

Strategic Sequential Bidding for Government Land Auction Sales – Evidence from Singapore¹

Sumit Agarwal
McDonough School of Business
Georgetown University
3700 O Street NW, Washington DC, 20057
Email: ushakri@yahoo.com

Jing Li
School of Economics
Singapore Management University
Singapore, 178903
Phone: (65)93870372
Email: lijing@smu.edu.sg

Ernie Teo
Sim Kee Boon Institute for Financial Economics
Singapore Management University
Singapore 188065
Email: ernieteo@smu.edu.sg

Alan Cheong
Research & Consultancy
Savills Valuation and Professional Services (S) Pte Ltd
30 Cecil Street #20-03
Prudential Tower, Singapore049712

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Abstract

This paper studies the extent to which equilibrium land auction prices are pushed up sequentially due to strategic bidding behaviors in government land auction sales. Using a unique dataset that covers the universe of tendering prices submitted by all developers for all residential land auction sales in Singapore, we find that a tenderer's bids are significantly higher where there was a previous land parcel sold within two years and located within four kilometers. The identified price margin decreases with time and geographic distance. Tracking sequential bids submitted by the same developer over time, we find that the incumbent winner of a previous auction is more likely to participate in subsequent nearby land sales as compared to the second-highest bidder of the same auction. However, it does not necessarily win the subsequent sites. We argue that the incumbent deliberately bids up the subsequent land prices to gain pricing advantages to their own parcels.

Key words: Land Sale Auctions, Strategic Sequential Bidding, Land Price, Housing Price, Product Differentiation

JEL Codes: D43, D44, L13, R31, R38

1 Introduction

In many Asian countries, a significant portion of land is provided for private development through lease-based transfers from government to private ownership (Giglio, Maggiori, and Stroebel 2015a, 2015b). In China, for example, 2.7 billion square meters of state-owned land were transferred for private residential and commercial development through leasehold sales in 2014 (China Land and Resources Statistical Yearbook).¹ Among various ways of leasing out state-owned land, auctions have been widely adopted to ensure transparency of the transaction process.² There has been an extensive literature on price formation of real estate auction sales, but less work has considered how equilibrium prices evolve in a sequence of land auctions.³ The latter is important because in many fast growing Asian countries, government land parcels are launched sequentially with high intensity to meet rising demand from economic growth. How land prices evolve along the sequence of auction sales becomes essential in understanding the dynamics of the Asian real estate market.

This paper studies the extent to which the equilibrium land auction price is pushed up sequentially due to developers' strategic sequential bidding behaviors in a first-price sealed-bid auction setting. This question is motivated by observations made on Singapore Government Land Sales (GLS). In the Singapore GLS case, we observe a significant increase in the auction prices for land parcels launched sequentially in a close time frame and also within close proximity to one another. This increasing trend in prices seems to be caused by the incumbent winner of a previous land auction who participates and places a significantly higher bid for an immediate subsequent launch of land parcels within the same area.⁴ Moreover, although the incumbent winner of a previous land auction tends to bid up the price for subsequent launches, the incumbent does not necessarily win the auction. This results in increased subsequent winning bids which are even higher than the incumbents' (already higher) bids.

Previous literature has provided various explanations for rising price-sales sequence patterns. For instance, prices may increase along the sales sequence if there exist uncertainties on the value of the goods which resolve gradually as the sequence evolves. This can be in the regime of either common value auctions or private value auctions as previous transactions may provide additional information that is either

¹ Singapore is as another standard example where the government regularly releases land for private sector development through the government land sales (GLS) program. In certain parts of Europe, such as Sweden and the Netherlands, central or local government also buys up land well ahead of anticipated development, and sells it to developers as it is required.

² Chinese land sales used to be conducted through negotiations in the 1990s. It had been heavily criticized for nurturing corruption and, hence, prompted a series of reforms. In particular, a 2002 law banned negotiated sales by land bureaus and required all urban leasehold sales for private development to be done through public auctions. Sealed bidding, as an example, has been widely adopted in Beijing and Shanghai, two largest cities in China.

³ Majority of the existing literature on real estate auctions are empirical studies. See for instance, Ashenfelter and Genesove (1992), Lusht (1996), Quan (2002), Ching and Fu (2003), Ooi and Sirmans (2004), Ooi et al. (2006), Tse et al. (2011), and Chow et al. (2014), etc. Comparatively, only a small fraction of the theoretical literature on auctions focuses specifically on real estate (Quan, 1994; Han and Strange, 2015).

⁴ It is so after adjusting key observed characteristics of both parcels of land.

publically available or private to the previous winner (Milgrom and Weber 1982; McAfee and Daniel 1993; Van den Berg et al. 2001). From a different perspective, prices may also increase if previous winners prefer to monopolize the local housing market to extract monopolistic profit or to exploit internal economies of scale. The third plausible explanation for bidding high for subsequent sites is to internalize potential externalities associated with upcoming projects (Sirmans et al. 1997; Rauch 1993).

The above hypotheses consider situations of repeated auctions or sales of *the final consumption goods* and explain the rising price-sales sequence relationship from a demand perspective.⁵ The general implications, however, are not necessarily consistent with the observations that developers often participate in the subsequent land auction sales but often do not win the subsequent sites.⁶ This paper proposes and tests an alternative hypothesis which explains the rising price-sales sequence relationship from the perspective of competition strategies adopted by auction bidders. To uncover the potential pricing competition from the supply perspective, we focus on sequential auction sales of land as *an intermediate good*. We show that the strategic bidding behavior not only generates the rising price pattern but also predicts that developers often participate but do not necessarily win the subsequently launched sites.

We test the hypothesis using a unique dataset published by the Urban Redevelopment Authority (URA) in Singapore. The dataset contains the universe of the tendering prices submitted by all land developers for all private residential land sales through the GLS program. The nature of the data allows us to track each individual developer's bidding behavior over time, regardless of whether they win the site or not. By geographically linking a land plot to its sequentially launched neighboring plots, we compare bids placed by the same developer along a sequence of highly substitutable land parcel auctions. This allows us

⁵ Final consumption goods, in a standard auction setting, are associated with either independent private values or common values unknown to bidders *ex ante*. The value of these goods directly adds to a buyer's payoff upon procurement. The procurement of land, however, is used as intermediate inputs in a bidder's profit maximization decision at a later stage. In this sense, the auction outcomes at the initial stage generate *externalities* that influence future interactions among bidders. There is a literature on simultaneous auctions with externalities that considered various situations where the change of ownership by auction sales affects the nature of subsequent interaction in the respective markets. Examples include changes in ownership in oligopolies through takeover and merger, the licensing of innovations to downstream competing producers, the deteriorated reputation that impacts subsequent winning probability, purchase of intermediate input from a manufacture, etc (Gilbert and newbery 1982; Kamien and Tauman 1986; Katz and Shapiro 1985, 1986; Hart et al. 1990; Kamien 1992; Segal 1999; Jehiel and Moldovanu 2000). Researchers in this field often assume that bidders have private information about incurred externalities and focus on the efficiency and revenue-maximizing procedures of implementing simultaneous auctions. So far to our knowledge, no studies have investigated auctions that involve *the sequential sale of an intermediate good* and specifically modeled the subsequent competition between final substitutable products. There is neither empirical work that rigorously verifies various implications of similar types of model.

⁶ If there is true benefit associated with winning the subsequently launched sites and that is not particular to the previous winner as in the case of common value auctions, we would imagine that the incumbent winner would not have a stronger incentive to participate in subsequent launches (after controlling for capacity constraints) compared to other bidders. If however benefits of obtaining subsequent sites accrue mainly to the winner of a previous site out of monopoly or externality reasons, the incumbent should incur a higher reserve price and hence will be more likely to win the subsequent sites (after controlling for capacity constraints). Hence the discrepancy in participating and winning the following sites (after controlling for potential capacity constraints) seem to be inconsistent with the hypotheses on uncertainties, monopoly, or externalities.

to test and confirm the rising price-sales sequence pattern after controlling for parcel specific characteristics and time and developer fixed effects. By tracking developers' bidding behaviors along the sequence, we also test the incumbent winner's tendency to participate and to win the subsequent land auctions.

A potential endogeneity concern in addressing the incumbent's tendency to participate and win a subsequent site resides in two major unobserved differences between the winners and other losing bidders. The first difference is their unobserved taste for sites in the same area. The incumbent wins maybe because the incumbent sees higher development potential in the area and hence is more likely to bid again for sites in the same area. We address this issue by comparing the previous winner and the second highest bidder with similar bids. This idea has been explored in Greenstone et al. (2010) in identifying agglomeration spillovers by comparing the winner and the secondly ranked loser of large plant openings.

The second set of factors explaining the tendency to participate and win a follow-up site is potential capacity constraints and financial constraints which are directly affected by winning or losing a prior site. We address the concern on capacity constraint by directly controlling for developer fixed effects and the accumulated gross floor area that the developer has engaged in developing in the previous two years at the time of bidding for a new site. We address the concern on financial constraint by comparing the rate of participating in and winning the subsequently launched parcels that are close in distance (serve as direct substitutes to the winning site) and those that are further away (do not compete directly with the winning site). The identification assumption is that the impact of financing constraints on the tendency to bid for subsequent sites is the same for sites at various distances and, hence, will be differenced out. The remaining comparison of the difference between the treatment group and the control group identifies the incumbents' tendency to participate or win subsequent nearby parcel launches out of the strategic bidding motive.

We obtain the following findings. We show that tenderers' bids are significantly higher when there was a previous land parcel sold within 2 years and located within 4 km in distance. We also find that the increased price margin decreases as the distance becomes larger or as the time gap between auctions gets longer. In other words, developers tend to bid higher for parcels that are more likely to be substitutable to an existing earlier parcel. Finally, we find that the incumbent winner is more likely to participate in the subsequent nearby land auction but does not necessarily win the auction. Our analysis shows that given the competitive environment in Singapore, land prices are mechanically driven up over time due to the strategic behavior of bidders. In times of rising property prices, this suggests possibilities of supply side cooling measures such as not launching parcels within close time and proximity.

These findings make three key contributions to the literature. First, we document how the equilibrium price is affected by strategic sequential bidding behaviors in a first-price sealed-bid auction setting. Previous literature has focused on comparing prices formed with different auction types as well as with other methods of sale (Ashenfelter and Genesove 1992; Lusht 1996; Quan 2002; and Chow and Ooi 2013). This paper proposes an important sequential bidding factor that needs to be taken into consideration while comparing different auction outcomes or with other methods of sale.

