China's Land Market Auctions: Evidence of Corruption?

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Abstract

In China, urban land is allocated by leasehold sales by local officials. Attempting to end widespread corruption, the government now requires sales to be conducted publically, by either English or "two-stage" auctions. However corruption persists through the choice of auction format and pre-auction side deals between favored bidders and local officials. Two-stage auctions have a first stage where favored developers signal that auctions are "taken", deterring entry of other bidders. Empirics show that both sales prices and competition are significantly less for two-stage than English auctions. Selection on unobserved property characteristics is positive: officials divert hotter properties to two-stage auctions.

Keywords: Land prices, auctions, corruption, China

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This article studies public auctions of leaseholds in the urban land market in China in 2003-2007. Urban land is owned "by the people" and its allocation done by the state, generally by each city's land bureau.[i] Before 1988, use rights for vacant land in the city are allocated through leaseholds, where, for a fixed sum, users obtained a lease of 30-70 years for a specified type of use (Ding and Knapp 2005). In the 1990s, most allocations were done by "negotiation" in a hidden process, where reportedly leaseholds often sold for a tiny fraction of market value, with certain city officials enriched. This procedure deprived cities of major revenues and in many cases surely leaseholds did not go to the best user.[ii] After reforms discussed next, in 2007 for the 15 cities we study in China, leasehold sales were about 21% of all locally funded public expenditures.

Discontent with corruption in urban land markets prompted a series of reforms in the early 2000s. Most critically, a 2002 law banned negotiated sales by land bureaus, with the last date for any negotiated sales being August 31, 2004. For the last 4 years, all urban leasehold sales for purely private development are done through public auctions, with details of all transactions posted to the public on the internet. Another reform in 2002 banned the secondary market for "land development rights," which had allowed large traditional holders (e.g., state owned enterprises) to, in effect, privately sell off their own land use rights (Zhu, 2004). From 2002 on, these allocations reverted to city land bureaus. As part of this serious anti-corruption campaign, there were visible indictments and convictions of high level officials connected with the land market.

For the key reform, the hope was that public auctions with details posted on the internet would offer transparency that would eliminate corruption. Indeed in terms of potential buyers' ability to enter an auction and of the bidding process once an auction is underway, auctions seem above board. However corruption persists. An evaluation by the National Audit Office of China in 11 cities reaches the following conclusion as reported in the *Asian Times* in June 2008:

> "Chinese government efforts to clean up land sales, a major source of official corruption…, face a rethink…according to an investigation published by the National Audit Office (NAO) last week. ….*Some cities have given a flexible interpretation to the rules and the auction system has often existed in name only, resulting in a lack of competition among developers and the winning developer being able to secure the land at below its true market value* [italics added]."

Why the failure? The new rules allow more than one auction type and there are two main types in most cities: regular English auction and a type we call a "two-stage auction." The second stage of a two-stage auction is an English auction which occurs if more than one bidder is still competing at the end of the first stage. The first stage is a time interval when bids are delivered to the land bureau and publicly posted in the order received. The procedures governing these auctions are detailed later, but we believe the option to choose two-stage auctions, with the potential for signaling that their first stage provides, gives the wiggle room for significant corruption to persist.

The raw data on auctions suggest something is amiss, based on auction type. Two-stage auctions are much more likely to be non-competitive and to typically yield lower prices. We use data on 2302 auctions from 2003 to 2007 in 15 large cities in China, which use both auction types. English auctions account for 28% of auctions. Figure 1 shows the distributions of the "spread", defined as the ratio of sales to reserve prices by auction type. In Figure 1, compared to English auctions, two-stage auctions tend to be absolutely massed around 1.0 for spread, so sales equal reserve prices. Later we will show that a ratio of 1 implies that there is just one bidder and thus no competition, whereas a ratio larger than 1 implies multiple bidders and competition. Figure 2 shows that the distribution of unit sales prices (price per sq. meter) for English auctions is shifted to the right of that for 2-stage auctions. Of course these suggestive patterns in the raw data are influenced by property characteristics and selection, for which we need to account econometrically. In the end we will conclude that city revenues from land sales would have been at least 30% higher if properties sold at two-stage auctions had been sold at English auctions.

