be an attempt by the auctioneer to use the latter tool to mitigate the potential negative of impact of the ROFR on auction outcomes. It remains to be seen whether empirically the effects of the ROFR and reserve price on the margins of auction outcomes such as the probability of auction success or sale of the asset, number of bidders that enter auctions, bidder behavior within auctions, expected seller revenue and profit are in fact offsetting.

Finally, it is likely that setting the reserve price in the presence of the ROFR would require knowing the circumstances of the bidders, the nature of the asset being auctioned, as well as the market condition for the asset being auctioned. The literature on optimal auction design (e.g. Myerson(1981), Riley and Samuelson (1981)), suggests that the seller should set a sizable reserve price, one that exceeds her own private value for the asset in order to maximize expected revenue. However, in practice there may be reasons why a seller may ostensibly select "suboptimal" reserve prices. For example, while the optimal reserve price in IPV auctions should not depend on the number of bidders, if there are very few bidders the reserve price may very well be the key determinant of the winning bid or sale price at the auction, and hence the seller expected revenue. This may cause the reserve to correlate positively with the number of bidders.

More to the point, in the context of the auctions analyzed in this paper the "leveling the playing field effect" of the ROFR may cause bidders to behave differently from what standard game theoretic models suggest. Indeed, when the reserve price is too high such that $b_n \geq v_f$, the favored bidder should decline to match (not bid at all). The seller then presents a take-it-or-leave-it" proposition to the non-favored bidder, where she strategically bids the reserve price or minimum bid, b_m, so long as her private value, $v_{nf} > b_m$, and otherwise decline to bid. Thus it is important to understand how reserve prices are set in Taiwan government land auctions particularly when the auction mechanism includes ROFR. As a point of exit we end our empirical analysis by analyzing the determinants of reserve price in Taiwan government auctions with the view to isolating the nature of the effect of ROFR (if any) on the reserve price set by the seller.

4.0 Data Description and Descriptive Statistics

We analyze data from Taiwan on 1012 government auctions conducted between January 2007 and October 2010. The assets for sale are mainly undeveloped lands. The auction mechanism used is first-price sealed-bid auction. A key feature of the auction design which constitutes the major focus of this research is the ROFR found in some of the auctions. Additionally, all the auctions in our sample have reserve price, the minimum bid below which the government will not sell the asset.

The auctions are conducted by branch offices of the NPA in three regional locations including Taipei metropolitan area consisting of Taipei city and suburbs, Taichung metropolitan area consisting of Taichung city and suburbs, and Kaohsiung metropolitan area consisting Kaohsiung city and suburbs. Data were tediously collected on an original sample of 2639 auctions from the websites and files of the branch offices of the NPA. After purging the sample for missing data which were concentrated exclusively in Kaohsiung auctions, the final sample size was reduced to 2012 clean auctions from Taipei and Taichung metropolitan areas only.[18]

The data provide details of all real estate assets to be auctioned whether the auction was successful or not and contains information about: (1) property attributes such as land use type, location, size in square meters; and (2) auction design attributes such as the presence of ROFR, reserve price or minimum bid, the date of the auction, etc. Also for each auction in the sample we collected information about the condition of the market at the time of the auction, measured as the contemporaneous quarter's house price return index. The categorization of auctions by location of the real estate to be auctioned opens up the possibility of investigating the impact of ROFR and reserve price on auction outcomes across distinct real estate markets that may significantly differ in terms of market architecture, intrinsic value of the asset to seller and potential buyers, potential number of entrants, and ultimately demand for the asset to be auctioned.

[18] Although first-price sealed auctions for the sale of government-owned lands in Taiwan began in 2002, five years worth of data on auctions conducted between 2002 and 2006 were missing from the websites of the branch offices of NPA before this project was conceived. Hence, our study does not cover those missing periods. Additionally, in 2011 the government instructed the NPA to suspend auctions for the sale of state-owned land in prime locations in an effort to curb skyrocketing real estate prices, particularly in Taipei.

4.1: Summary Statistics

We begin analysis of the data by providing summary statistics for the total sample shown in Table 2. Panel A shows key statistics for the entire sample consisting of successful and failed auctions. Of the 2012 auctions conducted between 2007 and 2010, roughly 41% were successful or resulted in asset sale. In terms of the variable of interest, about 9% of the auctions had ROFR as a policy tool. Further, the auctions were predominantly for the sale of land for residential real estate development. Over the study period (2007-2010), on average, slightly more than two bidders (2.25) placed bids on a real estate to be auctioned, although there is noticeable variation in the number of bidders as measured by the standard deviation (5.43) which is more than twice the mean number of bidders. The maximum number of bidders over the same period was approximately 23 times the average. Figure 1 provides additional insights on the number bidders. Panel A1 shows that 59% of the auctions had no bidders, i.e. these auctions failed and the assets did not sell. The within auction bidder distribution is shown in Panel A2 of Figure 1. It is clear that most of the auctions (38%) that resulted in asset sale had only one bidder. Other prominent in-auction cluster of bidders manifest around 2, 3-7, 8-12, 13-17 bidders, after which the clustering starts to fade rapidly.

Further examination of Panel A of Table 2 provides some perspective on the heterogeneity of auctioned land based on size, reserve price and the winning bid or sale price. The average reserve price was NT$43,360,000 or US$1.55M. On average an auctioned property sold for NT$108.5M (US3.62M), or nearly two and half times the mean reserve price (NT$46.54M), with a standard deviation of NT$353.36 (US$11.78M). Remarkably, Panel A also reveals that a property sold for as high as NT$5.37B or US$179M. Properties to be auctioned are also heterogeneous in terms of size. The mean property size to be auctioned is 555 sq. meters (approximately 6,000 sq. feet.) and the maximum size is 8,812 sq. meters (approximately 95,000 sq. feet). To summarize we make two observations. First, it would seem that properties slated for government auctions are heterogeneous and high valued assets. Second, the variability in the number of bidders may be due to heterogeneity of auctioned properties, different valuations of the bidders, and the presence of ROFR.

Panel B of Table 2 presents descriptive statistics by presence and absence of the ROFR. In all cases of the standard margins of auction outcomes such as number of bidders, reserve price and winning bid, the median figures for auctions without ROFR are significantly higher than the corresponding figures for auctions with ROFR. Auctions with ROFR attract on average 1.37 bidders, while for auctions with no ROFR, on average, 2.33 bidders enter. Similarly, as shown by the z scores for the median values of both the reserve price (z=-3.75) and the winning bid (z=-2.04), auctions with no ROFR significantly dominate auctions with the ROFR on these margins of auction outcomes. We also note that auctions with no ROFR are more successful (42%) compared to auctions with ROFR (30%). Likewise, it appears bidders in an auctions with no ROFR bid more aggressively (as measured by the ratio of winning bid to reserve price) than in auctions with ROFR. Panel C presents descriptive evidence on in-auction bidders' behavior, which is consistent with that for whole sample discussed above. In combination the results in Panels B and C suggest that bidders' behavior differ across the two auction designs (i.e. with and without ROFR).

In Panel D, we provide descriptive evidence based on auction success (i.e. whether or not the asset is sold). Two observations stand out among the statistics. On average successful auctions have significantly higher reserve prices than failed auctions. The difference in the mean reserve price is NT$ 26.5M (US$0.88M) with t-value = 2.28, which is significant at the 1% level. Further, unsuccessful auctions, on average, have significantly higher incidence of ROFR than the successful auctions (10.16% versus 6.30%). The difference in means is 3.89 with t-value of 2.26% which is significant at the 5% level.

In Panel E we focus on descriptive statistics based on the location of the property to be auctioned for the whole sample. On average auctions attract more bidders if the property to be auctioned is located in the city compared to a suburban location (3.11 versus 1.38), on the order of 2.25:1. The seller, on average, sets the reserve prices for properties to be auctioned that are located within the city at a multiple of 3.7 times of those located in the suburbs. Whereas the winning bid for a property located in the city is more than twice the mean reserve price, the winning bid for a property located in the suburb is only about 1.8 times the reserve price. Although, properties to be auctioned located in the suburbs do command less premium, they nevertheless, are on average much bigger in terms of square meters than their city counterparts. These observations make sense given the scarcity of land in urban areas and the fact that land use developments in urban areas (core city) are typically characterized by *intensive margins* as opposed to *extensive margins* in the suburban areas.

In panel F we provide within auction statistics for only successful auctions using the same metrics; the statistical evidence pretty much mirrors that for the whole sample (successful and failed auctions) both qualitatively and in terms of significance of difference of means and medians. In passing, we note that asset returns appear to be more volatile in the core city than in the suburbs. Overall, these observations suggest there are fundamental differences in market architecture and microstructure between the city and suburban locations, which may influence bidder behavior.

Finally, Figures 2, 3, and 4 respectively plot mean reserve price against the number of bidders, seller expected revenue (winning bid) against the mean reserve price, and seller expected profit (winning bid minus reserve price) against the reserve price. We can make several observations from the figures. First, in Figure 2, reserve prices increase with the number of bidders. This descriptive evidence contradicts standard auction theory. Davis et al (2008) suggest that when the number of bidders is small as in this study the optimal reserve price becomes even more critical in maximizing seller revenue. And as such the number of bidders may correlate with the reserve price. Indeed, as shown in Figure 1B approximately 38% of the successful auctions that resulted in asset sale had only one bidder. In this situation, most likely it is the reserve price that determines the sale price (or seller expected revenue) at the auctions. Second, consistent with auction theory, both seller expected revenue and seller expected profit increase with reserve prices, as revealed in Figures 3 and 4, respectively.