Second, our findings are related to the literature on rising or declining price anomaly. The law of one price implies no persistent price pattern for identical assets sold sequentially (Weber 1983). However, there is evidence of price-sales sequence anomalies that deviate from the expected result (Ashenfelter 1989; Ashenfelter and Genesove 1992; Black and de Meza 1992; Rauch 1993; McAfee and Daniel 1993; Beggs and Graddy 1997; Sirmans et al. 1997; Deltas and Kosmpolou 2004; Burguet 2005; Raviv 2006; Mezzeti 2011). Previous studies have proposed various rationales from the *demand side* to account for the observed rising or declining price-sales sequence relationship (Milgrom and Weber 1982; McAfee and Daniel 1993; Van den Berg et al. 2001; Mezzeti 2011). This paper provides a *supply side* perspective on price-sales sequence anomalies by focusing on the competition of final developed properties.

Finally, we also contribute to the literature on contracting with externalities. Previous studies have considered various scenarios in which contracting situations involve multilateral externalities. Hart et al. (1990) and Katz and Shapiro (1986) specifically considers the situation in which a downstream firm purchasing an intermediate input from a manufacturer which imposes a negative externality on competing firms. Jehiel and Moldovanu (2000) further take into consideration downstream externalities in an auction setting. This paper considers a specific case of sequential multi-object auctions which generate externalities and affect downstream interactions among bidders.

The rest of the paper is organized as follows. Section 2 presents the background of Singapore GLS and a specific example that illustrates the strategies adopted by land developers while participating in the GLS auctions. Section 3 discusses existing theories and also proposes an alternative hypothesis on sequential bidding strategies. Section 4 discusses the data and the identification strategy. Section 5 presents empirical findings. Section 6 concludes.

2 Background and Case Study

The Singapore Government owns more than seventy-five percent of the land nationwide. It releases land regularly through the GLS program for private sector development. The release of land is intended to meet rising demand from economic growth and also to stabilize prices in the housing market. The GLS is managed by three land sales agents: Housing Development Board (HDB), URA, and JTC Corporation (JTC). HDB usually sells land located within public housing estates. URA covers land sales for commercial, hotel, private residential and industrial developments island wide. JTC manages mainly industrial land sales. In this study, we focus only on private residential development lands sold by URA from 1990 to 2014.

The GLS program is planned and announced every six months. Land parcels on the confirmed list are sold at pre-determined dates through first-price sealed-bid auctions. The process is as follows. When a development site is released for sale, interested bidders are invited to purchase a Developer's Packet containing the planning and design guidelines for the site. The residential sites, which are the focus of this

paper, usually entail a leasehold tenure of 99 years.⁷ Interested bidders are then required to prepare the tender submission before the closing date of the auction. The bids are opened and the names of all bidders and their respective bids are posted on the same day. The site is then awarded to the highest bid exceeding the reserve price.⁸ Sealed-bid is the preferred method of sale in Singapore (instead of an open auction) because it is believed to reduce the probability of collusion among potential bidders.⁹

Once the highest bidder has been awarded the site, the government agency monitors the development progress closely in order to ensure that the outcome is in accordance with the planning and technical requirements stipulated in the auction submission. The successful bidder is also prohibited from selling the leasehold to outside parties. In addition, the bidder must complete the development within the specified time frame in order to avoid punitive fines for late completion. This ensures that there is no strategic land banking used to hedge against housing price volatilities.

The final completed projects of private residential condominiums compete with each other in pricing as well as in their amenities and location advantages. Location is generally considered as a very influential factor among potential condominium buyers given significant variation in access to workplace, schools, parks, and commercial/shopping centers. Within the same area though, newly completed condominium projects compete with each other in pricing especially at the initial presale stage (before project completion). This implies that condominiums that are in close proximity and are launched around the same period are highly substitutable.¹⁰ Hence developers often choose to bid strategically in the auction stage taking into consideration likely competition with projects completed around the same time in the same area.

One pattern arising from the data is that the incumbent winner (of land from a previous auction) often places a higher bid on subsequent launch of land parcels in the same area. We consider this as evidence consistent with a sequential bidding strategy adopted by developers, which eventually leads to rising land prices along the sequence of the auction sales. We illustrate the sequential bidding strategy adopted by land developers with a real-life case study discussed as follows.

In January 2011, the Singapore Government launched a land parcel along Bedok Reservoir Road in Bedok Urban Planning Area. The exact location of this plot is shown in Figure 1 and marked as Site 1.

⁷ There is only one residential site in our data that has 60-year leasehold tenure. This short-term lease site is zoned for residential development and can be developed into a condominium or flat.

⁸ The reserve price, which is not revealed to bidders, is set equal to 85% of the Chief Valuer's assessed market value for the development site. The valuation, which is submitted by the Chief Valuer in a sealed envelope before the tender closing date, is opened at the same time as the received bids.

⁹ Also in Asia, Chinese land sales used to be done by negotiation, which was notorious for corruption. For that reason, a 2002 law banned negotiated sales by land bureaus and introduced public auctions for leasehold land sales. In Hong Kong, the method of sale for the government sites is open auction, which is more susceptible to collusion among bidders (Ching and Fu 2003).

¹⁰ Condominiums in Singapore take up about 10% of the overall housing market share and are designed as luxury living quarters to cater high-income home buyers. As shown in Baltagi and Li (2015), they all contain fully furnished units and share similar designs and similar luxurious outdoor amenities. In the Singapore context, condominiums that are launched close in time and also close in proximity are highly substitutable.

This plot of land attracted eight bids submitted either solely or jointly by different land developers before it closed in March 2011. Details of the bidding information are presented in Table 1. The highest tenderer bid for this site was placed by UVD (United Venture Development Pte. Ltd.) with SGD 5,010 per Gross Floor Area (GFA). The second highest bid was SGD 4,885 per GFA and was submitted jointly by FE Lakeside Pte. Ltd., FCL Topaz Pte. Ltd., and Sekisui House Singapore Pte. Ltd. (referred to as FE-FCL-Sekisui in the following context).

Following site 1 and in the same Bedok Urban Planning Area, the Government launched another land parcel along Bedok South Avenue 3 in December 2011. This plot of land is also shown on Figure 1 and marked as Site 2. The distance between these two sites is roughly 3,200 meters. This time round, the site attracted seven bids from the market. Both the winner and the second highest bidder of Site 1 participated in the bidding for Site 2. Both parties have increased their tendering prices significantly. As shown in Table 1, the winner of Site 1 (UVD) increased its tendering price by 13%, after adjusting for GFA. This price ranked UVD the second highest in this new round of bidding for Site 2. The bidding price jointly submitted by FE-FCL-Sekisui increased by 18% compared to their previous bid for Site 1, which enables them to win this new plot of land.

The next land parcel launched in Bedok Planning Area was along Tanah Merah Kechil Road, which is about 1,000 meters away from Site 2 as shown on Figure 1. This land parcel was launched in June 2012 and closed in July 2012. Before its closing date, this site received thirteen bids altogether. Both UVD and FE-FCL-Sekisui, again, joined the bidding for Site 3. In the end, neither of these developers won this new site although both UVD and FE-FCL-Sekisui have increased their tendering prices by 18% and 4% respectively compared to their previous bids for Site 2. The winning bid was SGD 7,277 per GFA and was jointly submitted by Fragrance Group Ltd. and World Class Land Pte. Ltd..

There are two patterns arising from this example. First, we observe that bidding prices have increased substantially during this 18-month period. Specifically, the GFA adjusted tendering prices have increased overall by 33.57% and 22.74% for UVD and FE-FCL-Sekisui respectively. In fact, each subsequent parcel launch is associated with a notable jump in tendering prices, which accumulates to a significant overall increase in local land auction prices. Second, the incumbent winner of a previous land parcel tends to participate in subsequent launches of new sites in the same area but does not necessarily win the new sites. For example, UVD continued to participate GLS auctions for Site 2 and Site 3 after successfully winning Site 1. However, in both subsequent auctions, UVD did not win the sites even though UVD has substantially raised its tendering prices.

There are several possible explanations for the increase in bids for each nearby subsequent parcel launch that we observe in this case study. One may argue that the price run-ups along the sequence of the sale is due to better underneath topological features or better amenities in the close surrounding area of each subsequently launched parcel. In the following empirical analysis, we control for parcel specific characteristics and location fixed effects to address this issue. Alternatively one may argue that it is the rising housing prices and construction costs that drive up the bidding prices overtime. This is, however,

unlikely to be the cause given that the housing price index for private condominiums in Singapore merely increased by 2.5 % from March 2011 to July 2012 and the construction costs have been quite stable over the same period of time. In fact, as we document at the empirical section that after controlling for various observed characteristics of each land parcel and time-varying housing prices and construction costs, we still find significant evidence for price run-ups associated with sequential sale and land parcels in the same area.

Aside from potential omitted variables, previous literature has provided explanations for price run-ups along the sale sequence of highly substitutable goods. We explain different theories in the following section that likely explain part of what we have observed in the data. We also propose our own hypothesis which, we believe, is most in line with the anecdotal evidence as well as with our empirical findings.

3 Theory

There are various explanations for price run-ups along the sales sequence of highly substitutable goods. First of all, prices may increase for auctions taking place at the later stage of the sales sequence if there exist *uncertainties* on the value of the auctioned goods. In the framework of common value auctions, early sales may provide additional information for subsequent sales which reduces concerns about the winner's curse in subsequent auctions (Milgrom and Weber 1982; McAfee and Daniel 1993; Van den Berg et al. 2001). In the regime of private value auctions, winners of the previous auction may derive private information from owning the land and hence may capitalize the private information into higher bidding prices for subsequent auctions. For land auctions in particular, the intrinsic value of the land could be better revealed to late buyers as previous sales are used to validate perceived common asset values or to the winner of a previous auction as more private information was obtained from the previous win.

The second set of explanatory factors for subsequent higher bids is potential benefits associated with being a *monopoly*. The winner of a previous land auction may want to monopolize the local housing market to acquire monopolistic profit. It is also likely that developing two neighboring parcels together will allow the winner to better explore internal economies of scale which increases productivity and reduces costs. Both factors will lead to higher bidding prices for subsequently launched parcels.

The third plausible explanation for rising price-sales sequence relationship is the declining *externality* effect as new residential developments are being built out (Sirmans et al. 1997). The idea is that the early consumers or developers tend to face higher uncertain neighborhood externalities. As the sales sequence evolves, potential consumption risk may reduce which leads to higher willingness to pay for the subsequent sales. Moreover as more and more sites are being developed in the same area, agglomeration economies in the form of external economies of scale may serve as another plausible factor contributing to higher land prices over time (Ranch 1993).