Given that revenue from land sales is important to local government financing and prices from two-stage auctions appear lower, why would government officials so often choose two-stage auctions over English auctions? Is there an explanation other than two-stage actions are corrupt compared to English ones? We will argue based on both modeling and patterns in the data that there is not. Here we briefly review two key arguments. Aspects of non-corrupt two-stage auctions have been modeled in the jump-bid literature (Daniel and Hirshleifer, 1997). There the first stage of a two-stage auction allows sequential entry and gives a first bidder an opportunity to signal his valuation with a "jump bid" above reserve price. This raises the effective reserve price

for other subsequent potential bidders, discouraging them from entering the auction (Daniel and Hirshleifer, 1997). Because of this early-mover advantage, a first bidder is more likely to enter than in an English auction, so that two-stage auctions have a higher probability of any sale.[iii] For a special sample where detailed bidding information is available, we show opening bids in two stage auctions are *always* at reserve price, never at the expected jump bids. If these two-stage auctions are not corrupted, they are not working the way we would expect. But opening bids at reserve prices will be the outcome in our modeling of corrupted two-stage auctions.

Second, in estimation where we treat the choice of auction format as endogenous, we show that there is strong positive selection into two-stage auctions. This would be hard to explain in the absence of corruption. Modeling suggests that absent corruption, land bureau officials would likely choose two-stage auctions for land that is "cold" instead of "hot", where cold auctions are expected to attract few bidders (where the number of potential bidders is unobserved in the data). As noted above, two-stage auctions offer a higher chance of any sale and thus potentially higher expected revenues for cold properties compared to English auctions. That is, we might expect "negative selection" on unobservables into two-stage auctions in the absence of corruption, meaning cold relative to hot properties are more likely to be offered at two-stage auctions by a revenue maximizing auctioneer. However we find exactly the opposite, i.e., positive selection, in our data. We also find corroborating evidence on positive selection from ex post information on a sub-set of residential developments which can be matched back to the land transaction data. There, ex post housing prices relative to land prices are greater for land sold through two-stage auctions than those sold through English auctions controlling for property observables, suggesting such properties have good unobservable characteristics.

In summary, once we extend an auction model to allow for corruption of the form we believe occurs in China, the theory suggests outcomes consistent with the data: (1) two-stage auctions will have opening bids at reserve prices, not jump-bids and (2) selection is positive, so corrupt land bureau officials prefer two-stage over English auctions for hot properties.

How do we think corruption in land markets in China actually works? We think corruption takes the form of a side deal between a bidder and corrupt city official. That side deal includes special help from the land bureau official in developing the property in exchange for bribe payments from her partner bidder. Given a side-deal,

the first stage of a two-stage auction allows the corrupt bidder to signal with an early first stage bid at reserve price to other potential bidders that the auction is "corrupted", or taken. That signal of special help for the corrupt bidder can seriously deter entry by other potential bidders. However for English auctions, the possibility of corruption is less discouraging of entry for non-corrupt potential bidders because entry is simultaneous. Thus, a corrupt developer has a greater chance of winning the auction in a two-stage auction than in an English auction. This advantage of the corrupt bidder in two-stage auction compared to an English auction is relatively larger for hot properties where the potential competition could be intense, which is why there is positive selection because, to fulfill the side deal, the land bureau official must first help the corrupt developer win the auction.

In terms of a side deal and special help, a joint public announcement by China's Ministries of Urban Development and Construction and of Supervision in 2010 (http://www.gov.cn/gzdt/2010-04/30/content_1596790.htm) claims corruption typically involves differential enforcement of restrictions, most notably on floor to area [FAR] ratios. Increasing floor to area ratio can significantly increase a developer's profit. We show development restrictions on floor to area ratios are more likely to be violated under two-stage as opposed to English auctions, evidence of ex post "special help" from land bureaus and a direct link between corruption and two-stage auctions.