5.0: Estimation Results

In this section, we report estimates from multiple regression models that test predictions of theory on the effects of ROFR on auction outcomes. Specifically, we provide empirical evidence on the impact of the auction policy tool of interest, ROFR, and the seller reserve price, on five margins of auction outcomes such as probability of auction success, the number of bidders that enter the auctions, bidders' behavior within the auctions, expected seller revenue, and expected seller profit. We also provide empirical evidence on the determinants of reserve prices set by the seller. With regard to the reserve price we are interested in knowing how the seller sets reserve prices because theory predicts that reserve price can help maximize seller revenue, but may also discourage entry, and that reserve prices should be independent of the number of bidders. Moreover, in the context of this study, theory also suggests that the ROFR (our auction tool of primary focus) when combined with the reserve price may act as complements or offset each other's effects on auction outcomes. Thus, we are interested in knowing whether the ROFR influences the level of reserve price set by the seller.

5.1: The Probability of Auction Success

A potential bidder should, in theory, enter the auction and bid if the benefit, *B,* exceeds the cost, *C,* of doing so. Ultimately, the success of an auction, i.e. asset sale, would depend on bidder entry and bidding behavior. We assume both the benefit and cost that collectively induce entry and bidding are functions of the attributes of the auction design, *X*, in particular the ROFR and reserve price, the attributes of the asset to be auctioned including market condition, *V*. Let

$$B = G(X,V) = \beta_x X + \beta_v + w \qquad (9),$$

and

$$C = J(X,V) = \gamma_x X + \gamma_v + u \qquad (10)$$

where w and u are error terms. The potential bidder enters the auction and bids in the auction when

$$B > C \Rightarrow (\beta_x - \gamma_x)X + (\beta_v - \gamma_v)V + w - u > 0 \Rightarrow \beta Z + \varepsilon > 0 \qquad (11)$$

where Z is the short-hand notation for the summation of the attributes, *X* and *V*. Equation (11) states basically that an auction is likely to be successful (i.e. result in asset sale) if the net benefit *(B-C)* from entry and bidding in the auction is positive.

One approach to the problem of relating the auction outcome probabilities (i.e. successful or failed auction) to the underlying characteristics of the auction design and the asset/market condition is the conditional logistic function (McFadden, 1974, 1976).

$$P_i = P(\beta Z_i + \varepsilon_i > 0) = P(\varepsilon_i > -\beta Z_i = 1/\left[1 + \exp(-\beta Z_i)\right] \qquad (12),$$

where, βZ_i is the ***i**th* auction's outcome index, which measures the likelihood that the auction is successful or not successful (i.e. whether the asset is sold or not). While the index cannot be measured directly it is a function of the observable determinants of the auction decision process, i.e. the characteristics of the auction design and asset/market condition. We approximate the index linearly as follows:

$$\beta\hat{Z}_i = \hat{\beta}_0 + \hat{\beta}_1 ROFR_i + \hat{\beta}_2 RP_i + \hat{\beta}_3 RPRD_i + \hat{\beta}_4 LSDUM_i + \hat{\beta}_5 (HRI_i - \overline{HRI}) + \hat{\beta}_6 LOCDUM_i + \varepsilon_i \qquad (13)$$

The variables of (13) are defined in Table 1. A problem arises in estimating equation (13) due to potential endogeneity of the reserve price (*RP*). For example, the reserve prices set by the government (the seller) may reflect the quality aspects of the property to be auctioned and/or the market condition. To correct for the endogeneity of the reserve prices and obtain consistent estimates of its effects we use the Smith and Blundell (1986) two-step procedure. The first step consists of a linear regression of the reserve price on asset size as instrumental variable. In the second step the residuals from the first step OLS, labeled *RPRD* above are calculated and included in the second stage regression, equation (13). An F-test shows a significant partial correlation between the reserve price and instrumental variable.

Table 4 reports the estimated logit coefficients for the probability of auction success where some of the auctions have the ROFR. Column 1 in the table shows the results from OLS regression of equation (13), which does not control for endogeneity of the reserve price, and column 2 shows the 2SLS regression results that correct for the endogeneity of the reserve price. Column 3 reports calculated adjusted probabilities or elasticities designed to reveal changes in probability of auction success for interesting values of the significant variables based on the 2SLS regression. The results show that ROFR has a significant negative effect on the probability of auction success (χ^2=4.16). Holding constant other auction design variables and attributes of the asset to be auctioned and market condition, the presence of ROFR in an auction lowers the probability of auction success by 12%, compared to a standard auction with no ROFR.

The above result suggests that the presence of ROFR in auctions will lower the probability the asset is sold. Further, the result hints at the possibility that the presence of the ROFR in auctions will have a negative effect on expected seller payoff. This is inconsistent with the prediction of the branch of the theory that predicts that granting the ROFR will maximize seller expected revenue or the joint profit of the seller and the right holder.

Turning attention to the other important auction policy tool, reserve price, we see that the coefficient on *RP* is positive but insignificant in the OLS regression. However, after correcting for possible endogeneity of the reserve price, the coefficient on the residuals from the first step regression (*RPRD*) is positive and highly significant, suggesting that the reserve price is indeed endogenous. The probability of auction success increases from 9.8% to 10.6% as the reserve price residual *(RPRD)* changes from 1 standard deviation below its mean to 1 standard deviation above its mean. In general, the theory suggests that a higher reserve discourages entry of marginal bidders and decrease the probability of sale. Hence, these results are somewhat inconsistent with standard auction theory.

We rationalize the results as follows. First, intuition suggests that a higher reserve price may also signal the seller's private information about quality and the true value of the asset to be auctioned. In this regard, a higher reserve price or an unexpected increase in the reserve price may signal a higher valuation of the asset to be auctioned, which may encourage (rather than discourage) bidder entry, especially entry of strong bidders (those with higher valuation). Moreover, taken together the negative and positive impacts of the ROFR and reserve price on auction success suggest that the two auction policy tools may indeed offset in their impacts (Lee, 2008). Thus bidder behavior is likely to be more strategic when a higher level of reserve price from the seller signals higher valuation for the property to be auctioned, hence the positive effect of reserve price residual on the probability of auction success.

The estimated probability of auction success equation also includes asset characteristics such as land use type, location of the property and a proxy for market condition at the time of the auction. It is clear that an auction is less likely to succeed if the property to be auctioned is located in the suburbs; the probability of auction success is 23% lower if the land to be auctioned is located in the suburb as shown by the calculated adjusted probability. In contrast an auction is more likely to result in sale of the asset to be auctioned if it is designated for residential development, and if the auction is conducted when market condition is more favorable as measured by the housing return index *(HRI)*. In estimating the auction success equation, we centered the *HRI* variable by subtracting the mean return index for all returns across all auctions, i.e. $(HRI - \overline{HRI})$. The coefficient on $(HRI - \overline{HRI})$ is positive; hence we interpret the adjusted probabilities as saying that when market return increase by 1 standard deviation above the typical return, i.e. a hot market, the probability of auction success or asset sale increases by approximately 9%.

5.2: Bidder Behavior within Auctions and Seller Expected Value

Prior to this study, the predictions of the theory as to whether the ROFR induces bidders to bid more or less aggressively has not been empirically verified using real-world transaction data. Likewise, the ultimate effect of the ROFR on seller expected revenue and profit has not been empirically documented. More generally, there is now an elevated interest in empirically testing whether the behaviors of buyers and sellers in auctions accord with auction theory in general. We contribute to this research by specifically estimating the causal effects of the ROFR, reserve price and other relevant factors on four margins of auction outcomes. These include (1) the number of bidders that enter the auction, (2) in-auction bidding behavior as measured by the bid premium, (3) seller expected revenue conditional on asset sale, (4) and seller expected profit conditional on auction success. For each of the four models of auction outcomes the multiple regression equation to be estimated takes the following form:

$$OUTCOME_{i,j=1,2,3.4} = \lambda_0 + \lambda_1 ROFR + \lambda_2 RP + \lambda_3 RPRD + \lambda_4 LSDUM + \lambda_5 (HRI - \overline{HRI}) + \lambda_6 LOCDUM + \varepsilon_i, \quad (14)$$

where j=1,2,3,4 denotes a specific auction outcome as stated above. With the exception of the auction outcome relating to the number of bidders that enter the auctions, we also include as regressor the centered number of bidders, $(NBDRS - \overline{NBDRS})$, by subtracting the mean number of bidders in all the auctions from the number of bidders variable before estimating the other auction outcomes, i.e. bidders' behavior within auctions, expected seller revenue and expected seller profit. Again all the variables are defined in Table 1.

In addition to the endogeneity problem highlighted earlier the estimation of these models of auction outcomes is complicated for another reason. In each of the four models of auction outcomes we observe a continuous non-zero value for the dependent variable, i.e. the number of bidders, bid premium, winning bid or expected seller revenue and expected profit, only for the successful auctions. For the unsuccessful auctions the optimal choice for the response variable (dependent variable) for some potential bidders takes a value of zero with positive probability, whose exclusion in OLS estimation can result in inconsistent and biased estimates of the coefficients, λ_i, in equation (14). Woolridge (2002) labels this problem "*corner solution outcome*", and we follow his recommendation to use the standard censored Tobit model to correct for the inconsistent and biased estimates of the coefficients from an OLS regression.[19] Adjusting for this problem requires taking into account both successful and unsuccessful auctions.

5.2.1 Bidder Entry into Auctions

Table 5 reports the estimation results for the number of bidders' outcome model. Column 1 presents baseline OLS estimates on the impact of ROFR and reserve price on the number of entrants. In this regression the coefficient on ROFR is negative but insignificant while

[19] Note that the issue here is not data observability problem as in censoring or truncation. Rather the dependent variable (.e.g. the auction outcome for some potential bidders) takes a value of zero with positive probability when the auction fails, but is a continuous random variable for other bidders when the auction is successful and the asset is sold.

coefficient on reserve price is positive and significant at the conventional level. Thus, conditional on asset sale, the reserve price increases the number of bidders who enter the auctions.