The above hypotheses hinge greatly on the rationale that a subsequently launched land parcel is associated with higher real benefits which accrue to higher reserve price upon bidding for a subsequent parcel. These arguments help to explain rising price-sales sequence relationship from a demand perspective. However, they seem to be inconsistent with the observation that developers often participate in the subsequent land auction sales but at the same time, do not necessarily win the subsequent site. To

reconcile the discrepancy in participating and winning the subsequent site, we argue that the incumbent winner of the previous auction participates in the subsequent parcel launch in order to push up potential rival's land cost and gain pricing advantages for its own parcel at the sales stage.

We present a simple model to explain the underlying mechanism. Suppose that firm 1 and firm 2 are two identical land-developing companies competing for two identical land parcels launched sequentially (assume that the sale of the second parcel was announced after the auction of the first parcel). We also assume that firm 1 is the incumbent firm who has won a prior bid at c_1 . After that, firm 1 and 2 simultaneously bid for the second land parcel (the winning bid is denoted by c_2).¹¹ If firm 1 loses the second bid, both firms compete in a differentiated price duopoly. Assume that their respective profits are as shown in Figure 2 (the red line and the blue line and labeled as π_1 and π_2). We note that in this case, $\frac{\partial \pi_1}{\partial c_2} > 0$ and $\frac{\partial \pi_2}{\partial c_2} < 0$.¹² If firm 1 wins the second bid, it will act as a monopoly in choosing prices for both developments. We assume that the monopolistic profit is as shown in Figure 2 as the green line (labeled as Π). Since firm 1 owns both land parcels in this case, we have $\frac{\partial \Pi}{\partial c_2} < 0$. We assume that Π will intersect π_1 due to potential capacity constraints or high financing costs associated with developing two parcels simultaneously. Intuitively, this implies that monopoly will incur lower profit when the cost of obtaining the second land parcel becomes too high to justify the cost for monopolizing the market. The intersection of the blue and the red line is c_1 since $\pi_1 = \pi_2$ when $c_1 = c_2$ due to symmetry of identical firms. The intersection of the green and red line is denoted by c_2^* .

The incumbent firm 1 will try to maximize profits by comparing π_1 and Π that correspond to different winning bid c_2 associated with the second land parcel. If firm 2 places a bid below c_2^* (the intersection of π_1 and Π), the incumbent would be better off forming a monopoly since $\Pi > \pi_1$. In this case, firm 1 would bid slightly higher than firm 2's bidding price to win the auction. Firm 2, given positive profits, also has incentive to outbid firm 1, which eventually causes the winning bid for the second land parcel, c_2 , to infinitely approach c_2^* . If firm 2 places a bid above c_2^* , the incumbent firm would prefer to lose the auction by bidding slightly lower than firm 2's bid (since $\Pi < \pi_1$). Given positive profits, firm 2 would still want to outbid firm 1 to win the second parcel. Knowing firm 2's desire to win, the incumbent would want to push up the value of c_2 and maximize firm 2's winning bids. The largest firm 2 could possibly bid is given by c_2^{max} at which firm 2 makes zero profits.

¹¹ Both c_1 and c_2 can be endogenously solved for a sub-game perfect Nash equilibrium. However, this paper will not solve the whole model but instead we focus on how profit maximization in the second stage leads to differences in c_1 and c_2 in the auction stage.

¹² $\frac{\partial \pi_1}{\partial c_2} > 0$ because, as noted by Salop and Scheffman (1983), high-cost rival may reduce output, allowing the predator to raise price or market share. This is true especially if firms are financially constrained with their investments. With a large amount of investment to obtain patent, for example, financially constrained investors end up having less resources at disposal to expand business. In the context of land sales, financially constrained rivals, once have spent a significant amount to obtain the land parcel, may end up cutting output which increases the predator's profit.

If we impose a tie-breaking rule which gives firm 2 priorities if having equal bids, then we can find a set of Nash Equilibriums. We can show that any equal bids between c_2^* and c_2^{max} would form a Nash Equilibrium which implies that the realized winning bid c_2 is greater than c_1 . The reason is as follows. Since $\Pi < \pi_1$ when $c_2 \geq c_2^*$, letting firm 2 win the bid is optimal for firm 1 when $c_2 \geq c_2^*$. In this scenario, firm 1's best response to firm 2's bid is any bid which is below or equal to firm 2's bid if firm 2's bid is above or equal to c_2^* . Firm 1 strictly prefers not to win the bid but its participation is required to keep the bid price high. In the meanwhile, firm 2 has a dominant strategy to win the auction as long as the winning bid c_2 yields positive profits for firm 2. To achieve the highest profit given firm 1's bid, firm 2 would place a bid equal to firm 1's bid and would not have incentive to deviate from it. Therefore, the pair of bids, (c_1, c_2) , becomes Nash Equilibrium, which imposes that the winning bid of the second land parcel, c_2 , is greater than c_1 .

4 Empirics

4.1 Data and Variables

This paper empirically tests the proposed hypothesis using a unique dataset in Singapore. The primary dataset is a GLS core file that is compiled from three different government sources: URA, HDB, and JTC. The compiled GLS dataset contains all tendering prices submitted by land developers for all parcels that have been launched in Singapore ever since 1990. For the purpose of this study, we restrict the GLS to only those designated for the development of private residential condominiums (mainly sites sold by URA). This ensures sufficient substitutability between successively launched parcels when developers consider potential price competition between final developed projects. Altogether, we have 248 parcels launched through the GLS program between 1990 and 2014 and that were developed into private condominiums in our dataset.

Summary statistics of land parcel characteristics are presented in Table 2a. The mean of the gross floor area across all parcels is 45,790 square meters. On average, each parcel auction attracts 6.7 bidders. The average winning bid is 161 million Singapore dollars. Among all condominium projects, one project is associated with 60-year tenure status with the rest being standard 99-year leasehold projects.¹³ Parcel launches vary with time in response to the general housing cycles in Singapore. The number of condo parcels launched in each year is reported in Table 2b. When the housing market was booming, such as the years prior to the 1998 Asian financial crisis, the number of new parcels launched within a year was as high as 38. During market downturns, such as in 1998 and 1999, no residential condominium land parcels have been launched due to subdued demand.

Among various characteristics of each land parcel, we are particularly concerned with locational advantages in accessing the CBD area and the closest MRT station. This is because the CBD area and areas close to the existing MRT stations tend to be developed earlier in the sequence and are often associated

¹³ The one site that is associated with 60-year tenure status is located at Jalan Jurong Kechil.

with higher prices. This will imply a downward price-sequence relationship that goes to the opposite direction to our proposed increasing price sequence pattern. To capture the extent of the downward bias, we explicitly control for each land parcel's distance to the CBD and its distance to the closest MRT stations. We do so by pinpointing each land parcel's geographic location and linking the site to its nearby amenities. Specifically, relying on GIS software (MapInfo and MapBasic), we measure the distance of a particular private residential land parcel to the Singapore CBD area (as captured by the location of the Raffles Place MRT station) and to the nearby closest MRT station. As reported also in Table 2a, the average distance to Singapore downtown area is 9,511 meters. The average distance to the closest MRT station is 960 meters.

The GIS technique is also crucial for us to link a parcel to its nearby parcels so as to capture whether two subsequent launches are within close distance. We do so by first creating pairs of existing land parcels. Having pinpointed the latitude and longitude associated with each site, we use the GIS software to calculate pair-wise distances in kilometers. Based on the closing date of each auction sale, we also calculate the time lag between two parcel sales within each pair. This allows us to identify those parcels that had a previous launch taken place within 4 km and within the last 2 years. According to the hypothesis proposed earlier, those parcel prices tend to be bid up by the incumbent winners of previous parcel sales in the same area. Hence, we create dummies that identify these land parcels with higher extent of substitutability to the earlier sites to capture any price margin associated with them. We have also experimented with setting 3.5 km and 4.5 km circles in geographic distance as well as time lag categorized as within half a year, between half a year and one year, and between one year and two years. These different categories capture the different extent of parcel substitutability and allow us to examine the impact of the extent of production differentiation on the exact magnitude of the elevated price margin.

We invested substantial amount of efforts to identify the unique bidder participating in government land auction sales repeatedly. This is because in the original dataset, we have only the name of the bidders identified. These bidders identified by unique names, however, do not always correspond to the ultimate decision making entities that manage auction bids. Many property developers in Singapore have a number of subsidiary companies with each separately identified by a unique name in the data. The profit maximizing decision is however made at the parent company level, taking into consideration of production taking place at all subsidiary companies. To capture the sequential bidding behavior exhibited by the same parent company, we manually link each bidder reported in the data to its corresponding parent company. Eventually, 567 unique bidders reported in the data are matched to 335 unique parent companies. The linkage substantially reduced the number of participating entities in sequential land auctions. As summarized in Figure 3, within all parent companies identified, 167 companies bid only once, which are often the case of private individuals bidding for small land parcel sales. More importantly, there are a few large developers that have been participating government land parcel sales repeatedly. The sequential bidding behaviors of these repeated participants are the focus of this paper.

Table 2c presents the summary statistics at the tenderer level. Aside from the standard controls that vary by parcels, we have also included tenderer specific characteristics upon bidding for a particular site. These include whether the developer submits the bidding price jointly with other developers (joint bid), the tenderer's accumulated experience (captured by the accumulated gross floor area of previous winning sites), and the tenderer's likelihood of being capacity constrained (captured by the accumulated gross floor area of the previous 2 years of winning sites). As shown in the table, 40% of the bids are submitted jointly by more than one land developers. The average accumulated land development area among all bidders upon bidding for a new site is roughly 128,000 square meters, ranging from no prior experience at all to 807,518.8 square meters. The average accumulated land development area in the previous 2 years is about 53,000 square meters.

4.2 Identification

There are two goals to achieve in the empirical exercise. The first goal is to identify the price premium associated with subsequently launched land parcels that are highly substitutable to the prior sites. To do so, we estimate a standard hedonic regression with a set of dummies capturing the extent of product substitutability between two successively launched parcels. The specification is as follows:

$$\log(P_{ijt}) = \alpha_0 + \alpha_1 D_{jt} + \mathbf{X}_{ijt} \boldsymbol{\beta} + \mu_i + \delta_t + \varepsilon_{ijt} \quad (3.1)$$

In the above specification, i represents a tenderer, j stands for a land parcel, and t indexes the quarter in which the parcel auction closes. Initially, D is a dummy variable capturing whether subsequently launched parcels are highly substitutable to the prior site. The extent of substitution of a site is captured by whether it is associated with a previous site launched within 4 km and also within 2 years. Later on, D is broken into three categorical dummies to capture the different extent of substitution/production differentiation: whether the previous launch within the same distance took place within half a year, between half a year and one year, and between one year and two years. We expect to observe declining increased price margins as the two parcels become less substitutable given that they are less likely to directly compete with each other in pricing.