One might ask, why not allow auctions to proceed competitively and have side-deals for special help be separate and ex post? There are three reasons. First, harsh punishment if caught implies that a corrupt official is most likely to team up with some developer she trusts. And this *somebody* may not be the ex post winner of the auction absent ex ante help. Second, an ex-ante agreement should raise bribes that can be collected by the corrupt official(s), compared to ex post contracting. This occurs because use of a corrupted two stage auction lowers the expected price a developer will have to pay for the land. In addition, because properties and buyers are highly heterogeneous and properties involve huge developments, a developer may only be interested in a limited set of properties. (There are few repeat winners over the years in any city's data). Therefore linking a corrupt developer to a corrupt land bureau official for a particular property ex ante means the developer is more likely to win the particular property he wants to develop. Finally, ex-post side deals favor neither auction format, whereas we see strong evidence of corruption associated with two-stage auctions: the lack of jump-bids, price

differentials, positive selection into two-stage auctions, and special help more associated with two-stage auction properties than English.

Although the contribution of this article is in part to improve our understanding of an important public policy issue in China, it contributes to two other literatures. First is the corruption literature (see Rose-Ackerman, 2006). One point is that whereas significant policy reforms can help in fighting widespread corruption, in a weak institutional environment corrupt government officials and their partners can still find cracks. In the context of China, recent studies have identified other "tricky" cases of corruption and illegal activities, for example, tariff evasion (Fisman and Wei, 2004) and corruption and bribery using travel and entertainment expenses (Cai, Fang and Xu, 2011). Fighting corruption is a long term process whose success relies on and is a part of the gradual improvement of the overall institutional environment. Another point is that often, as in this article, corruption, as in the form of bribe payments, is not directly observed. However a researcher can bring a variety of indirect evidence to establish patterns of possible corruption, which may help improve corruption detection and suggest institutional changes to reduce corruption.

Second, we contribute to the auctions literature by modeling corruption in auctions in a new way, where corruption takes the form of (1) choice of auction type as opposed to corruption in a give auction format and (2) a side deal between a bidder and the auctioneer in an open auction context (as opposed to sealed bid), without a bidding ring (c.f., McAfee and McMillan, 1992, Burguet and Che, 2004, Compte, Lambert-Mogiliansky and Verdier, 2005, Menezes and Monteiro, 2006). Lengwiler and Wolfstetter (2006) describe bid rigging, bid orchestration and distortion of quality ranking as three forms of corruption in procurement auctions. In their recommended remedies for these forms of corruption, running an open auction with transparent bidding process tops the list. In our case, corruption takes a very different form, and the auction format and bidding process may look very clean. We believe this form of corruption applies in public auction contexts in other countries.

The article is organized as follows. We start with background information on land markets and auction formats. We then present a conceptual framework to model the key differences between the auction formats. Section 3 estimates a reduced form model of price differences between the two auction types, and discusses

instruments for auction type used to estimate selection into auction type. In Sections 4 and 5, we split the analysis of price differences into its two key components: whether a property is likely to have multiple bidders and sell competitively or not depending on auction type; and whether there are price differences across auction types, conditional on a property selling competitively. Concluding remarks are in Section 6.

1. Background

To learn about auctions in China, apart from many conversations with officials and developers connected with land markets in Beijing, we conducted surveys of land bureau officials in 20 cities, asking questions regarding the differences between the two auction formats and reasons for choosing one auction type over another. Our modeling is informed by our survey findings. Although detailed procedures may differ somewhat across cities, the typical procedure works as follows. There is a local planning bureau which does long term land use planning. Based on these plans, each year a land use allocation committee decides the use and development restrictions (e.g., floor to area ratio) and the sequencing of sales of leaseholds on properties about to be available for (re)development during the year, from both acquisition of rural lands ("green-field") and assembly of urban lands ("brown-field"). Each plot of land is large with, in our sample, a median area of 22,300 square meters and a median sales price of US $7 – 8 million. The allocation committee is typically a city-wide committee, with members such as the mayor and heads of relevant local bureaus (e.g., planning and land bureaus). Properties are then turned over to the land bureau for any clearing, choice of auction type, and auction. The setting of reserve price is also important (although not critical) to our empirical formulation. Each piece of property is appraised by an independent appraiser, based on comparables. Reserve price is set by the allocation committee given this appraisal (e.g., "minimum market value"), before the property is turned over to the land bureau and choice of auction type is made. Indeed, conditional on property characteristics, in our data, reserve price is uncorrelated with both auction choice and the political variables we use as instruments.