Column 2 shows the estimation results for the standard censored Tobit model based on the full sample that corrects for the corner solution outcome. Adjusting for the corner solution outcome turns out to be important. Both the coefficients on the ROFR and $(HRI - \overline{HRI})$ variables are now significant. Also, interestingly, the coefficient estimates for the Tobit MLE regression correspond to those of the OLS estimates in sign and the statistical significance of the estimates is similar, with the exception of those of the two variables mentioned earlier. The last but one column of Table 5 reports the results of Tobit MLE estimates that also corrects for the endogeneity of the reserve price.

It is clear from the regression results that granting the ROFR discourages entry of bidders into auctions as reflected by the negative and significant coefficient on the ROFR variable, which is consistent with the theory that the right may discourage the entry of marginal bidders. Note also that while the coefficients on both the reserve price and reserve price residuals are significant they have opposite signs. Specifically, the negative coefficient on the reserve price suggests that higher reserve price might discourage entry of potential and actual bidders. This result is consistent with standard auction theory that suggests that higher reserve price might weed out marginal bidders. However, it is possible for the prediction of theory to be violated. Indeed, we also see that the coefficient on the unexpected component of the reserve price, i.e. the residuals of the reserve price, has a positive sign and it is significant. To the extent that reserve prices act as signal for private value attached to the object by the seller, an unexpected increase in the reserve price may induce some bidders (the strong bidders) to enter the auction with the conviction that the asset to be auctioned is valuable enough, or more valuable than they thought.

As a final observation Table 5 shows that with the exception of the coefficient on reserve price, the absolute magnitudes of the Tobit estimates are at least twice as much as the OLS estimates. For example, the Tobit coefficient on ROFR reported in column 3 is roughly six times that of the OLS estimate. However, it is not informative to conclude from this that the Tobit model implies a much greater response of number of bidders to ROFR. To interpret the coefficients correctly we multiply the Tobit estimates by the adjustment factors given in Table 5 to obtain the marginal effects or elasticities for important variables. The adjusted marginal effects are reported in last column of Table 5. For example conditional on the number of bidders being positive (i.e. successful auctions), an auction design with ROFR (with other variables at their means) decreases expected number of bidders that enter the auction by -18% (.3227x-0.5606 = -0.1809).

However, unconditionally or accounting for both potential bidders who did not enter the auction as well as those who did enter and bid, we see that the magnitude of the marginal effects of each independent variable is larger than when we condition only on those who entered the auction and bid. For example, the marginal effect or elasticity of ROFR is now -24% (0.422x-0.5606 = 0.2366), which is comfortably above the OLS estimate.

Turning to the marginal effects of other variables, it is clear that an unexpected increase in the reserve price, *RPRD*, has an important effect on the number of bidders who enter the auctions; unconditionally the potential number of bidders increases by about 14%. The location of the property to be auctioned has a dramatic effect on the number of bidders who enter the auction; compared to a city location suburban location of auctioned land, on average, reduces the number of bidders by 39%, unconditionally. In contrast, if the land is designated or zoned for a residential real estate development, the number of bidders who enter the auction increases by about 28%. Taken together, these results suggest that there are important market dynamics and asset differences that affect entry into auctions, quite apart from those emanating from auction design such as the ROFR and the reserve price.

5.2.2. Bidders' Behavior within auctions

Table 6 provides evidence on how bidders bid when faced with auction design that includes both ROFR and reserve price. Our measure of bidders' behavior (more or less aggressive bidding) is the ratio of the winning bid (sale price of the asset) to the reserve price. Column 1 in Table 6 shows the results from the OLS regression of equation (14), conditional on observing the winning bid or selling price. This regression does not control for corner solution outcome or endogeneity of the reserve price. The estimation results show that while the ROFR is negative and insignificant the reserve price has a significant and positive impact on the degree of aggressive bidding, although the coefficient is small. The second column of Table 6 shows the results of the standard censored Tobit regression of bidding behavior in the presence of the ROFR and reserve price based on the entire sample (successful and unsuccessful auctions). We do not correct for potential endogeneity of the reserve in this version of the model. The coefficient on the ROFR is now very significant (t-value =-2.04) and the reserve prices continues to be significant as well. Indeed, accounting for the auctions with no bidders or unsuccessful auction as well as successful auctions is important in that the coefficient on the land use dummy *(LSDUM)* and the centered house return index $(HPRI - \overline{HPRI})$ are now both significant.

To shed more light on the results, we note that the presence of the ROFR, the variable of interest, decreases aggressive bidding by about 8% (-.2420x.3354 =0.0812), conditional on asset sale; unconditionally the corresponding figure is about 11%. Similarly, accounting for both auction success (asset sale) and auction failure (no asset sale), the marginal effect of reserve price though positive is quite small, 0.022%., particularly when compared with the absolute value for marginal effect of ROFR. Column 3 shows the estimated standard censored Tobit that also corrects for endogeneity of reserve price. The coefficient on the first-stage residuals is positive and significant, suggesting that the reserve price is indeed endogenous as revealed in previous regression results.

Finally, column 4 of Table 6 repeats the regression model (14) with one additional variable, the centered number of bidders $\left(NBRS - \overline{NBRS}\right)$ calculated as the number of bidders minus the average number of bidders faced by the seller in all successful auctions. This innovation has a dramatic effect on both the impact of the ROFR and reserve prices, as both variables cease to be significant. Interestingly, the coefficient on the centered number of bidders is positive and highly significant, suggesting bidders bid more aggressively as the number of bidders increase; the increase in aggressive bidding is about 3.5% (0.4748x0.0733=0.0348), for each additional bidder. This result is consistent with the observation of Bulow and Klemperer (1996) that adding one more bidder is preferable over setting an optimal reserve price, since aggressive bidding is more likely to increase seller revenue.

5.2.3 Expected Seller Revenue and Expected Seller Profit from Auctions

In this section, we examine the causal effects of auction policy tool of interest, right-of-first-refusal, and the reserve price on seller expected payoff. As pointed out earlier the theoretical literature is divided into two camps regarding the direction of impact of the ROFR on seller expected payoff. One camp concludes that granting the right can maximize seller expected revenue or the joint profit of the seller and right-holder, while the other the camp essentially predicts the opposite. Obviously, determining which of the two antithetical predictions holds is an empirical exercise. We undertake this exercise by estimating equation (14) for the winning bid, our proxy for seller expected revenue, and the winning bid minus reserve price, our proxy for seller expected profit, as dependent variables.

Table 7 provides empirical evidence of the effects of ROFR and reserve price on seller expected revenue, while controlling for other contributing factors, and Table 8 provides complementary evidence on the effects of the two auction policy tools on seller expected profit. As before, we have taken time to correct for the two complicating problems that plaque our estimation of the regression equations. From the two tables we can make a number of observations: First, the ROFR clearly reduces seller expected revenue and profit. Based on the results of standard censored Tobit regression shown in the last but one column, the ROFR reduces expected revenue and expected profit; holding constant other variables the presence of ROFR reduces the winning price or expected seller revenue by NT$0.40 and seller expected profit by NT$0.07, when we account for both successful and failed auctions. This empirical evidence provides support for the cluster of theory of ROFR that predicts the right will reduce expected seller payoff. Thus the *right-of-first-refusal* may be inimical to seller welfare, unless there is some upfront compensation from the right holder to the seller.

Second, consistent with standard auction theory the reserve price increases both seller expected revenue and seller expected profit, conditional on asset sale and unconditionally. The effect of first-stage residuals of the reserve price on expected seller revenue or the winning bid, although positive and significant, its marginal effect is NT$0.185 (0.463x0.4004) for every NT$1.0 unexpected increase in reverse price, which is not sufficient to completely offset the negative marginal effect of ROFR on expected revenue. As in our earlier results of auction outcomes these results suggest that the reserve price partially counterbalances the negative effect of the ROFR on seller expected revenue

Next, we examine the effects of other independent variables on expected seller revenue and profit. Both seller revenue and seller profit increase with the number of bidders consistent with auction theory. The coefficient on the centered number of bidders is positive and highly significant in both the seller expected revenue and expected profit regressions. As shown by the calculated marginal effects in Tables 7 and 8 (last column), each additional bidder increases seller expected revenue by 13 cents and seller expected profit by 8 cents. The location of the auctioned property has a huge effect on seller expected revenue. For example, seller expected revenue decreases by 64 cents if the auctioned property is located in the suburb compared to a city location, holding other variables constant. Although the coefficient on the centered house return index is positive and significant, the marginal effect of each additional return is relatively small when compared and contrasted with the impact of other variables.

5.3 Determinants of seller Reserve Price

The objective of this final empirical analysis is to understand and provide empirical evidence on how the seller sets reserve prices in auctions where in some of the auctions the auctioneer has some control in determining the winner, i.e. price formation and decouple are decoupled. The motivation for this exercise comes from two sources. First, the empirical literature has documented that in practice some bidder behaviors are not in accordance with prescriptions of auction theory. Second, to this point our own analyses show that with the exception of one auction outcome, the reserve price positively impacts every other margin of auction outcome we investigate, in sharp contrast to the negative effects of the ROFR on the same auction outcomes. Third, intuitively, the presence of the ROFR complicates the real-world auction environment we analyze; thus it would be interesting to find out whether this auction policy tool influences how reserve prices are set by the seller.