The second goal of the empirics is to explore the mechanism that may give rise to the price increase associated with subsequently launched sites in the same area. We argue that prices are bid up by incumbent winners to gain pricing advantages of final developed properties. This implies that the incumbent winner of the previous site will be more inclined to participate in auctions for subsequently launched parcels that may become substitutable to their winning site and that will directly compete with their sites in pricing at the sales stage. However participation itself does not necessarily lead to winning the site due to capacity or financing constraints often associated with managing multiple parcels within a short time frame.

We empirically test these implications by examining the probability of participating/winning subsequent parcel auction sales by the incumbent winner of a previous site as compared to other losing bidders of the same site. To do so, we first create pairs of a prior site and a follow-up site for sites that are

launched less than two years apart of each other. This paring strategy will allow us to explore whether the winner of a prior site has a higher probability to participate in and win the follow-up site. Do note that one prior site can be matched to several follow-up sites launched within the next two years. This leads to an expansion of the sample size.

One source of endogeneity in identifying the tendency to participate in and win the following site is that the winners vary significantly from other auction participants in their unobserved taste for subsequent sites in the same area. For instance, an incumbent winner of a site may see greater development potential for the area compared to other bidders and hence are more likely to participate/win subsequent parcel sales in the same area. This will lead to an overestimation of the tendency of incumbent winners to participate/win subsequent nearby parcel launches with the purpose of gaining pricing advantages. We address this endogeneity issue by restricting the comparison to between the previous winner and the second highest bidder with a bid difference less than 5% of the winning bid. This ensures that the treated group (previous winners) share similar unobserved characteristics to the control group (second highest bidders with almost same bids), as reflected by their willingness to pay for the same prior site.

The tendency to participate/win subsequent parcel auctions is also subject to the difference in capacity/financing constraint between previous winners and losers. The incumbent winner is likely to be capacity constrained or financially constrained. This causes the incumbent winner to be less likely to bid for and hence, win subsequent site launches, which leads to an underestimation of the tendency to participate/win. To this end, we directly controlling for developer fixed effects and capacity constraint. We also address the issue with financial constraint by further comparing participation/winning rate for subsequently launched parcels that are close in distance (serve as direct substitutes to the winning site) and those that are further apart (do not compete directly).

This identification lends itself naturally to a difference-in-differences strategy. The identification assumption is that the impact of financial constraint on the tendency to bid for subsequent sites is the same for sites at various distances and, hence, will be differenced out. The remaining comparison of the difference between the treated group and the control group identifies the impact of winning a site on the tendency to participate subsequent nearby parcel launches with the purpose of gaining pricing advantages for final developed properties. The corresponding specification is shown below,

$$\begin{aligned} Pr(\text{Participate}_{psi}) & & (3.2) \\ &= \alpha_0 + \alpha_1 T_{psi} + \alpha_2 D_{ps} + \alpha_3 T_{psi} \times D_{ps} + \alpha_4 C_{psi} + \mu_i + \varphi_p + \theta_s \\ &+ \varepsilon_{psi} \end{aligned}$$

$$\begin{aligned} Pr(\text{Win}_{psi}) &= \alpha_0 + \alpha_1 T_{psi} + \alpha_2 D_{ps} + \alpha_3 T_{psi} \times D_{ps} + \alpha_4 C_{psi} + \mu_i + \varphi_p + \theta_s & (3.3) \\ &+ \varepsilon_{psi} \end{aligned}$$

where, p stands for the previous site, s stands for the subsequently launched sites within the next 2 years, i indexes the tenderer, T is a dummy variable indicating the treated group (incumbent winner of a previous site), D identifies subsequent sites that are within 4 km. C controls for the tenderer's capacity constraint at

the time of bidding. The coefficient of the interaction term identifies the tendency for incumbent winner to participate/win subsequently launched sites to gain pricing advantages.

5 Results

To explain tenderer's bids placed on each government land auction sales, we first estimate a standard hedonic regression with log tenderer prices as the dependent variable. Results are reported in Table 3. We experimented with various specifications including time fixed effects, tenderer fixed effects, or both time fixed effects and tenderer fixed effects. The estimated coefficients vary slightly in magnitude. The estimated shadow prices associated with various hedonic characteristics are consistent with intuition. First, the tenderer bids increase with the gross floor area. 1 percent increase in gross floor area is associated with 0.8 percent increase in tenderer bids. 60-year tenure status is associated with significantly lower tendering bids when compared to those with the standard 99-year lease. Besides, the distance to Downtown and the distance to the closest MRT stations are both negatively correlated with tenderer's bids, with the estimated elasticity 0.34 and 0.06 respectively. Moreover, the number of bids is included in the regression to capture how popular a land sale is or the intensity of the competition. We see that a higher number of bids is associated with higher bidding prices. Finally, when developers submit bids jointly, they tend to bid higher as they are, in this instance, less likely to be capacity constrained. With more bidding experiences accumulated, developers bid higher. If developers are more likely to be capacity constrained, as captured by the accumulated areas in the previous two years, bidding prices will be lower.

We next explore the extent to which prices have been pushed up along the sales sequence and the extent to which the increased price margin is affected by the extent of substitutability. The latter is captured by varying two aspects of two successively launched land parcels: the time distance and the geographic distance. We first identify parcels that have a prior launch taken place within 4 km and within the previous 2 years. As reported in Table 4 Columns 1-3, these parcels receive tenderer bids that are roughly 80% higher compared to other parcels. When the time distance is further decomposed into three categories: previous half a year, between half a year and 1 year, and between 1 year and 2 years, we observe a declining increased price margin along the time distance (Table 4, Columns 4-6). When two sequential nearby launches take place within half a year, the subsequent parcel receives the highest increased price margin, 61% as compared to other parcels that are either beyond the 4 km distance or launched more than 2 years ago. The price margin reduces to 40% when the time distance is between half a year and 1 year. For parcels had previous launches within 4 km but time wise between 1 year and 2 years, the price margin is not significantly different from the omitted category. Evidence suggests that the subsequent tendering prices have been pushed up mainly for sites that are launched within the next one year. This could be because closely launched sites are more likely to appeal to the same group of homebuyers and, hence, will directly compete with each other. The directly competition is also partly explained by the likelihood that the previous project has not completely sold out all the units at the presale stage which creates incentives for previous winner to defend its price.

As further robustness checks, we also experimented with varying the geographic distance between two parcels. Instead of using 4 km as the threshold, we have also experimented with 3.5 km and 5 km as reported in Table A1 and Table A2. The results on the declining increased price margins along the time distance hold in all cases with the exact magnitude varying within an understandable range. To incorporate various situations in a more visual setting, we have shown in Figure 4 the estimated coefficients associated with various time distances and spatial thresholds. Table A3 reports another scenario in which we vary the geographic distance while holding the time lag being constant at 2 years. We also observe that the increased price margin declines with geographic distance. For example, parcels with previous launch taken place with 2 years and within 4 km is associated with 13% higher tenderer bids compared to those either beyond 2 years or beyond 12 km. The magnitude reduces to 11.0% when a parcel had a previous launch within 2 years and within 8 km. The results are consistent with our hypothesis that the elevated price margin declines with the extent of product differentiation.

Another concern on the baseline specification is the possibility of other unobserved location amenities that may also influence the key estimated coefficients. To address this concern and also for further robustness checks, we have included urban planning area fixed effects and planning area by year fixed effects in our estimation. Results are reported in Table 5. The estimated coefficients on the previously included distance to CBD and distance to the closest MRT stations become insignificant as expected. The estimated price increase associated with subsequently launched land parcels is still positive and significant, even though the magnitude reduces to 50%. The evidence on declining increased price margin as two successive parcels become less substitutable in time dimension remains consistent.

To better understand how the results vary with market cycles, we further conduct the analysis separately for the housing boom period versus the housing bust period. Results are reported in Table 6. As shown in the table, the evidence on competitive bidding behaviors is mainly shown during the housing boom period. Whereas during market downturns, we do not observe evidence showing developers trying to sabotage competitors by bidding up subsequent land prices. This could be potentially driven by the significantly reduced number of parcels launched during market downturns. As shown in table 2b, the number of parcels launched by the government varies with market cycles. When market is in the bust phase, the supply of land parcels is significantly reduced or even diminished for a select number of years. Without sufficient land parcels launched sequentially and close to each other, we lack sufficient variation in capturing the close substitutability between two parcels and identifying the developer's incentives to push up the following land price.

We now assess the impact of the competitive bidding behaviors from a different perspective – consider sites that are launched in isolation. The idea is that if sites were launched in isolation, land developers would not have incentive to push the price up and the associated tenderer bids would be much lower. We capture isolated sites using a dummy variable that identifies parcels with NO previous nearby launch within 2 years and NO subsequent nearby launch within 2 years. As shown in Table 7, isolated sites are associated with 70% decrease in tenderer prices, which is also consistent with our hypothesis.

Next we report results on the incumbent's tendency to participate and win subsequently launched sites. Table 8 columns 1-3 focus on the decision to participate. Columns 4-6 are on the probability of winning subsequent sites. The estimated coefficients associated with the interaction term are significantly positive for the decision to participate. The magnitude ranges from 0.0467 to 0.1027. These are fairly large effect given the fact that the majority of the bidders are small developers or individuals who tend not to engage in repeated competition with other large developers. In fact, the mean probability of consecutive participation is 22%. We show that compared to the second highest bidder, the incumbent is at least 21% (5.26/22) more likely to participate in subsequent nearby parcel launches. This suggests that the incumbent has a strong incentive to participate in the immediate subsequent land auction if the site is closer in distance to the previous winning site. The tendency to win the next nearby site is, however, insignificant. Estimated coefficients on the relative tendency to win subsequent sites (columns 4-6) are negative and insignificant. These findings are consistent with the proposed mechanism that the incumbent winner of the previous site tends to participate in the subsequent launch to push up the equilibrium bidding price. However, due to various considerations, they do not necessarily win the subsequent sites.

As a falsification test, in a different exercise we treat the *second highest* bidder of a previous site as a pseudo incumbent winner. We compare the pseudo incumbent winner's tendency to bid for and win the subsequent site to that of the *third highest* bidder of the same site with very similar bids. Results are shown in Table 9. As expected, the previously identified incentive to participate in subsequent nearby land auctions is no longer present for the pseudo incumbent. The tendency to win the subsequent nearby site is still insignificant.

6 Conclusion

Motivated by Government Land Sales in Singapore where several large developers interact in land auctions repeatedly, we set out to find if there are any strategic implications of the secondary developed property market on the primary land market auction outcomes. Our simple model suggests that the incumbent winner of the previous land auction prefers the cost of the second land parcel be high so as to gain pricing advantages for its own parcel at a later sales stage. To ensure this happens, the incumbent often participates in the subsequent land sales and places significantly higher bids to push up the price. At the same time, the incumbent does not necessarily win the sites due to potential capacity constraints or financing constraints.