There are three types of auctions used in China's land market. About 97% of sales in major cities are accounted for by two of these, with the third used almost exclusively in Beijing and Shanghai. We ignore this third type and our econometric specifications exclude Beijing and Shanghai which do not hold English

auctions.[iv] The two main types of auction are *guapai* which we call two-stage auction and *paimai* which is an English auction. English auctions are standard ascending bid auctions, usually publicly announced 20 working days before the auction. At announcement, basic details (e.g., use restrictions, reserve price, location) are publicized; and potential bidders can inspect the site and for a small fee can obtain more detailed information. Participation in the auction requires "qualification"-- the key part being a cash deposit, usually about 10% of the reserve price. [v] This is a non-trivial requirement given the large sizes and sales prices of such properties. English auctions are public, often video-taped with the press present, in which qualified bidders openly raise bids by at least a required increment until there is only one bidder remaining who then wins the auction and pays his last bid. Winning bidders in principle must develop the land themselves. Once into the auction process itself, both types of auctions are clean: participants cannot be arbitrarily excluded or their bids ignored.

As with English auctions, two-stage auctions are announced about 20 working days in advance; details of the plot are made public; and the 10% deposit is required upon participation in the auction. The first stage normally lasts 10 working days after the auction starts. In the second stage, at the end of the 10 working days, if more than one bidder is competing for the property, the auction ends on the spot with an English auction where active bidders from the first stage participate. In the first stage during the 10 working days between the starting date of the auction and the potential ending English auction, people may enter the auction after obtaining qualification, and submit ascending bids to the land bureau. Bids as they arrive are immediately posted on the trading board of the land bureau, as well as typically on the internet, although the identity of bidders is not posted. If, at the end of 10 working days, there is only one remaining participant bidding, that bidder is assigned the property at his bid price (but not less than the reserve price). If there is more than one bidder competing at the end, the auction is converted to an English auction on the spot and the first-stage bidders automatically gain entry permission to that auction.

The two auction formats have a key difference in potential bidders' entry decisions. In English auctions, potential bidders enter simultaneously. In contrast, in two-stage auctions, potential bidders make entry decisions sequentially in the first stage, so a bidder reveals to other potential bidders that he is entering the auction. Two-stage auctions have two features that we think make possible the advantage to an "insider" bidder. Although the

auction is announced *about* 20 working days in advance, the exact date of the start of the first stage of the auction may not be specified. Second, although bidders can apply during the announcement period before the first stage starts, approvals to participate, or qualification can be delayed until after the first stage is under way. Thus the insider bidder alone may know the exact time the first stage starts and he alone may be qualified to submit a bid at that time. As a result, if there is a bid at reserve price as soon as the auction opens, other bidders can infer from that signal that it is likely that the auction has been corrupted.

In summary, corruption in China's land market usually takes the form of an under-the-table side deal between the land bureau official(s) and a partner developer. With the possibility of harsh punishments if caught, they must trust each other, either through repeated interactions or other bonds. The side deal between a corrupt official and her partner developer includes special help in developing the property, such as better clearing of the site to be developed, better provision of local infrastructure, and perhaps most commonly, relaxed interpretation of development restrictions. The corrupt official then deliberately chooses the format of two-stage auction. Given ex post help and the first stage signal in a two-stage auction, a corrupt developer in league with the land bureau has a better chance of winning the auction and getting the property for development at reserve price.