Myerson (1981) and Riley and Samuelson (1981) both stress that a revenue maximizing seller should set a reserve price above her own value, v_0, for the object, $r^* = v_0 + \frac{(1 - F(r^*))}{f(r^*)}$ where r^* is the optimal reserve price, and F is the distribution function with density given by $F' = f$, from which bidders draw their private values for the object to be auctioned. Note that in this setting the optimal reserve price does not depend on the number of bidders at the auction. We investigate how the seller sets the reserve price by estimating the following regression model.

$$LOGRP_{i,} = \lambda_0 + \lambda_1 ROFR + \lambda_2 (NBDRS - \overline{NBDRS}) + \lambda_3 LDA + \lambda_4 LSDUM + \lambda_5 (HRI - \overline{HPRI}) + \lambda_5 LOCDUM + \lambda_6 YRDUMS + \varepsilon_i, \quad (15)$$

In the above model we have included both the centered house return index ($HPRI - \overline{HPRI}$) and the year fixed effects *(YRDUMS)* to account for changing market conditions and learning in setting the reserve price.

Table 9 reports the regression results on the determinants of the reserve price. From Table 9 we can make the following observations. First, reserve prices are clearly not independent of the ROFR; all else equal the ROFR decreases the reserve price by NT$23.0, per NT$100 of reserve price. Second, contrary to theory the reserve price is not independent of the number of bidders either. The coefficient on the centered number of bidders, $(NBDRS - \overline{NBDRS})$, is positive and significant, suggesting that for each additional bidder the seller increases the reserve price by NT$4.63, per NT$100 of the reserve price.

Although the behavior of the seller in setting the reserve price is inconsistent with the theory as it relates to the impact of the number of bidders it may be a rational response to the distribution of bidders across auctions. For example, our data show that more than one third of the successful auctions, i.e. auctions that result in sale, had only one bidder. In this situation the number of bidders will likely influence the reserve price and ultimately seller expected revenue and profit. Next, the effects of asset characteristics on the reserve are obvious as revealed by the significant coefficients on land area *(LNDA)* and the location dummy *(LOCDUM)*, although they have opposite effects. For each additional square meter increase in asset size, the seller increases the reserve price by NT$66.0, per NT$100 unit of reserve price; and relative to a city location, the reserve price declines by NT$107 (per NT$100 unit of reserve price) if the land to be auctioned is located in the suburbs.

To account for the possibility of learning and responding to changing market conditions in setting the reserve price, we included two measures of market condition: a broad measure using year dummies as proxy and a narrow measure based on the house return index centered on its mean, as independent variables. Table 9 shows that over time the seller increases reserve prices rather considerably; for example relative to the base year (2007) the seller increases reserve prices by NT$33.83, NT$51.38 and NT$27.71 in 2008, 2009 and 2010, respectively, per NT$100 of reserve price. In contrast, the coefficient on the centered house return index, $(HRI - \overline{HRI})$, is negative and significant (t-value = -4.0) suggesting that the seller decreases reserve prices slightly by -NT$4.19 as market returns rise above their mean, per NT$100, which seems counter intuitive.

6.0 Discussion

This section revisits our findings in light of some major economic transaction where the ROFR was utilized as mechanism for allocation. Thus far our empirical results strongly suggest that the presence of ROFR in auctions reduces the likelihood of asset sale, discourages bidder entry into auctions and ultimately reduces seller expected revenue and profit. These results are robust even after controlling for potential endogeneity of the reserve price and accounting for both successful and unsuccessful auctions. At the policy level, our analysis and results have broad relevance on economic transactions that use ROFR to accomplish the transaction and could be used to shed light and better understand the practical effects of this hybrid mechanism on bidders' behavior, entry and ultimately the auctioneers expected payoff in the real-world economic transactions.

To illustrate, consider first the Miami Dolphins Sports franchise sale. In 1994 bids were solicited for the sale of this sports franchise. At that time Wayne Huizenga, the founder of Blockbuster video, owned a 15% stake in the sports franchise, and also strategically had a ROFR on the sale of the franchise. Rather inauspiciously, the sale attracted only one other buyer whose bid was considered to be considerably below the valuation of the football franchise (see Bikchandani et al 2005). Mr. Huizenga exercised his ROFR and purchased the Miami Dolphins at the winning bid.[20] Our empirical evidence is consistent with outcome of this economic transaction in showing that the ROFR discourages entry into auctions, creates incentive for the non-favored bidder to bid less aggressively, thereby reducing seller expected revenue and profit.[21] In this instance, the holder of the right may have benefited at the expense of seller of the interest, the late Joe Robbie family.

Next, consider also the case of the U.S. National Park Service (NPS) concession contracts. NPS concession contract is big business; for example in 1994 the gross revenue of concessioners on federal lands was about $2.2 billion, but only about 3% was paid to government in fees. Until 2001 all concession contracts on federal lands gave the incumbent concessioners the ROFR on contracts that are due for renewal. The GAO in several reports suggested *inter alia* that the ROFR is to blame for the fewer number of bidders, non-competitive bids and ultimately the meager rate of return for the government.[22] Although there was little empirical evidence to back this claim the issue became so contentious that in May 2000, the NPS eliminated the ROFR in concession contracts with gross revenue of $500,000 and above. In retrospect this study provides empirical support for the action taken by the NPS, in showing that the presence of ROFR indeed decreases the number of bidders that enter the auctions and ultimately decrease seller expected surplus or profit.[23] Further, given our result that the presence of the reserve price tends to attenuate the negative effects

[20] Although the purchase price was not officially disclosed, according to the New York Times (January 25, 1994), Huizenga paid about $140 million to acquire the remaining 85% interest.

[21] Presumably the right holder may have won the contest with a lower valuation, which is inefficient.

[22] See for example GAO (1996), Testimony before the Subcommittee on National Parks and Public Lands, Committee on Resources, House of Representatives

[23] Theoretical analysis of this decision by Couinard (2005) concluded that the NSP is indeed better off with auctions for the sale of concession contracts that do not employ the ROFR.

of ROFR, it would be advisable and reasonable for NPS to institute a reserve price policy if and when it grants the ROFR.

While the ROFR is typically explicitly granted and transparent, it is at times granted, *implicitly*. For example, the evolution of the 2003 Airbus Industries invitation for bids to supply jet engines for its military transportation aircraft, A400M, was in effect a bid solicitation with ROFR if not in name. The two leading bidders were Pratt & Whitney and the European consortium, EuroProp International. Pratt & Whitney's bid was considered by many observers to be by far the most competitive. Due to European government intervention, Airbus subsequently allowed EuroProp, the "domestic favored" bidder to revise its original bid. The revised bid reportedly matched Pratt & Whitney's and EuroProp won the procurement auction contract to supply the jet engines worth over €4.0 billion (US$5.6 billion). The fact that Pratt & Whitney was not allowed to revise its bid meant that EuroProp *implicitly* was granted the ROFR that enabled it to win the auction simply by matching the bid of the non-favored bidder, Pratt & Whitney.

Our empirical evidence has relevance on the political economy of this politically sensitive and high stake economic transaction. Based on our empirical results, we conjecture that in this particular instance the ROFR may have played a role akin to a reserve price in helping to establish the most competitive bid price to match above which Airbus will not procure the engines from Euro Prop, i.e. a take-it-or-leave situation. Given the intervention by European government it is reasonable to conclude that the domestic favored bidder will eventually win the contract. Intuitively, the ROFR induced the Euro Prop to reduce its bid by matching the most competitive bid, thereby reducing the procurement cost of Airbus which presumably increased its expected surplus.[24], [25]. In this context one may conclude the procurement auction with implicit ROFR may have maximized the joint profit of the Airbus (buyer of the input) and Euro Prop (seller of the input).

[24] In view of the politically sensitive nature of the contract Lee (2008) opines that "from the outset both bidders were aware of the possibility that the European government would intervene on behalf of their firm, the domestic bidder. Hence, the granting of the ROFR in the midst of the transaction is not altogether unanticipated.

[25] A somewhat similar situation was the sale of bankrupt South Korean brewery company, Jinro, where the domestic bidder, Oriental Brewery, after submitting its bid learned the terms of the bid submitted by the more competitive bidder, Coors. Subsequently, Oriental Brewery apparently favored by the seller was allowed to revise its bid, presumably matched that of Coors and was accepted as the winning bid.

Finally, although, we do not provide empirical evidence a standard prediction of the theory (and ours as well) is that a rational holder of the ROFR will match only if her valuation is above the winning bid submitted by a non-favored bidder [See for example Bkhchandani et al (2002), Choi (2009), Chouinard (2005) and Lee (2008)]. A real-world transaction in point was Carnival Corporation case, a cruise shipping firm that solicited bids to build the Queen Mary II ocean liner in 2000. As narrated in Lee (2008) one of the two finalists, Harland & Wolf, a struggling but tradition-rich British ship yard, who in fact built the original Queen Mary, was given time to revise its bid after the receipt of a competitor's bid, which effectively amounted to granting a ROFR. However, the revised bid failed to match the terms of the bid proposed by the non-favored rival, Chatiers de L'Atlantique, which ultimately won the contract. It may very well be that the ROFR as a policy tool for the leveling the playing field may have induced the winner, Chatiers de L'Atlantique, to bid more aggressively to a point where it's winning bid exceeded the private value of Harland &Wolf, the presumed holder of the ROFR.[26]

Summary and Conclusions

This paper contributes to the auction literature by providing the first empirical evidence of the effects of ROFR on several margins of auction outcomes, based on 2012 auctions for the sale of Taiwan government-owned lands. In order to discriminate among the competing predictions of the theory regarding the impact of ROFR, we estimate several multiple regressions of auction outcomes. We find that the presence of the ROFR in auctions: (i) decreases the probability of auction success or asset sale, (ii) discourages bidder entry into auctions, (iii) induces bidders to bid less aggressively within auctions, and (iv) decreases both seller expected revenue and expected profit, conditional on the asset being sold, as well as unconditionally.