Using government land sales data from Singapore, we find supporting evidence for our hypotheses. Specifically we show that tendering prices are significantly higher when there was a previous launch taken place in the past two years and also within 4 km distance. At the same time, the incumbent winner of a previous land auction is more likely to participate in subsequent nearby land sales but does not necessarily win the new sites. This seems to suggest that the strategic bidding behavior causes winning bids for GLS to go up and consequentially may lead to higher prices in the developed property market. In this case, potential supply-side cooling measures that target at this behavior may be effective in reducing property prices. For example, the government may limit incumbent firms from participating in certain

auctions or choose not to release lands that are close together in a sequential fashion. Our results give us insights into the strategic nature of land auctions, which should not be overlooked by policy makers.

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Table 1: Case Study^a

Rank	Site 1 3/2011 Bedok Reservoir Road		Site 2 2/2012 Bedok South Avenue 3		Site 3 7/2012 Tanah Merah Kechil Road	
	Tenderer	Price(S\$) / GFA(sqm)	Tenderer	Price(S\$) / GFA(sqm)	Tenderer	Price(S\$) / GFA(sqm)
1	United Venture Development Pte Ltd	5010	FE Lakeside Pte Ltd FCL Topaz Pte Ltd Sekisui House Singapore Pte Ltd	5750 (18%)^b	Fragrance Group Ltd World Class Land Pte Ltd	7276
2	FE Lakeside Pte Ltd FCL Topaz Pte Ltd Sekisui House Singapore Pte Ltd	4885	United Venture Development Pte Ltd	5665 (13%)	Areca Investment Pte Ltd	7146
3	Best Desire Investments Ltd	4579	Kingsford Development Pte Ltd	5007	United Venture Development Pte Ltd	6692 (18%)
4	First Changi Development Pte Ltd	4431	MCL Land Ltd	4771	Verwood Holdings Pte Ltd TID Residential Pte Ltd Intrepid Investments Pte Ltd Sherwood Development Pte Ltd	6674
5	Allgreen Properties Ltd	4008	Intrepid Investments Pte Ltd Hong Realty Ltd Sunmaster Holdings Pte Ltd Mezzo Development Pte Ltd	4470		6572
6	Sunmaster Holdings Pte Ltd	3875		4123	Sing Holdings Ltd Maxdin Pte Ltd	6172
7	Leng Hoe Development Pte Ltd	3366	Soilbuild Group Holdings Ltd	3910	Qingjian Realty Group Pte Ltd Hock Lian Seng Holdings Ltd Meadows Bright Development Pte Ltd	6141 6128
8	Mezzo Development Pte Ltd	3147				
9					FE Lakeside Pte Ltd FCL Topaz Pte Ltd Sekisui House Singapore Pte Ltd	5996 (4%)
10					Sunway Developments Pte Ltd Hoi Hup Realty Pte Ltd Hoi Hup Jv Development Pte Ltd	5996
11					Teneriffe Development Pte Ltd	5812
12					Oue Reef Development Pte Ltd	5692
13					Trident Assets Pte Ltd	5154

^a This table provides details of the bids submitted for auctions for three government land parcels sequentially launched at the Bedok Planning Area in Singapore. Tenderer names highlighted in bold are two bidding entities that participated all three auction sales.

^b Numbers in brackets indicate the percent increase in Gross Floor Area adjusted bidding prices submitted by the same tenderer in the auction sequence.

Table 2a: Summary Statistics (by parcel) ^a

	Observations	Mean	Std. Dev.	Min	25 th percentile	50 th percentile	75 th percentile	Max
Gross Floor Area (sqm)	248	45788.96	54399.49	138.6	2211.71	41934	59384.66	588383
Number of Bids	248	6.729839	3.967938	1	4	6	9	23
Winning Bids	248	1.61E+08	1.31E+08	750000	6.29E+07	1.40E+08	2.24E+08	6.83E+08
Term being 60 Years instead of 99 Years	248	0.0040323	0.0635001	0	0	0	0	1
Distance to Downtown (meters)	248	9511.404	4623.385	1448.07	5479.71	10074.26	12742.56	18117.73
Distance to the Closest MRT Station (meters)	248	960.0077	762.9375	38.66269	353.20	824.88	1374.86	4306.37

^a Parcel-specific characteristics for all parcels launched by URA between 1990 and 2014 and that are developed into private condominiums.

Table 2b: Parcel Launches by Year

Year	# of private condo land parcel launches
1990	5
1991	2
1992	2
1993	7
1994	9
1995	14
1996	38
1997	28
2000	15
2001	7
2002	4
2003	2
2005	1
2006	3
2007	10
2008	10
2009	4
2010	23
2011	25
2012	23
2013	11
2014	5

Table 2c: Summary Statistics (by bid)

	Observations	Mean	Std. Dev.	Min	25 th percentile	50 th percentile	75 th percentile	Max
Tenderer Bids	1848	1.74E+08	1.18E+08	738380	9.14E+07	1.48E+08	2.30E+08	6.83E+08
Gross Floor Area (square meters)	1848	49208.28	49013.78	138.6	32200	45761	60154	588383
60-Year Tenure Status	1848	0.0146104	0.1200197	0	0	0	0	1
Distance to Downtown (meters)	1848	10019.94	4242.719	1448	6011	10712	13012	18117
Distance to the Closest MRT Station (meters)	1848	793.4029	722.1452	38	234	519	1110	4306
Number of Bids	1848	9.19697	4.339311	1	6	8	12	23
Joint Bid	1848	0.4393939	0.4964477	0	0	0	1	1
Bidding Experience (Accumulated Gross Floor Area – square meters)	1848	128233	167814.7	0	0	64280.5	190308.3	807518.8
Capacity Constraint (Accumulated Gross Floor Area in Past 2 Years – square meters)	1848	53066.47	76444.8	0	0	0	86894.8	588383

Table 3: Hedonic Regressions
Dependent Variable: Log Tenderer Bid
(t statistics are reported in parenthesis using clustered standard errors at the tenderer level)

	(1)	(2)	(3)	(4)
Log (Gross Floor Area)	0.8868 (15.10)	0.9678 (30.68)	0.7031 (13.22)	0.7969 (14.83)
60-Year Tenure Status	-0.8711 (-9.34)	-1.2682 (-15.84)	-0.7607 (-5.83)	-1.0023 (-10.52)
Log (Distance to Downtown)	-0.1044 (-2.18)	-0.2868 (-12.64)	-0.2548 (-7.86)	-0.3439 (-15.70)
Log (Distance to the Closest MRT Station)	-0.0957 (-5.94)	-0.0521 (-5.20)	-0.0560 (-3.62)	-0.0571 (-4.86)
Number of Bids	0.0642 (9.64)	0.0349 (8.53)	0.0302 (6.84)	0.0190 (3.83)
Joint Bid	0.1491 (2.14)	0.0464 (2.34)	0.1990 (1.80)	0.0702 (3.04)
Bidding Experience (Log Accumulated Gross Floor Area)	0.0233 (4.49)	0.0101 (3.73)	0.0830 (7.47)	0.0123 (3.14)
Capacity Constraint (Log Accumulated Gross Floor Area in Past 2 Years)	0.0046 (0.86)	-0.0037 (-1.39)	-0.0071 (-0.96)	-0.0067 (-2.62)
Quarter × Year Fixed Effects	NO	YES	NO	YES
Tenderer Fixed Effects	NO	NO	YES	YES
Observations	1,848	1,848	1,848	1,848
R-squared	0.5688	0.8895	0.8137	0.9349

Table 4: Competitive Bidding
Dependent Variable: Log Tenderer Bid
(t statistics are reported in parenthesis using clustered standard errors at the tenderer level)

	(1)	(2)	(3)	(4)	(5)	(6)
Previous launch within 4000 meters & Previous launch within 2 year	0.7110 (4.80)	0.9572 (7.50)	0.7877 (4.68)	- -	- -	- -
Previous launch within 4000 meters & Previous launch within half a year	- -	- -	- -	0.5918 (6.53)	0.7922 (11.88)	0.6147 (6.18)
Previous launch within 4000 meters & Previous launch between half a year and 1 year	- -	- -	- -	0.4002 (4.02)	0.1346 (4.40)	0.4012 (3.16)
Previous launch within 4000 meters & Previous launch between 1 year and 2 years	- -	- -	- -	0.1068 (0.78)	0.1008 (1.85)	0.0633 (0.36)
Log (Gross Floor Area)	0.9520 (30.59)	0.7732 (20.60)	0.8352 (19.18)	0.9705 (34.19)	0.8176 (20.73)	0.8676 (21.40)
60-Year Tenure Status	-1.2462 (-16.40)	-0.7178 (-6.15)	-0.9907 (-10.52)	-1.1876 (-15.91)	-0.6943 (-6.71)	-0.9486 (-10.27)
Log (Distance to Downtown)	-0.2284 (-7.66)	-0.2547 (-8.20)	-0.2930 (-11.38)	-0.2148 (-7.17)	-0.3065 (-12.26)	-0.2833 (-10.76)
Log (Distance to the Closest MRT Station)	-0.0568 (-5.45)	-0.0561 (-4.13)	-0.0585 (-5.04)	-0.0700 (-6.93)	-0.0636 (-4.55)	-0.0723 (-6.68)
Number of Bids	0.0309 (7.96)	0.0286 (6.88)	0.0188 (4.28)	0.0299 (7.93)	0.0281 (7.25)	0.0187 (4.41)
Joint Bid	0.0485 (2.43)	0.1618 (1.67)	0.0643 (2.85)	0.0491 (2.68)	0.1521 (1.86)	0.0543 (2.39)
Bidding Experience	0.0100 (3.91)	0.0725 (8.04)	0.0121 (3.34)	0.0110 (4.48)	0.0639 (8.25)	0.0152 (4.26)
Capacity Constraint	-0.0040 (-1.58)	-0.0078 (-1.16)	-0.0071 (-3.42)	-0.0052 (-2.17)	-0.0100 (-1.72)	-0.0088 (-4.28)
Quarter × Year Fixed Effects	YES	NO	YES	YES	NO	YES
Tenderer Fixed Effects	NO	YES	YES	NO	YES	YES
Observations	1,837	1,837	1,837	1,837	1,837	1,837
R-squared	0.8974	0.8386	0.9414	0.9087	0.8576	0.9483

Table 5: Competitive Bidding – Robustness Check
Dependent Variable: Log Tenderer Bid
(t statistics are reported in parenthesis using clustered standard errors at the tenderer level)