2. Conceptual framework

In this section we provide a brief description of our theoretical analysis that guides our empirical strategy and interpretation of empirical findings. Many of the details of our theoretical analysis are relegated to Appendix A.

Basics of the model

For an auction there are *N* potential bidders, of which some endogenous number *n* pay an entry cost, *C,* and become active bidders.[vi] We assume auctions are independent private valuation. Specifically, a potential bidder i's valuation is $V_i = v_0 + v_i$, where v_0 is the (expected) common value that is the same for every bidder (based on property characteristics and local market conditions) and v_i is the private value component only known to bidder i. v_i's are i.i.d. Because v_0 is common knowledge, the analysis of auctions follows the independent private valuation approach, rather than the common value one. We make the standard assumption that all bidders

are risk neutral and maximize their expected payoff. Let $V_i \propto F(V)$ on $[0, \bar{V}]$ be the distribution function of bidder *i*'s valuation, and let $f(V)$ be the associated density function. Bidder *i*'s payoff when winning the auction with a bid B_i is $U_i = V_i - B_i - C$.

The land bureau official can be either non-corrupt or corrupt. A non-corrupt land bureau official seeks to maximize the expected sales revenue for the city. If the land bureau official is corrupt and she has an agreement with a particular developer, say, developer 1, if he wins the land auction, she will provide special help and receive a bribe payment. Let Q be the value of the land bureau official's special help to developer 1. And let $q \le Q$ be the bribery payment developer 1 makes to the land bureau official, if he wins the auction, reflecting the developer's gratitude for the land bureau official's special help in developing the land as well winning the auction at a lower price. For simplicity, we let q be fixed. Define $\kappa \equiv Q - q$ as the net gain in valuation of the property to developer 1 from having an under-the-table deal with the land bureau official. For any land sale, we assume with probability p the auction is corrupted. Only the land bureau official and her partner know about any under-the-table arrangement, and other potential bidders only know with probability p that the auction may be corrupted.

Assume the land bureau official's payoff function is given by

$$(1-\lambda)ER + \lambda q\omega. \tag{1}$$

In (1), ER is the expected revenue from the land auction (that goes to the city coffers). $\lambda \in [0,1]$ gives the weight on corruption income by the official. Although λ may reflect pure preferences of the official, it may also reflect the anti-corruption environment or penalties associated with being caught (which could also be added on directly), which will vary over city and time in the empirics. When $\lambda = 0$, the official is non-corrupt and seeks to maximize the expected revenue from the sale of land. As λ becomes larger, the land bureau official cares more about her own expected bribery income, ωq, in the second term in (1) and less about the city's fiscal

revenue. ω is the probability of the joint event that developer 1 and the official are in league and that developer 1 enters the auction and wins.

We consider the following game. In the first period, the land bureau official chooses the auction format between English and two-stage auctions, and announces to the public. In the second period, potential bidders who know their own valuation decide whether to participate in the auction by paying the participation cost. In the English auction, potential bidders make participation decisions simultaneously. In the two-stage auction, participation decisions are made sequentially and come with actual bids in the first stage. In the third period, in the case of English auction, active bidders bid openly until there is only one bidder remaining who then is declared the winner and pays his last bid for the property. In the case of two-stage auction, if there is active bidding at the end of the first stage, an English auction is run to select the winner. After the auction, the winner pays the city his winning bid and obtains the right to develop the land. If the land bureau official is corrupt and her partner developer wins the auction, she provides the help to him during the development stage and he pays the bribe as promised.