Interestingly, with the exception of entry into auctions, the reserve price, another important auction policy tool uniformly present in all the auctions we analyzed, partially offsets the negative effects of ROFR on standard auction outcomes. Also remarkably, on the

[26] The right of first refusal is also used in entertainment and sports contracts. In 2001 Paramount Studios, the producer of the successful TV show *Frasier*, renegotiated its expired contract with NBC, where NBC, as the incumbent network at the time held the ROFR. NBS was given 10 days to match the terms offered by CBS (Grosskopf and Roth 2009). Likewise, in the National Football League (NFL) the incumbent team has the right to match the best offer a player has from another team to retain the player once he becomes a restricted free agent.

determinants of the reserve price set by the seller, the ROFR is shown to have a negative impact on the level of reserve prices. On the substantive question of the nature of the impact of the ROFR on auction outcomes, the logical conclusion from the synthesis of our empirical evidence is that we can discriminate in favor of the branch of the theory that predicts that the ROFR will have negative effects on auction outcomes, especially seller expected payoff, although it may benefit the right holder.

At policy level, the collective results of our analysis would seem to question the wisdom of granting ROFR, since all the margins of auction outcome we analyze suggest that the seller would most likely not be able to maximize her expected value by granting the right. A natural question to ask is why the ROFR is often found in economic transaction involving vast sums of money. Although our goal in this paper is not to address this question we offer the following comments. First, in the case of procurement auctions for awarding contracts, the process cannot be reduced to a single dimension of price, there may other considerations (Engelbrecht-Wiggns and Katok 2004). For example, the importance of establishing long-term relationship in procurement is well recognized (see for example Moncka, et al 2005). Pure standard auction are not flexible enough to promote the establishment of long-term relationship.

Second, one possible justification for granting the right is that it could "level the playing field" among bidders of different strengths thereby inducing the bidder with the highest valuation to bid more aggressively (see Lee 2008). On the contrary, our empirical evidence suggests that the ROFR discourages rather than induces aggressive bidding. However, our results also do suggest that bidders' valuation may correlate with auction design, asset and market characteristics. Hence, the valuation of bidders who could potentially have entered the auctions, but did not may differ from those that participated in the auction. Intuitively, this line of reasoning suggests that the auction winners may not be marginal participants.

Third, another rationale for granting the ROFR is that the favored bidder paid upfront compensation to the seller. Indeed, Burget and Perry (2009) show that the expected joint surplus of the buyer and the right holder is higher in the auctions with ROFR compared to a standard suction, if the right is auctioned off ahead of time. Finally, given the statutory origin of the ROFR in Taiwan, one may conjecture that in some instances the right may have been granted as an inducement and a chance to a previous owner to reclaim her interest in property that was extinguished and became government land due noncompliance with provisions of the Land Act.

Finally, our results may suggest a future research direction. A ubiquitous result of our analysis is that the reserve price tends to counterbalance the negative effect of ROFR. Hence, a potential direction of future research on auction design could concentrate on developing a hybrid mechanism that preserves the "benefit" of ROFR, e.g. establishing long-term relationship, but mitigate its detrimental effects. Indeed, based on our results the policy of granting ROFR by the seller may be locally optimal if it is combined with the reserve price, given the counterbalancing effect of the latter policy tool. This is in the sense that the reserve price may tilt the mix of auction entrants towards more experienced, knowledgeable bidders (with high valuation for the asset being auctioned), and thus more aggressive bidders, which may mitigate the reduction in expected seller revenue or profit induced by the presence of the ROFR. .

References

Arozamena, L., and F. Weinschelbaum, 2009. The Effect of Corruption on Bidding Behavior in First-Price Auctions. *European Economic Review*, 53, 645-657.

Bikhchandani, S., Steven Lippman, and Reade Ryan. (2005). On the Right of First Refusal. *Advances in Theoretical Economics*, Vol. 5: No. 1, Article 4.

Brooks, R, and K.E. Spier: "Trigger happy or gun shy? Dissolving common-value partnerships with texas shootouts", Kellogg School of Management Mimeo, 2004.

Burguet, R., and M.K. Perry, 2009. Preferred Suppliers in Auction Markets. *The RAND Journal of Economics*, 40, 283-295.

Choi A.,(2009) "A Rent Extraction Theory of the Right-of-First-Refusal", *The Journal of Industrial Economics*, Vol. 57 (2) (2009), pp. 252-262.

Chouinard, Hayley H. 2005. "Auctions With and Without the Right of First Refusal and National Park Service Concession Contracts." *American Journal of Agricultural Economics*, 87(4):1083-1088.

Davis, D. Razzolini, L., Reilly, R. and Wilson, B. (2006). "Raising Revenues for Charity: Auctions Versus Lotteries." in (D. Davis and R. M. Isaac, eds.), *Research in Experimental Economics*, pp. 49-95, New York: JAI Press.

Elmaghraby, W., Manu Goyal and Ali Pilehvar, The Right-of-First-Refusal in Sequential Procurement Auctions, September 2013, the University of Maryland working paper.

Engelbrecht-Wiggans, Richard. (1987). "On Optimal Reservation Prices in Auctions." *Management Science*, 33(6), 763-770

Grosskopf B. and Roth A., "If You Are Offered the Right of First Refusal, Should You Accept? An investigation of Contract Design", *Games and Economic Behavior*, Vol. 65 (1) (2009), pp. 176-204.

Kahan, Marcel; Leshem, Shmuel; and Sundaram, Raghu, "First-Purchase Rights: Rights of First Refusal and Rights of First Offer" (2007). New York University Law and Economics Working Papers. Paper 110.

Lee J. S., "Favoritism in asymmetric procurement auctions", *International Journal of Industrial Organization*, Vol. 26 (2008), pp 1407-1424.

McAfee, R. Preston, John McMillan. 1987. Auctions and bidding. *J. Economic Literature*, 25, 699–738.

McFadden, D. (1974) "Conditional logit analysis of qualitative choice behavior." Pp. 105-142 in P. Zarembka (ed.), *Frontiers in Econometrics*. Academic Press.

McFadden, D. (1976). Quantal choice analysis: a survey. *Annals of Economic and Social Measurement* 5, 363-390.

Milgrom, Paul R. 1987. Auction theory. Truman Bewley, ed. Advances in Economic Theory: Fifth World Congress. Cambridge University Press, Cambridge, U.K.

Milgrom, Paul, Auction Theory. In Bewley Truman, ed. *Advances in Economic Theory, 1985. Fifth World Congress*. London: Cambridge University Press, 1987, pp. 1-32.

Milgrom, P., and Robert J. Weber. 1982. A theory of auctions and competitive bidding. *Econometrica* 50 1089–1122.

Myerson, R. (1981). Optimal Auction Design. *Mathematics of Operations Research*, 6, 58-73.

Riley, J., and W. Samuelson. (1981). Optimal Auctions. *American Economic Review*, 71, 381-392.

Rothkopf MH, Harstad RM and Fu Y (2003). Is subsidizing inefficient bidders actually costly? *Management Science* **49**: 71–84.

Smith, R and R. Blundell (1986): “An Exogeneity Test for a Simultaneous Equation Tobit Model with an Application to Labor Supply”, *Econometrica*, 54, 679-685.

Vickery, W. (1961). Counter speculation, auctions, and competitive sealed tenders. *Journal of Finance*, 16, 8–37.

Walker D.,"Rethinking Rigths of First Refusal", Harvard Law School John M. Olin Center for Law, Economics and Business Discussion Paper Series. Paper 261.(1999)

Wolfstetter, E. (1999), Topics in Microeconomics, Cambridge University Press.

Wooldridge, J.M., 2002. Econometric Analysis of Cross Section and Panel Data. MIT Press, Cambridge, MA.

Table 1 Definition of Variables

Variable	Definition
ROFR	Equals 1 if someone has a right-of-first-refusal on the land to be auctioned and 0 otherwise.
RP	Reserve price , or the minimum bid set by the seller in millions of New Taiwan dollars(NT$MM)
RPSD	Residuals of reserve price from first stage least squares regression
NBDRS	Number of bidders in the auction.
NBDRS- $\overline{NBDRS}$	Number of bidders minus the average number of bidders
LSDUM	Equal 1 if the land use for the property to be auctioned is residential and 0 otherwise.
LDA	Natural logarithm of land area in square meters
LOCDUM	Equals 1 if the land to be auctioned is located in suburb and 0 otherwise
HRI	House price return index
HRI - $\overline{HPRI}$	House return index minus the average house return index
Seller Expected Revenue	Winning bid (highest price) at each auction (NT$MM).
Seller Expected Profit	Winning bid minus the reserve price (NT$MM)
Bid Premium	Winning bid divided by the reserve price (proxy for aggressive bidding).

Table 2 Summary statistics of land auctions

The sample consists of 1012 auctions for the sale of government-owned land in Taiwan between 2007–2010. The auction was conducted in Taipei metropolitan area and Taichungg metropolitan area. This table shows summary statistics of variables. *Number of bidders (NBDRS)* is the number of bidders that enter the auctions. *Reserve price* (*RP)* (NT$1MM) is the minimum or floor price at each auction, below which the government will not sell the land. The exchange rate at the end of 2010 was US$1 =NT$30. *Seller Expected Revenue* is the highest price bid at each auction. *Bid premium* is the winning price divided by the reserve price. *Land Area* is measured in square meters. *%successful auctions* is the number of successful auctions divided by the total number of auctions. *% auctions with ROFR* is the number of auctions with the right-of-first refusal divided by the total number of auctions. *% residential* is the number of lands designated for residential development divided by the number of all lands to be auctioned

Panel A, summary statistics of whole sample (successful and failed acutions)

Variables	Mean	Median	Std.dev.	Min	Max
NBDRS	2.25	0	5.31	0	52
RP (in NT$1MM)	46.53	14.95	155.22	0.000255	2,291.85
Seller Expected Revenue (in NT$1MM)	108.51	19.28	350.72	0.156	5,367.89
Bid premium	1.38	1.15	1.57	1	32.09
Land Area (m^2)	555.05	212.7	902.96	1	8,812
HRI (%)	2.97	3.87	3.68	-5.84	8.64
% of successful auctions	40.81				
% of auctions with ROFR	8.6				
% of residential usage	83.79				
N	1,012				

Panel B: Comparative statistics for total auction sample with and without right of first refusal.