	(1)	(2)	(3)	(4)
Previous launch within 4000 meters & Previous launch within 2 year	0.6669 (5.77)	0.5253 (3.02)	- -	- -
Previous launch within 4000 meters & Previous launch within half a year	- -	- -	0.7081 (6.09)	0.4647 (2.61)
Previous launch within 4000 meters & Previous launch between half a year and 1 year	- -	- -	0.4707 (4.05)	0.2526 (1.21)
Previous launch within 4000 meters & Previous launch between 1 year and 2 years	- -	- -	-0.1578 (-1.08)	-0.1921 (-0.55)
Log (Gross Floor Area)	0.8176 (18.51)	0.8477 (11.47)	0.8401 (20.44)	0.8477 (11.47)
60-Year Tenure Status	-1.0737 (-8.47)	-1.5072 (-7.55)	-1.0148 (-8.18)	-1.5072 (-7.55)
Log (Distance to Downtown)	0.0502 (0.62)	0.1923 (1.32)	-0.0266 (-0.36)	0.1923 (1.32)
Log (Distance to the Closest MRT Station)	-0.0380 (-3.00)	0.0579 (1.77)	-0.0705 (-5.50)	0.0579 (1.77)
Number of Bids	0.0198 (4.07)	0.0201 (3.25)	0.0200 (4.01)	0.0201 (3.25)
Joint Bid	0.0278 (1.47)	0.0186 (1.12)	0.0224 (1.21)	0.0186 (1.12)
Bidding Experience	0.0130 (3.94)	0.0130 (4.86)	0.0147 (4.73)	0.0130 (4.86)
Capacity Constraint	-0.0072 (-3.79)	-0.0066 (-4.44)	-0.0082 (-4.43)	-0.0066 (-4.44)
Quarter × Year Fixed Effects	YES	YES	YES	YES
Tenderer Fixed Effects	YES	YES	YES	YES
Planning Area Fixed Effects	YES	YES	YES	YES
Planning Area × Year Fixed Effects	NO	YES	NO	YES
Observations	1,837	1,837	1,837	1,837
R-squared	0.9540	0.9803	0.9593	0.9803

Table 6: Temporal Heterogeneity
Dependent Variable: Log Tenderer Bid
(t statistics are reported in parenthesis using clustered standard errors at the tenderer level)

	Housing Boom Period			Housing Bust Period		
	(1)	(2)	(3)	(4)	(5)	(6)
Previous launch within 2 years & Previous launch within 4000 meters	0.7631 (4.22)	0.9842 (7.42)	0.8153 (4.02)	0.3375 (3.44)	0.1170 (1.15)	0.1130 (1.00)
Log (Gross Floor Area)	0.9337 (28.28)	0.7271 (17.01)	0.7966 (16.86)	1.1681 (30.70)	0.9653 (19.94)	1.1351 (18.46)
60-Year Tenure Status	-1.2707 (-16.44)	-0.7728 (-6.23)	-1.0140 (-10.14)	- -	- -	- -
Log (Distance to Downtown)	-0.2103 (-6.46)	-0.2411 (-6.46)	-0.2927 (-10.37)	-0.3614 (-9.27)	-0.4053 (-6.59)	-0.3669 (-6.23)
Log (Distance to the Closest MRT Station)	-0.0655 (-5.72)	-0.0561 (-3.78)	-0.0594 (-5.23)	0.0010 (0.04)	-0.0551 (-2.01)	-0.0047 (-0.13)
Number of Bids	0.0319 (7.83)	0.0261 (6.26)	0.0177 (3.88)	0.0257 (3.86)	0.0205 (2.00)	0.0272 (2.63)
Joint Bid	0.0592 (2.62)	0.1814 (1.78)	0.0776 (2.92)	0.0214 (1.12)	0.1357 (0.95)	0.0662 (1.31)
Bidding Experience	0.0098 (3.23)	0.0751 (7.25)	0.0141 (3.44)	0.0107 (3.29)	0.0577 (4.14)	0.0096 (1.21)
Capacity Constraint	-0.0044 (-1.46)	-0.0084 (-1.04)	-0.0080 (-3.13)	-0.0014 (-0.42)	-0.0023 (-0.31)	0.0010 (0.26)
Quarter × Year Fixed Effects	YES	NO	YES	YES	NO	YES
Tenderer Fixed Effects	NO	YES	YES	NO	YES	YES
Observations	1,550	1,550	1,550	287	287	287
R-squared	0.8939	0.8413	0.9423	0.9466	0.9278	0.9758

Table 7: Competitive Bidding – Isolated Sites
Dependent Variable: Log Tenderer Bid
(t statistics are reported in parenthesis using clustered standard errors at the tenderer level)

	(1)	(2)	(3)
No previous nearby launch within 2 years & No Subsequent nearby launch within 2 years – ISOLATED SITES	-0.8715 (-5.71)	-0.8411 (-4.91)	-0.6908 (-5.64)
Log (Gross Floor Area)	0.9766 (38.27)	0.8487 (21.20)	0.8326 (18.71)
60-Year Tenure Status	-1.2461 (-16.48)	-0.9926 (-10.49)	-1.0981 (-8.75)
Log (Distance to Downtown)	-0.2164 (-7.08)	-0.2917 (-11.22)	0.0705 (0.85)
Log (Distance to the Closest MRT Station)	-0.0538 (-5.29)	-0.0572 (-4.93)	-0.0373 (-2.96)
Number of Bids	0.0322 (9.03)	0.0196 (4.50)	0.0208 (4.35)
Joint Bid	0.0489 (2.47)	0.0637 (2.85)	0.0285 (1.50)
Bidding Experience	0.0100 (3.97)	0.0120 (3.34)	0.0129 (3.90)
Capacity Constraint	-0.0041 (-1.68)	-0.0071 (-3.49)	-0.0072 (-3.81)
Quarter × Year Fixed Effects	YES	YES	YES
Tenderer Fixed Effects	NO	YES	YES
Planning Area Fixed Effects	NO	NO	YES
Observations	1,837	1,837	1,837
R-squared	0.9006	0.9421	0.9540

Table 8: Probability of Participating in and Winning the Immediate Subsequent Land Auction
(t statistics are reported in parenthesis using clustered standard errors at the tenderer level)

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variables	Participate	Participate	Participate	Win	Win	Win
Incumbent Winner ¹	-0.1432 (-4.87)	-0.1666 (-5.57)	-0.0169 (-0.51)	-0.0217 (-4.82)	-0.0212 (-4.61)	-0.0001 (-0.01)
Subsequent Site launched within 4 km	0.0217 (0.81)	0.0252 (0.94)	0.0441 (1.57)	0.0268 (1.55)	0.0247 (1.71)	0.0271 (1.90)
Incumbent Winner × Subsequent Site launched within 4 km	0.1027 (3.30)	0.0832 (3.22)	0.0467 (1.91)	-0.0123 (-0.72)	-0.0125 (-0.76)	-0.0180 (-1.13)
Bidding Experience	YES	YES	YES	YES	YES	YES
Capacity Constraint	YES	YES	YES	YES	YES	YES
Previously Launched Parcel Fixed Effects	NO	YES	YES	NO	YES	YES
Subsequently Launched Parcel Fixed Effects	NO	YES	YES	NO	YES	YES
Tenderer Fixed Effects	NO	NO	YES	NO	NO	YES
Observations ²	6,079	6,079	6,079	6,079	6,079	6,079
R-squared	0.0626	0.2059	0.3486	0.0146	0.0884	0.1262

¹ The bidding behavior of the previous winner is compared with that of the second highest bidder of the same auction. The difference of the tendering prices between the winner and the second highest bidder is restricted to be within 5% of the winning bid.

² The increase in number of observations is due to paring of a previous land parcel to a subsequent land parcel. For areas with intensive launch of multiple sites within a short period of time, the number of pairs of sites can easily exceeds the actual number of sites launched.

Table 9: Probability of Participating in and Winning the Immediate Subsequent Land Auction – Placebo Test
(t statistics are reported in parenthesis using clustered standard errors at the tenderer level)

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variables	Participate	Participate	Participate	Win	Win	Win
Pseudo Incumbent Winner	0.0440 (1.76)	0.0268 (1.47)	-0.0157 (-0.62)	-0.0047 (-0.83)	-0.0060 (-0.98)	-0.0390 (-3.70)
Subsequent Site launched within 4 km	0.0350 (1.83)	0.0211 (1.31)	0.0295 (1.90)	0.0054 (0.57)	-0.0010 (-0.09)	0.0010 (0.09)
Pseudo Incumbent Winner × Subsequent Site launched within 4 km	-0.0049 (-0.14)	0.0003 (0.01)	-0.0146 (-0.51)	0.0169 (1.08)	0.0170 (1.04)	0.0134 (0.81)
Bidding Experience	YES	YES	YES	YES	YES	YES
Capacity Constraint	YES	YES	YES	YES	YES	YES
Previously Launched Parcel Fixed Effects	NO	YES	YES	NO	YES	YES
Subsequently Launched Parcel Fixed Effects	NO	YES	YES	NO	YES	YES
Tenderer Fixed Effects	NO	NO	YES	NO	NO	YES
Observations ²	5,930	5,930	5,930	5,930	5,930	5,930
R-squared	0.0010	0.2171	0.3704	0.0013	0.1167	0.1420

¹ The pseudo incumbent winner refers to the second highest bidder of the previous auction. As a placebo test, the bidding behavior of the second highest bidder is compared with that of the third highest bidder of the same auction. The difference of the tendering prices between the second and the third highest bidder is restricted to be within 5% of the winning bid.

² The increase in number of observations is due to paring of a previous land parcel to a subsequent land parcel. For areas with intensive launch of multiple sites within a short period of time, the number of pairs of sites can easily exceeds the actual number of sites launched.