Comparison of English and two-stage auctions without corruption

To review auction basics and as a benchmark, we first consider the case when it is common knowledge that the land bureau official is non-corrupt ($\lambda = 0$) and she chooses an English auction. Given an English auction is outcome-equivalent to a second price Vickery auction, the setting is equivalent to that of Tan and Yilankaya (2006), who analyze a simultaneous move entry game in a second price auction with independent private valuations and participation costs. A fundamental equation we will build on involves the valuation threshold $\hat{V}$, for an entrant. In a symmetric equilibrium a bidder will decide to enter the auction if and only if his valuation is above a certain value $\hat{V} > r + C$, for r the reserve price and C the entry cost.[vii] For a bidder with valuation exactly equal to $\hat{V}$, he gets a rent of $\hat{V} - r$, only if he is the lone bidder, which happens with probability $F(\hat{V})^{N-1}$ (all other potential bidders have valuations below $\hat{V}$). Therefore, the valuation threshold for entry $\hat{V}$ must satisfy

$$F(\hat{V})^{N-1}(\hat{V}-r)=C\ . \tag{2}$$

Equation (2) tells us that $\hat{V}$ depends on $(r, C, N, \overline{V})$. and is increasing in r, C, N . The probability of selling at the reserve price is $NF(\hat{V})^{N-1}[1-F(\hat{V})]$. One can go on to solve for other usual English auction outcomes, those with two or more bidders or no bidders, along with the expressions for the probabilities of different numbers of active bidders, expected rent for any bidder and expected revenues.

Two-stage auctions without corruption are more difficult, and the details are in Appendix A. The basic analysis is related to the jump-bid literature (see Daniel and Hirshleifer 1997 for the case of private valuation and Avery 1998 for the case of common valuation). As noted earlier, in the first stage, a first bidder can signal his valuation to other bidders with a bid above reserve price, which discourages subsequent potential entrants from entering, because they know that, if they enter, the prior signaler is prepared to bid up to his valuation, which effectively raises their reserve price and reduces their expected rents from entering. In Appendix A.1, we characterize a separating signaling schedule for the first bidder that is monotonic in his valuation, and other potential bidders will enter the auction only when they draw high valuations. In this signaling equilibrium, the first bidder has an early mover advantage by submitting a signaling bid and thus is more motivated to enter than in the English auction (entry threshold is less than $\hat{V}$), whereas other bidders are less likely to enter (entry threshold is greater than $\hat{V}$).

Comparing English and two-stage auctions absent corruption suggests two things: (1) two-stage auctions are less likely to have competitive bidding than English auctions because the first bidder's ability to signal his valuation discourages entry; and (2) the probability of sale is higher for two-stage auctions than for English auctions when the number of potential bidders N is small (as long as the entry cost is not too small). For the second point, the expected revenue from an auction with entry depends on the probability of sales (having at least one bidder) and the conditional probability that there is competitive bidding. When the number of potential bidders is small, the deterrence effect on competitive bidding may be less important in maximizing expected revenue for the auctioneer than having at least one bidder enter the auction so that any sale occurs. This notion also leads to the idea of negative selection into two-stage auctions absent corruption.

As noted above, a property is "hot" ("cold") when the number of potential bidders, N, is large (small), holding constant the common value and distribution function of valuations. The number of potential bidders may be reasonably clear to participants (including the land bureau officials) of the auction due to their experience and knowledge, but is unobservable to outsiders. When land is "cold", the expected revenue of a two-stage auction can be greater than that of an English auction, because the probability of any sale is higher under a two-stage auction and the dampening of conditional competition is less important. When land is "hot", so a sale is very likely, an English auction is more likely to have competitive bidding, thus potentially leading to greater expected revenue than a two-stage auction. In Appendix A.2, we detail examples where a revenue-maximizing land bureau steers hot properties towards English auctions, so that there is *negative selection* on unobservables into two-stage auctions.

Entry Strategies in English and two-stage auctions under corruption

We now turn to the case where the land bureau may be corrupt. We focus on the entry decisions of potential bidders in the second period of the model after the land bureau official has chosen the auction format. For now, we ignore the belief updating by potential bidders on the chance that the land bureau official is corrupt, and suppose that from the point of view of non-corrupt potential bidders, there is a probability of p that the auction is corrupt and there is a corrupt bidder with total valuation of $V_1 + \kappa$. With probability of $1 - p$ the auction is not corrupt and bidder 1's valuation is V_1.