Sample	Without right					With right					Difference			
Variables	Mean	Median	Std.dev.	Min	Max	Mean	Median	Std.dev.	Min	Max	Mean	t	Median	Z
NBDRS	2.33	0	5.43	0	52	1.37	0	3.68	0	22	0.97	(2.23)**	0.00	(-2.26)**
RP (in NT$1MM)	46.54	15.78	150.52	0.000255	2291.85	46.45	9.75	199.56	0.18	1727.67	0.09	(0.00)	6.03	(-3.75)***
Seller Expected Revenue (in NT$1MM)	108.73	20.78	353.36	0.156	5367.89	105.21	10.38	314.95	1.13	1467.8	3.52	(0.05)	10.40	(-2.04)**
Bid premium	1.39	1.15	1.62	1.00	32.09	1.27	1.10	0.41	1.00	2.69	0.12	(1.09)	0.05	(-1.75)*
Land Area (m²)	556.40	210	919.03	1	8812	540.73	220.45	714.15	1	4232.88	15.66	(0.19)	-10.45	(0.71)
HRI (%)	2.96	3.87	3.71	-5.84	8.64	3.08	3.94	3.43	-5.84	8.64	-0.12	(-0.29)	-0.07	(0.31)
% of successful auctions	41.84					29.89					11.95	(2.30)**		
% of residential usage	82.38					98.85					-16.47	(-9.69)***		
N	925					87								

Panel C: Comparative Statistics for successful auction with and without right of first refusal.

Sample	Without right					With right					Difference			
Variables	Mean	Median	Std.dev.	Min	Max	Mean	Median	Std.dev.	Min	Max	Mean	t	Median	Z
NBDRS	5.58	2	7.24	1	52	4.58	1.5	5.59	1	22	1.00	(0.87)	0.50	(-0.75)
RP (in NT$1MM)	62.74	16.86	157.03	0.15	1727.67	55.21	7.93	139.38	1.13	546.60	7.53	(0.26)	8.93	(-2.09)**
Seller Expected Revenue (in NT$1MM)	108.73	20.78	353.36	0.16	5367.89	105.21	10.38	314.95	1.13	1467.80	3.52	(0.05)	10.40	(-2.04)**
Bid premium	1.39	1.15	1.62	1	32.09	1.27	1.1024274	0.41	1	2.69	0.12	(1.09)	0.05	(-1.75)*
Land Area (m²)	462.61	200	809.86	1	8812	415.84	118	941.90	22.33	4232.88	46.76	(0.25)	82.00	(-1.41)
HRI (%)	3.51	3.94	3.52	-5.84	8.64	2.71	2.35	4.09	-5.27	2.69	0.8	(0.97)	1.59	(-0.82)
% of auctions with ROFR	0.84	1	0.37	0	1	1	1	0	1	1	-0.16	(-8.66)***		
N	387					26								

Panel D: Comparative for successful and failed auctions

Sample	Unsuccessful auctions					Successful auctions					Difference			
Variables	Mean	Median	Std.dev.	Min	Max	Mean	Median	Std.dev.	Min	Max	Mean	t	Median	Z
RP (in NT$1MM)	35.68	13.97	154.00	0.000255	2291.85	62.27	15.92	155.83	0.15	1727.67	-26.59	(-2.68)***	-1.94	(3.90)***
Area	620.82	247.87	952.51	1	7060	459.66	194.91	817.58	1	8812	161.15	(2.88)***	52.96	(-2.83)***
HRI (%)	2.64	2.93	3.73	-5.84	8.64	3.46	3.94	3.55	-5.84	8.64	-0.82	(-3.54)***	-1.01	(3.32)***
% of auctions with right	10.18					6.30					3.89	(2.26)**		
% of residential usage	83.14					84.75					-1.61	(-0.69)		
Sample size	599					413								

Panel E: Comparative statistics for the whole auction sample by location of property to be auctioned

Sample	Core area					Suburb					Difference			
Variables	Mean	Median	Std.dev.	Min	Max	Mean	Median	Std.dev.	Min	Max	Mean	t	Median	Z
NBDRS	3.11	1	6.08	0	36	1.38	0	4.21	0	52	1.73	(5.27)***	1.00	(-7.29)***
RP (in NT$1MM)	72.85	20.18	212.59	0.18	2291.85	19.68	9.51	34.49	0.000255	495.25	53.1	(5.58)***	10.67	(-8.27)***
Seller Expected Revenue (in NT$1MM)	150.31	29.01	429.77	0.38	5367.89	35.98	10.88	90.13	0.16	760.08	114.33	(4.15)***	18.13	(-5.26)***
Bid premium	1.48	1.19	1.95	1.00	32.09	1.22	1.08	0.33	1.00	2.83	0.27	(2.15)**	0.11	(-4.37)***
Land Area (m^2)	305.23	130	614.70	1	7060	809.85	448	1065.06	1	8812	-504.62	(-9.21)***	-318.00	(10.11)***
HRI (%)	2.81	3.87	4.30	-5.84	8.64	3.14	2.93	2.92	-4.38	7.15	-0.33	(-1.40)	0.94	(0.21)
% of successful auctions	51.27					30.14					21.13	(7.00)***		
% of auctions with ROFR	5.68					11.58					-5.90	(-3.35)***		
% of residential usage	79.84					87.82					-7.98	(-3.47)***		
N	511					501								Z

Panel F: Comparative statistics for successful auction by location of property to be auctioned

Sample	Core area					Suburb					Difference			
Variables	Mean	Median	Std.dev.	Min	Max	Mean	Median	Std.dev.	Min	Max	Mean	t	Median	Z
NBDRS	6.06	2	7.3695612	1	36	4.57	2	6.67	1	52	1.49	(2.11)**	0.00	(-2.68)***
RP (in NT$1MM)	83.52	23.41	188.55	0.38	1727.67	25.39	10.55	51.80	0.15	495.25	58.13	(4.69)***	12.86	(-5.11)***
Seller Expected Revenue (in NT$1MM)	150.31	29.01	429.77	0.38	5367.89	35.98	10.88	90.13	0.16	760.08	114.33	(4.15)***	18.13	(-5.26)***
Bid premium	1.48	1.1922519	1.95	1	32.09	1.22	1.08	0.33	1	2.83	0.27	(2.15)**	0.11	(-4.37)***
Land Area (m^2)	312.09	162	533.53	1.45	4405.94	715.71	266	1112.05	1	8812	-403.62	(-4.19)***	-104.00	(3.82)***
HRI (%)	3.67	3.94	3.89	-5.84	8.64	3.10	2.65	2.88	-4.38	7.15	0.57	(1.71)*	1.29	(-2.36)**
% of auctions with ROFR	6.49					5.96					0.53	(0.21)		
% of residential usage	83.21					87.42					-4.21	(-1.18)		
N	262					151								

Table 3 Logistics regression of probability of auction success or asset sale

The dependent variable is a dummy variable, equals 1 if the auction was successful and 0 otherwise. *ROFR* dummy equals 1 if someone has the right of first refusal on the land and 0 otherwise. *RP* is reserve price or minimum bid set by seller measured in NT$1MM. *RPRD* is reserve price residual from first stage OLS regression. *LSDUM* dummy equals 1 if land use is residential and 0 otherwise. $(HRI-\overline{HRI})$ is the current quarter's house return index minus the average house return index. *LOCDUM* is location dummy which equal 1 if the land to be auctioned is located in the suburb and 0 otherwise. We control the fixed effects by including the year dummies. ∗∗∗, ∗∗, and ∗ denote significance at the 1%, 5%, and 10% levels, respectively.

	Logistic regression		Accounting for endogeneity		Marginal effect		
	Estimates	χ2	Estimates	χ2	Adjusted probability		
ROFR	**-0.4747**	**(3.50)***	**-0.5268**	**(4.16)****		**-0.12033**	
RP	0.0008	(2.54)	-0.0009	(2.70)	-0.03583		-0.03488
RPRD			0.2889	(22.06)***	0.09830		0.10626
LSDUM	0.3690	(3.85)**	0.4937	(6.31)**		0.11441	
HRI	0.0990	(21.06)***	0.1017	(21.56)***	0.08647		0.09257
LOCDUM	-0.9246	(39.16)***	-0.9656	(41.47)***		-0.22905	
Intercept	-0.6357	(10.38)***	-0.7809	(14.42)***			
Year dummy	yes		yes				
-2 Log likelihood	1280.906		1257.535				
Pseudo R^2	0.0830		0.1039				
N	1,012		1,012				