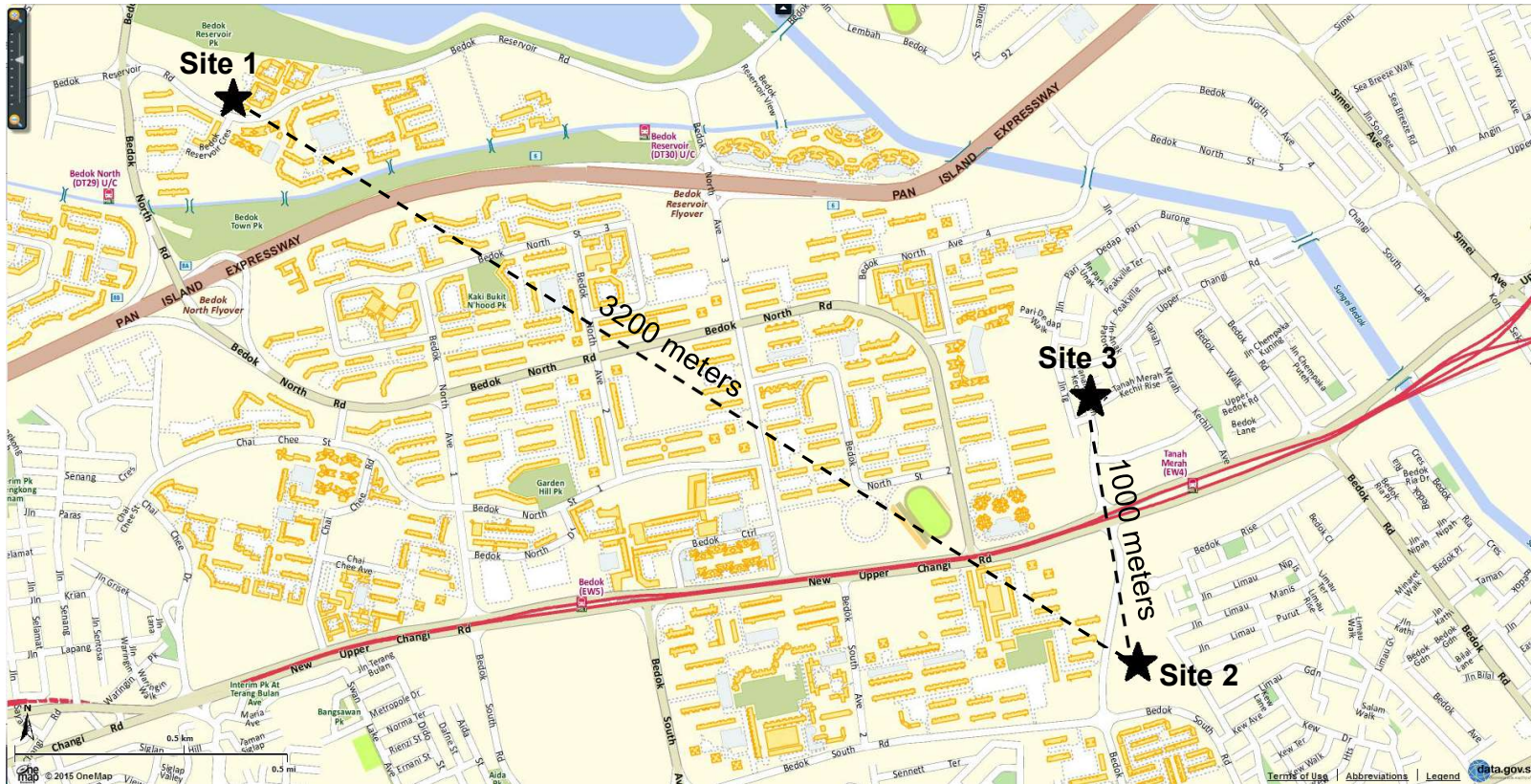


Figure 1: Three Sequential GLs in Bedok Urban Planning Area

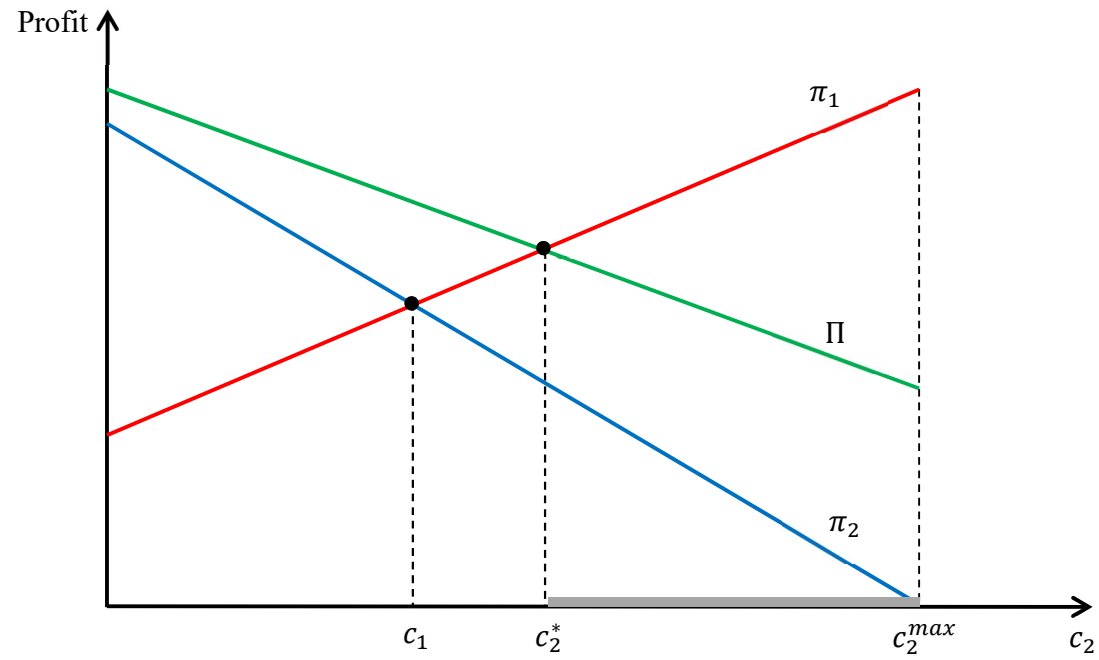


Figure 2: Expected profits given winning bid c_2

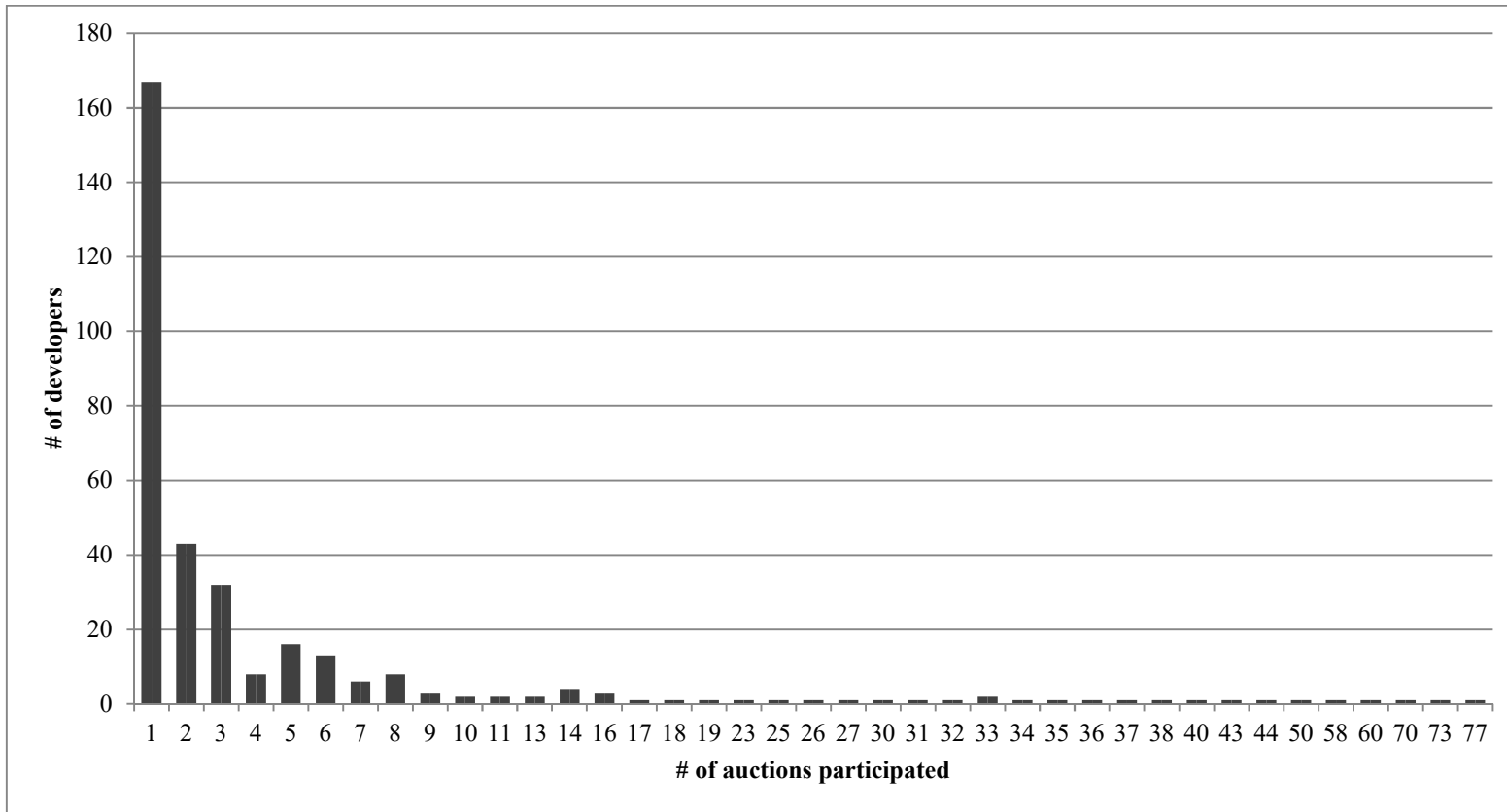


Figure 3: # of developers versus # of auctions participated

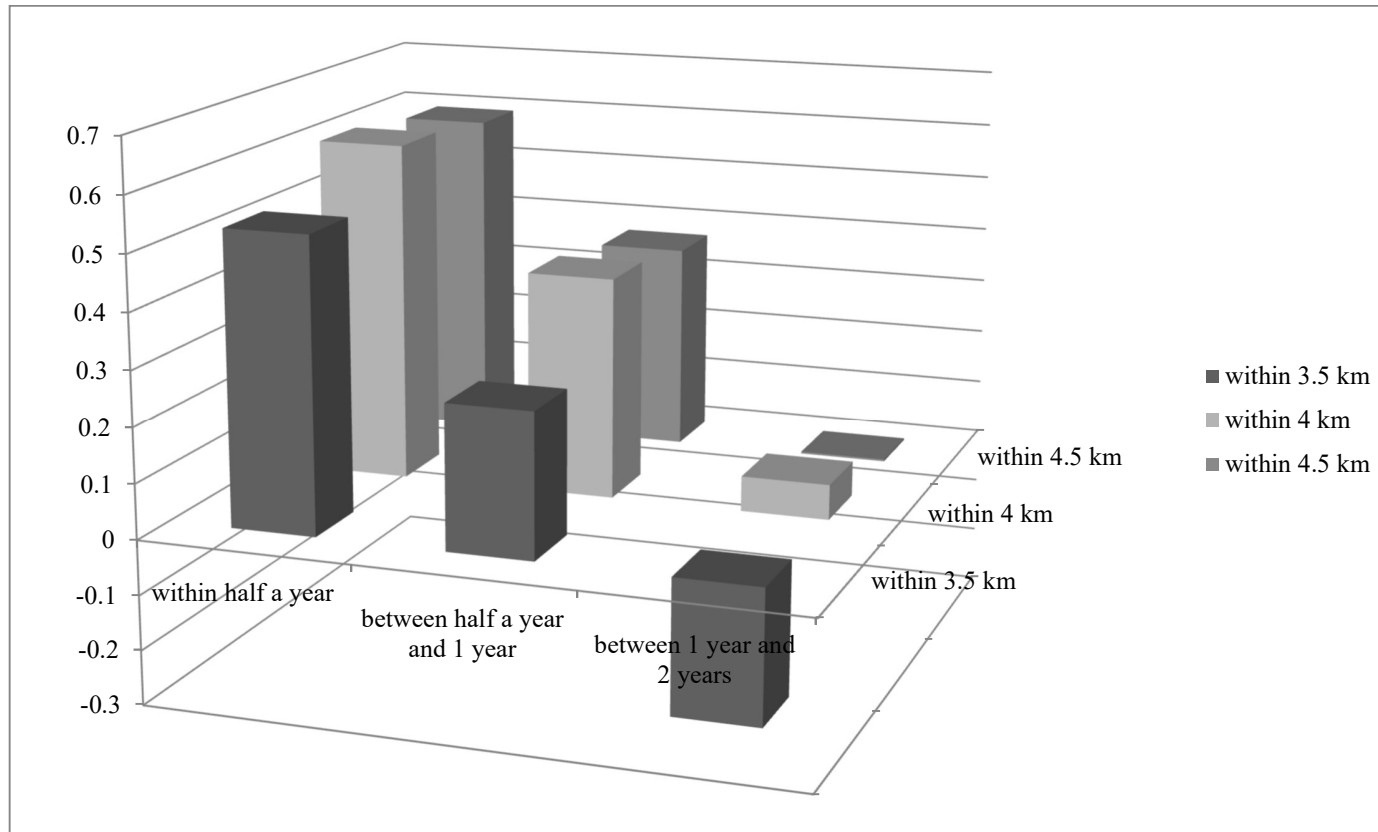


Figure 4: Three Dimensional Effects by Time and Space

Appendix

Table A1: Competitive Bidding – Robustness Check
Dependent Variable: Log Tenderer Bid
(t statistics are reported in parenthesis using clustered standard errors at the tenderer level)

	(1)	(2)	(3)	(4)	(5)	(6)
Previous launch within 3500 meters & Previous launch within 2 year	0.3401 (3.60)	0.7849 (6.04)	0.3380 (4.11)	- -	- -	- -
Previous launch within 3500 meters & Previous launch within half a year	- -	- -	- -	0.4814 (5.89)	0.6948 (9.85)	0.5302 (5.81)
Previous launch within 3500 meters & Previous launch between half a year and 1 year	- -	- -	- -	0.3032 (4.04)	0.1079 (2.95)	0.2612 (2.82)
Previous launch within 3500 meters & Previous launch between 1 year and 2 years	- -	- -	- -	-0.1291 (-1.31)	0.0699 (1.38)	-0.2448 (-1.99)
Log (Gross Floor Area)	0.9563 (29.54)	0.7342 (15.62)	0.8040 (15.10)	0.9549 (29.70)	0.7667 (14.97)	0.8098 (14.51)
60-Year Tenure Status	-1.2561 (-16.12)	-0.7408 (-6.12)	-0.9958 (-10.54)	-1.2164 (-15.70)	-0.7247 (-6.59)	-0.9648 (-10.46)
Log (Distance to Downtown)	-0.2598 (-10.34)	-0.2566 (-8.30)	-0.3236 (-14.70)	-0.2450 (-9.47)	-0.3009 (-11.52)	-0.3131 (-13.85)
Log (Distance to the Closest MRT Station)	-0.0570 (-5.31)	-0.0603 (-4.12)	-0.0601 (-5.00)	-0.0677 (-6.66)	-0.0634 (-4.39)	-0.0709 (-6.35)
Number of Bids	0.0329 (8.31)	0.0289 (6.84)	0.0185 (3.83)	0.0312 (7.69)	0.0280 (7.00)	0.0170 (3.43)
Joint Bid	0.0479 (2.41)	0.1754 (1.74)	0.0678 (2.89)	0.0497 (2.65)	0.1652 (1.87)	0.0621 (2.53)
Bidding Experience	0.0101 (3.79)	0.0750 (7.79)	0.0123 (3.20)	0.0112 (4.26)	0.0676 (7.80)	0.0149 (3.85)
Capacity Constraint	-0.0039 (-1.51)	-0.0088 (-1.25)	-0.0070 (-3.06)	-0.0050 (-1.99)	-0.0109 (-1.75)	-0.0084 (-3.78)
Quarter × Year Fixed Effects	YES	NO	YES	YES	NO	YES
Tenderer Fixed Effects	NO	YES	YES	NO	YES	YES
Observations	1,837	1,837	1,837	1,837	1,837	1,837
R-squared	0.8888	0.8269	0.9345	0.8948	0.8439	0.9385

Table A2: Competitive Bidding – Robustness Check
Dependent Variable: Log Tenderer Bid
(t statistics are reported in parenthesis using clustered standard errors at the tenderer level)

	(1)	(2)	(3)	(4)	(5)	(6)
Previous launch within 4500 meters & Previous launch within 2 year	0.6626 (4.56)	0.8714 (7.16)	0.7067 (4.28)	- -	- -	- -
Previous launch within 4500 meters & Previous launch within half a year	- -	- -	- -	0.5761 (6.56)	0.7550 (12.20)	0.5953 (6.28)
Previous launch within 4500 meters & Previous launch between half a year and 1 year	- -	- -	- -	0.3848 (4.10)	0.1308 (4.37)	0.3746 (3.18)
Previous launch within 4500 meters & Previous launch between 1 year and 2 years	- -	- -	- -	0.0653 (0.50)	0.0819 (1.45)	0.0033 (0.02)