Consider the English auction first. In this case, let $\hat{V}_{1P}$ be the valuation threshold for entry for bidder 1 when corrupt, and let $\hat{V}_{-1}$ be the valuation threshold for entry for all other bidders. With the possibility that bidder 1 is corrupt, other bidders make entry decisions in an asymmetric bidding game. The entry condition is similar to equation (2) except now a non-corrupt bidder must allow for the fact that there may be a corrupt bidder. Given that, $\hat{V}_{-1}$ must satisfy the following equation:

$$F(\hat{V}_{-1})^{N-2}\left\{p\left[F(\hat{V}_{-1}-\kappa)-F(\hat{V}_{1p})\right]E\left[(\hat{V}_{-1}-V_1-\kappa)\,|\,V_1\in[\hat{V}_{1p},\hat{V}_{-1}-\kappa]\right]+\right.$$
$$\left.pF(\hat{V}_{1p})(\hat{V}_{-1}-r)+(1-p)F(\hat{V}_{-1})(\hat{V}_{-1}-r)\right\}=C. \qquad (3)$$

The bracketed expression on the left hand side represents a non-corrupt bidder's expected rent in each of three cases: (i) the corrupt bidder enters but has an evaluation less than the non-corrupt entrant; (ii) the corrupt bidder 1 does not enter; and (iii) bidder 1 is not corrupt and does not enter. Note that the above equation assumes that if bidder 1 is not corrupt, he acts like any other bidder by using the same entry strategy.[viii] If there is a corrupt bidder, his valuation threshold for entry $\hat{V}_{1P}$ satisfies

$$F(\hat{V}_{-1})^{N-1}(\hat{V}_{1p}+\kappa-r)+\sum_{m=1}^{N-1}\hat{w}_m=C \qquad (4)$$

where $\hat{w}_m$ is bidder 1's expected rent when his valuation is $\hat{V}_{1P}+\kappa$ and there are m other active bidders, whose valuations are above $\hat{V}_{-1}$ but less than $\hat{V}_{1P}+\kappa$.

In evaluating the influence of corruption on a standard English auction, in equilibrium, $\hat{V}_{1P}<\hat{V}<\hat{V}_{-1}$, where $\hat{V}$ is the entry threshold absent corruption. With details footnoted[ix], the intuition is that thanks to the favor from the land bureau official, the corrupt developer 1 has a better chance of having the highest valuation. So he is more likely to enter ($\hat{V}_{1P}$ is lower than $\hat{V}$) than in a non-corrupt auction. Facing the possibility that bidder 1 may be favored, the other potential bidders are less likely to win and thus are less likely to enter ($\hat{V}_{-1}$ is higher than $\hat{V}$).

Consider now the two-stage auction. In the two-stage auction, if the land sale is corrupted so that bidder 1 and the land bureau official are in league, bidder 1 acts as soon as stage 1 ensues. Because both would like to let all other potential bidders know that this land is "claimed," a simple and natural way to send that signal is for bidder 1 to obtain qualification and to make a bid right after the auction is started, before other potential bidders are granted qualification to bid, and perhaps even before they know that the auction has actually started. Because bidder 1 is only signaling that he has the agreement with the land bureau official, he only needs to signal the

agreement, by bidding just the reserve price (to increase the rent from winning the auction). When the extra help he gets from the land bureau official, κ, is relatively large, such signaling by bidder 1, if believed by other bidders, will seriously deter entry by other bidders given an entry fee (c.f., Hirshleifer and Png 1990 and Ockenfels and Roth 2002), because they see little hope of outbidding bidder 1.