Table 4 Bidders Entry into auction regression

The dependent variable is the natural logarithm of the number of bidders in an auction. *ROFR* dummy equals 1 if someone has the right of first refusal on the land and 0 otherwise. *RP* is reserve price or minimum bid set by seller measured in NT$1MM. *RPRD* is reserve price residual from first stage OLS regression. *LSDUM* dummy equals 1 if land use is residential and 0 otherwise. *HRI* is the current quarter's house return. *LOCDUM* is location dummy which equal 1 if the land to be auctioned is located in the suburb and 0 otherwise. We control the fixed effects by including the year dummies. Model 1 is OLS. Model 2 is standard censored Tobit regression. Model 3 is standard censored Tobit regression corrected for possible endogeneity of the reserve price. Adjustment factor1 and adjustment factor2 used to adjust Tobit MLE coefficient conditional and unconditiona on asset sale or auction success, respectively. R^2 for Tobit model is computed by correlating the dependent variable with the predicted value and squaring the result. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	Model 1 (OLS)		Model 2 (standard censored Tobit)		Model 3 (Tobit with correction of endogeneity)		Adjusted marginal effect	
	Estimates	t-value	Estimates	t-value	Estimates	t-value	Uncensored	Censored and uncensored
ROFR	**-0.0884**	**(-1.08)**	**-0.4912**	**(-2.04)****	**-0.5606**	**(-2.39)****	**-0.1809**	**-0.2366**
RP	0.0010	(2.98)*	0.0011	(2.87)***	-0.0010	(-2.00)**	-0.0003	-0.0004
RPRD					0.3316	(6.49)***	0.1070	0.1399
LSDUM	0.2056	(2.56)*	0.4151	(2.38)**	0.5653	(3.29)***	0.1824	0.2386
HRI	0.0091	(0.72)	0.0908	(4.47)***	0.0880	(4.47)***	0.0284	0.0371
LOCDUM	-0.1343	(-5.66)**	-0.9045	(-6.55)***	-0.9277	(-6.93)***	-0.2994	-0.3915
Intercept	1.5121	(17.56)***	-0.8004	(-2.83)***	-0.9685	(-3.47)***	-0.3125	-0.4087
Year dummy	yes		yes		yes			
Adjustment factor 1			0.3223		0.3227			
Adjustment factor 2			0.4212		0.4220			
R^2	0.0731		0.0683		0.1044			
Number of observations	413		1,012		1,012			
Number of censored obs.			599		599			

Table 5: Within Auction Bidder's Behavior

The dependent variable is the log winning price divided reserve price (bid premium). *ROFR* dummy equals 1 if someone has the right of first refusal on the land and 0 otherwise. *RP* is reserve price or minimum bid set by seller measured in NT$1MM. *RPRD* is reserve price residual from first stage OLS regression. *(NBDRS- $\overline{NBDRS}$)* is the number of bidders minus the average number of bidders across auctions. *LSDUM* dummy equals 1 if land use is residential and 0 otherwise. *HRI* is the current quarter's house return. *LOCDUM* is location dummy which equal 1 if the land to be auctioned is located in the suburb and 0 otherwise. We control the fixed effects by including the year dummies. Model 1 is OLS. Model 2 is standard censored Tobit regression. Model 3 is standard censored Tobit regression corrected for possible endogeneity of reserve price. Model 4 is standard censored Tobit regression, corrected for with the endogeneity of reserve price, with centered number of bidders as additional regressor. Adjustment factor1 and adjustment factor2 are as described previous tables. R^2 for censored model is computed by correlating the dependent variable with the predicted value and squaring the result. ∗∗∗, ∗∗, and ∗ denote significance at the 1%, 5%, and 10% levels, respectively.

	Model 1 (OLS)		Model 2 (standard censored Tobit)		Model 3 (Tobit with correction of endogeneity)		Model 4 (Tobit with correction of endogeneity and NBDRS)		Adjusted marginal effect	
	Estimates	t-value	Estimates	t-value	Estimates	t-value	Estimates	t-value	Uncensored	Uncensored and Censored
ROFR	**-0.0300**	**(-1.12)**	**-0.2420**	**(-2.04)****	**-0.2710**	**(-2.31)****	**-0.1504**	**(-1.59)**	**-0.0526**	**-0.0714**
RP	0.0003	(4.04)**	0.0005	(2.46)**	-0.0004	(-1.59)	-0.0002	(-0.72)	-0.0001	-0.0001
RPRD					0.1375	(5.35)***	0.0326	(1.51)	0.0114	0.0155
NBDRS- $\overline{NBDRS}$							0.0733	(16.03)***	0.0256	0.0348
LSDUM	0.0290	(2.3)	0.1725	(2.00)**	0.2338	(2.72)***	0.0710	(1.02)	0.0248	0.0337
HRI	-0.0021	(-0.89)	0.0433	(4.30)***	0.0422	(4.28)***	0.0255	(3.19)***	0.0089	0.0121
LOCDUM	-0.0601	(-4.8)**	-0.4602	(-6.72)***	-0.4713	(-7.00)***	-0.2963	(-5.42)***	-0.1037	-0.1407
Intercept	0.8638	(47.92)***	-0.3455	(-2.46)**	-0.4190	(-2.99)***	-0.2633	(-2.30)**	-0.0921	-0.1250
Year dummy	yes		yes		yes		yes			
Adjustment factor 1			0.3354		0.3355		0.3499			
Adjustment factor 2			0.4472		0.4474		0.4748			
R^2	0.1032		0.0746		0.0930		0.3082			
Number of observations	413		1,012		1,012		1012			
Number of censored obs.			599		599		599			

Table 6: Expected sellers' revenue

The dependent variable is the log of winning price. *ROFR* dummy equals 1 if someone has the right of first refusal on the land and 0 otherwise. *RP* is reserve price or minimum bid set by seller measured in NT$1MM. *RPRD* is reserve price residual from first stage OLS regression. *(NBDRS-* $\overline{NBDRS}$) is the current quarter's house return index minus the average house return index. *LSDUM* dummy equals 1 if land use is residential and 0 otherwise. *HRI* is the current quarter's house return. *LOCDUM* is location dummy which equal 1 if the land to be auctioned is located in the suburb and 0 otherwise. We control the fixed effects by including the year dummies. Model 1 is OLS. Model 2 is standard censored Tobit regression. Model 3 is standard censored Tobit regression and is corrected with the endogeneity of reservation price. Model 4 is standard censored Tobit regression, corrected for possible endogeneity of reserve price, and. Adjustment factor1 and adjustment factor2 are recommended by Wooldridge (2002) for reporting the marginal effects on the expected value for *y* for uncensored observations and marginal effect on the expected value for y (censored and uncensored). R^2 for censored model is computed by correlating the dependent variable with the predicted value and squaring the result. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	Model 1 (OLS)		Model 2 (standard censored Tobit)		Model 3 (Tobit with correction of endogeneity)		Model 4 (Tobit with correction of endogeneity and NBDRS)		Adjusted marginal effect	
	Estimates	t-value	Estimates	t-value	Estimates	t-value	Estimates	t-value	Uncensored	Uncensored and censored
ROFR	**-0.4906**	**(-1.66)**	**-1.1504**	**(-2.34)****	**-1.3223**	**(-2.83)*****	**-0.8596**	**(-2.22)****	**-0.2954**	**-0.3980**
RP	0.0062	(5.19)**	0.0041	(5.49)***	-0.0008	(-0.84)	0.0002	(0.24)	0.0001	0.0001
RPRD					0.7935	(8.01)***	0.4004	(4.76)***	0.1376	0.1854
NBDRS- $\overline{NBDRS}$							0.2835	(15.62)***	0.0974	0.1313
LSDUM	0.1542	(0.74)	0.6988	(1.98)**	1.0633	(3.14)***	0.4296	(1.53)	0.1476	0.1989
HRI	0.002	(0.11)	0.1912	(4.63)***	0.1817	(4.68)***	0.1179	(3.66)***	0.0405	0.0546
LOCDUM	-0.5467	(-3.31)**	-2.0298	(-7.23)***	-2.0590	(-7.77)***	-1.3992	(-6.37)***	-0.4808	-0.6478
Intercept	3.2608	(10.9)***	-1.4203	(-2.47)**	-1.7933	(-3.25)***	-1.2290	(-2.66)***	-0.4223	-0.5690
Year dummy	yes		Yes		yes		yes			
Adjustment factor 1			0.3297		0.3323		0.3436			
Adjustment factor 2			0.4358		0.4410		0.4630			
R^2	0.4679		0.1288		0.2236		0.3855			
Number of observations	413		1012		1012		1012			
Number of censored obs.			599		599		599			

Table 7 Expected sellers' surplus regression

The dependent variable is the log of dollar premium measured as the difference of winning price and the reservation price. *ROFR* dummy equals 1 if someone has the right of first refusal on the land and 0 otherwise. *RP* is reserve price or minimum bid set by seller measured in NT$1MM. *RPRD* is reserve price residual from first stage OLS regression. *(NBDRS-* $\overline{NBDRS}$*)* is the current quarter's house return index minus the average house return index. *LSDUM* dummy equals 1 if land use is residential and 0 otherwise. *HRI* is the current quarter's house return. *LOCDUM* is location dummy which equal 1 if the land to be auctioned is located in the suburb and 0 otherwise. We control the fixed effects by including the year dummies. Model 1 is OLS. Model 2 is standard censored Tobit regression. Model 3 is standard censored Tobit regression and is corrected with the endogeneity of reservation price. Model 4 is standard censored Tobit regression, corrected with the endogeneity of reservation price, and. Adjustment factor1 and adjustment factor2 are recommended by Wooldridge (2002) for reporting the marginal effects on the expected value for *y* for uncensored observations and marginal effect on the expected value for y (censored and uncensored). R^2 for censored model is computed by correlating the dependent variable with the predicted value and squaring the result. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	Model 1 (OLS)		Model 2 (standard censored Tobit)		Model 3 (Tobit with correction of endogeneity)		Model 4 (Tobit with correction of endogeneity and NBDRS)		Adjusted marginal effect	
	Estimates	t-value	Estimates	t-value	Estimates	t-value	Estimates	t-value	Uncensored	Uncensored and censored
ROFR	**-0.3338**	**(-1.49)**	**-0.9429**	**(-2.16)****	**-1.1078**	**(-2.67)*****	**-0.5890**	**(-1.98)****	**-0.1513**	**-0.1667**
RP	0.0065	(4.6)**	0.0041	(6.15)***	-0.0005	(-0.65)	0.0005	(0.88)	0.0001	0.0001
RPRD					0.7475	(8.58)***	0.3326	(5.19)***	0.0854	0.0942
NBDRS- $\overline{NBDRS}$							0.2837	(20.50)***	0.0729	0.0803
LSDUM	0.1978	(4.06)**	0.6316	(2.01)**	0.9809	(3.27)***	0.3023	(1.41)	0.0776	0.0856
HRI	-0.0165	(-2.1)	0.1595	(4.34)***	0.1501	(4.38)***	0.0781	(3.16)***	0.0201	0.0221
LOCDUM	-0.6741	(-8.37)***	-1.8720	(-7.48)***	-1.8972	(-8.09)***	-1.1567	(-6.85)***	-0.2970	-0.3275
Intercept	1.8508	(12.08)***	-2.2240	(-4.35)***	-2.5731	(-5.28)***	-1.7869	(-5.04)***	-0.4589	-0.5059
Year dummy	yes		yes		yes		yes			
Adjustment factor 1			0.2635		0.2616		0.2568			
Adjustment factor 2			0.2978		0.2937		0.2831			
R^2	0.4148		0.1339		0.2423		0.5297			
Number of observations	413		1012		1012		1012			
Number of censored obs.			599		599		599			