Log (Gross Floor Area)	0.9495 (30.07)	0.7639 (19.45)	0.8241 (18.52)	0.9645 (33.19)	0.8089 (19.79)	0.8508 (20.07)
60-Year Tenure Status	-1.2257 (-16.37)	-0.7063 (-5.99)	-0.9639 (-10.29)	-1.1568 (-15.79)	-0.6806 (-6.47)	-0.9122 (-10.04)
Log (Distance to Downtown)	-0.2224 (-7.11)	-0.2474 (-7.96)	-0.2848 (-10.45)	-0.2048 (-6.50)	-0.2962 (-11.82)	-0.2713 (-9.63)
Log (Distance to the Closest MRT Station)	-0.0632 (-5.52)	-0.0610 (-4.09)	-0.0658 (-5.19)	-0.0797 (-6.96)	-0.0691 (-4.44)	-0.0819 (-6.58)
Number of Bids	0.0301 (7.80)	0.0278 (6.58)	0.0173 (3.82)	0.0284 (7.64)	0.0273 (6.92)	0.0166 (3.76)
Joint Bid	0.0465 (2.34)	0.1639 (1.62)	0.0649 (2.87)	0.0460 (2.52)	0.1531 (1.76)	0.0557 (2.45)
Bidding Experience	0.0097 (3.81)	0.0727 (8.06)	0.0119 (3.17)	0.0105 (4.32)	0.0644 (8.32)	0.0148 (3.98)
Capacity Constraint	-0.0034 (-1.35)	-0.0071 (-1.07)	-0.0067 (-3.15)	-0.0043 (-1.78)	-0.0092 (-1.62)	-0.0081 (-3.98)
Quarter × Year Fixed Effects	YES	NO	YES	YES	NO	YES
Tenderer Fixed Effects	NO	YES	YES	NO	YES	YES
Observations	1,837	1,837	1,837	1,837	1,837	1,837
R-squared	0.8962	0.8358	0.9401	0.9067	0.8546	0.9463

Table A3: Competitive Bidding – Robustness Check
Dependent Variable: Log Tenderer Bid
(t statistics are reported in parenthesis using clustered standard errors at the tenderer level)

	(1)	(2)	(3)	(4)	(5)	(6)
Previous launch within 2 years & Previous launch within 12000 meters	0.2779 (4.70)	0.4180 (5.04)	0.2196 (3.09)	- -	- -	- -
Previous launch within 2 years & Previous launch within 4000 meters	- -	- -	- -	0.1925 (4.20)	0.2571 (5.98)	0.1270 (3.49)
Previous launch within 2 years & Previous launch between 4000 meters and 8000 meters	- -	- -	- -	0.1222 (2.69)	0.1932 (4.19)	0.1129 (2.21)
Previous launch within 2 years & Previous launch between 8000 meters and 12000 meters	- -	- -	- -	0.0118 (0.21)	-0.0398 (-0.64)	0.0389 (0.55)
Log (Gross Floor Area)	0.9602 (30.19)	0.6956 (12.68)	0.7914 (14.60)	0.9729 (32.15)	0.7280 (14.91)	0.8084 (15.96)
60-Year Tenure Status	-1.2795 (-15.71)	-0.7817 (-6.13)	-1.0121 (-10.56)	-1.2456 (-15.82)	-0.7621 (-6.08)	-0.9916 (-10.26)
Log (Distance to Downtown)	-0.2707 (-11.50)	-0.2385 (-7.48)	-0.3335 (-15.09)	-0.2596 (-9.58)	-0.2243 (-6.81)	-0.3244 (-13.73)
Log (Distance to the Closest MRT Station)	-0.0533 (-5.30)	-0.0561 (-3.72)	-0.0579 (-4.95)	-0.0552 (-5.24)	-0.0628 (-3.92)	-0.0609 (-4.90)
Number of Bids	0.0346 (8.45)	0.0296 (6.84)	0.0189 (3.81)	0.0333 (8.61)	0.0286 (6.54)	0.0189 (3.86)
Joint Bid	0.0486 (2.47)	0.1959 (1.87)	0.0689 (2.96)	0.0487 (2.45)	0.1913 (1.96)	0.0686 (2.92)
Bidding Experience	0.0099 (3.68)	0.0719 (7.39)	0.0117 (3.07)	0.0097 (3.66)	0.0683 (7.34)	0.0113 (2.94)
Capacity Constraint	-0.0038 (-1.46)	-0.0078 (-1.09)	-0.0069 (-2.78)	-0.0037 (-1.43)	-0.0076 (-1.11)	-0.0071 (-2.86)
Quarter × Year Fixed Effects	YES	NO	YES	YES	NO	YES
Tenderer Fixed Effects	NO	YES	YES	NO	YES	YES
Observations	1,837	1,837	1,837	1,837	1,837	1,837
R-squared	0.8879	0.8202	0.9338	0.8903	0.8250	0.9347