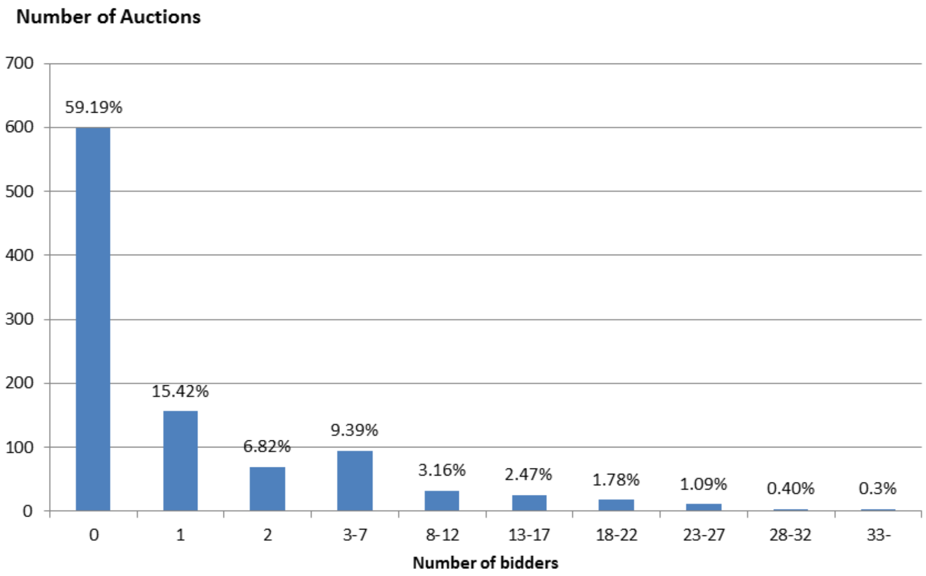
Table 8 Hedonic regression for reservation prices

The dependent variable is the natural log of the reservation price (NT$1MM). *ROFR* dummy equals 1 if someone has the right of first refusal on the land and 0 otherwise. *LDA* is the natural logarithm of land area. *LSDUM* dummy equals 1 if land use is residential and 0 otherwise. ($HRI-\overline{HRI}$)is the current quarter's house return-the average of quarterly house return. *LOCDUM* is location dummy which equal 1 if the land to be auctioned is located in the suburb and 0 otherwise. We control the fixed effects by including the year dummies. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Variable	Estimates	t-value
ROFR	-0.2620	(-2.87)***
LDA	0.6146	(27.75)***
LSDUM	-0.0062	(-0.06)
$HRI-\overline{HRI}$	-0.0353	(-3.61)***
LOCDUM	-1.1571	(-17.91)***
Year=2007		
Year=2008	0.3827	(5.21)***
Year=2009	0.5500	(5.99)***
Year=2010	0.3355	(3.54)***
Intercept	4.0272	(30.29)***
R^2	0.5641	
N	1012	

Figure 1 Frequency of number of bidders

Panel A, whole sample



Panel B, successful sample

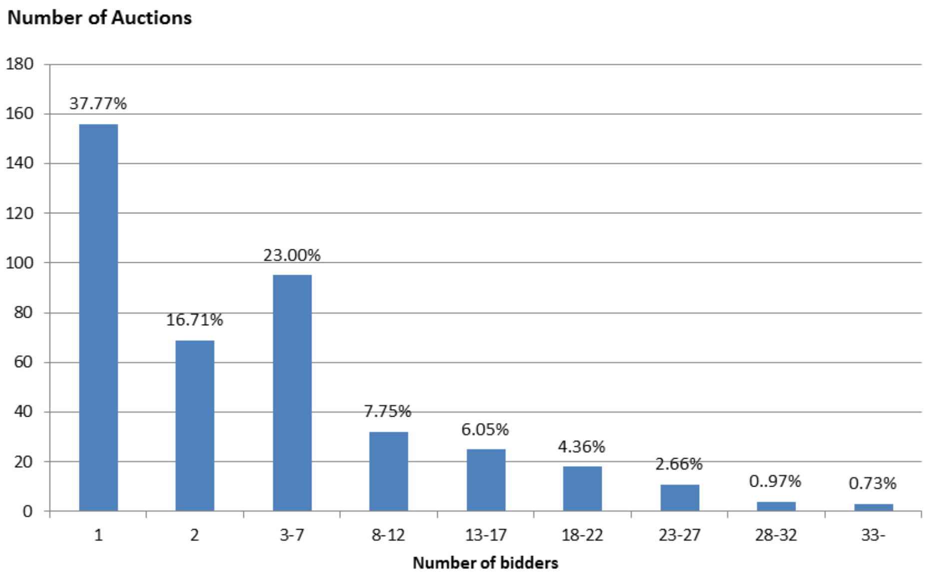


Figure 2 reserved price vs. number of bidders

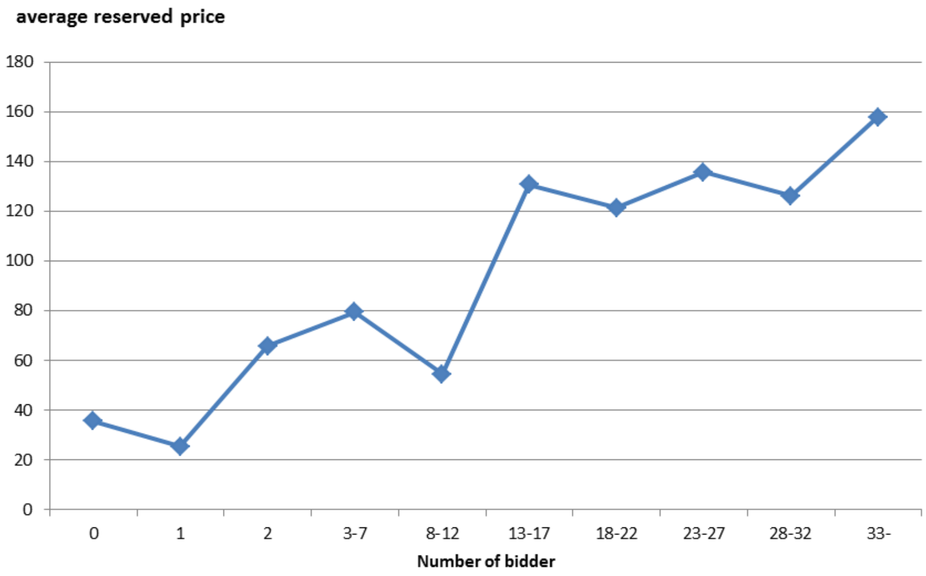


Figure 3 Seller expected revenue vs reserved price

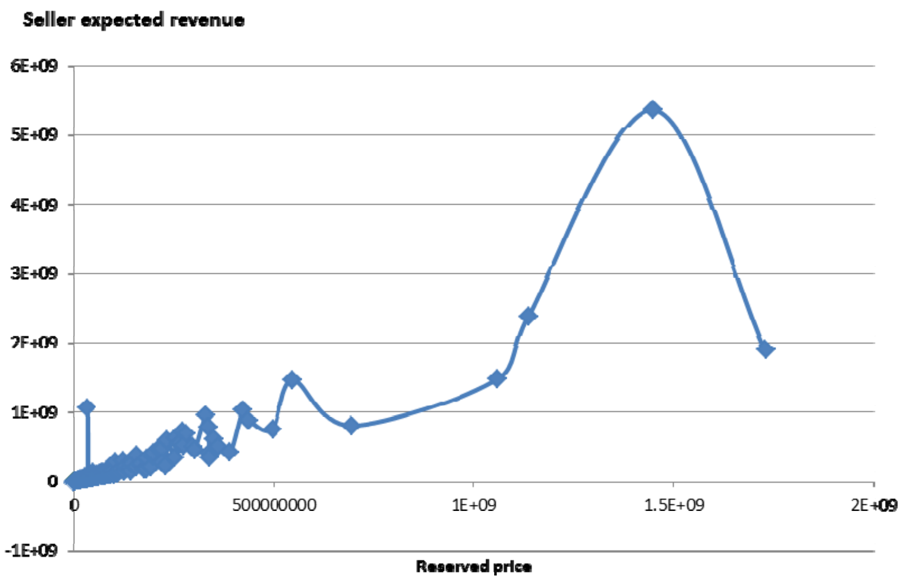


Figure 4 Seller expected profit vs reserved price