To formalize such intuition, we consider the following equilibrium entry strategies. Let $\tilde{V}_C$ be the minimum threshold in which bidder 1 will send a signal by bidding the reserve price. If seeing that bidder 1 bids at the reserve price right after the auction is announced, all the other potential bidders understand that bidder 1's valuation is $V_1 + \kappa$, where $V_1 \in [\tilde{V}_C, \bar{V}]$. As a simplification, other bidders decide simultaneously whether to enter. Although other bidders could also decide in some arbitrary sequence in stage 1 whether to enter or not, we collapse that into a simultaneous decision to make calculations tractable. By construction, this staging also eliminates any potential snapping strategy by a non-corrupt bidder to also bid early, but such snapping is highly unlikely in the more general case if κ is large, as discussed in Appendix A.3. If $\tilde{V}_0$ is the valuation threshold for all other potential bidders, it satisfies

$$F(\tilde{V}_0)^{N-2}\left[\frac{F(\tilde{V}_0-\kappa)-F(\tilde{V}_C)}{1-F(\tilde{V}_C)}\right]E\left[(\tilde{V}_0-V_1-\kappa)\,|\,V_1\in[\tilde{V}_C,\tilde{V}_0-\kappa])\right]=C\,, \tag{5}$$

where now a non-corrupt bidder knows if a corrupt bidder has entered ($V_1 \geq \tilde{V}_C$). Second, $\tilde{V}_C$ must satisfy an equation similar to equation (4) with $\tilde{V}_C$ replacing $\hat{V}_{1\mathrm{P}}$ and $\tilde{V}_0$ replacing $\hat{V}_{-1}$, yielding

$$F(\tilde{V}_0)^{N-1}(\tilde{V}_C+\kappa-r)+\sum_{m=1}^{N-1}\tilde{w}_m=C\,, \tag{6}$$

where $\tilde{w}_m$ is the corrupt bidder's expected rent when his valuation is $\tilde{V}_C + \kappa$ and there are m other active bidders, whose valuations are above $\tilde{V}_0$ but less than $\tilde{V}_C + \kappa$. When no one bids at the reserve price right after the auction is announced, then bidders understand that the auction is not corrupted, in which case we have an ordinary English auction with *N-1* potential bidders.

Note that signaling in the two-stage auction takes quite different forms with or without corruption. Without corruption, signaling aims to signal valuations and thus takes the form of a monotonic bidding schedule above the reserve price, whereas with corruption signaling aims to signal special relationships with the official and thus takes the form of a bid at reserve price. In Section 3, for a special Beijing data set, as noted in the introduction we will show that, in the first stage, there are no jump bids, unlike what would be expected in the absence of corruption.

As noted, an issue about the hypothesized equilibrium of signaling corruption in two-stage auctions is whether other non-corrupt potential bidders can fake it by bidding at the reserve price at the very beginning of the first stage and snap away the land. In Appendix A.3, we show that as long as the corrupt bidder gets a sufficient amount of help from the official and thus obtains a large advantage over non-corrupt bidders, the snapping strategy by a non-corrupt bidder will fail because he will likely be outbid by the corrupt developer and waste his entry fee. Practically, corrupt bidders are probably much more likely to obtain qualifications and submit a first bid before others because of their ties with government officials, and developers are not keen on antagonizing government officials by snapping away land that they and their partnership developers are interested in.

Comparison of English and two-stage auctions under corruption

With corruption, an important point of our analysis is that the corrupt bidder is more likely to win the auction in a two-stage auction than in an English auction. To see this, note that with a first day bid at the reserve price signaling a corrupt auction, non-corrupt bidders are less likely to enter a two-stage auction than an English auction and thus there is less likely to be competition. Correspondingly, bidder 1 is more likely to participate in a two-stage auction than an English auction. These points follow from the respective facts that $\tilde{V}_0 > \hat{V}_{-1}$ and $\hat{V}_{1p} > \tilde{V}_C$. With details footnoted[x], the intuition is that, in the case of an English auction, other potential bidders don't know whether bidder 1 is corrupt or not. They only know that he is corrupt with probability p, and they make entry decisions simultaneously with bidder 1. However, in the two-stage auction, the other potential bidders know whether bidder 1 is corrupt or not. When he is corrupt, other potential bidders have a much smaller

chance of winning the auction if bidder 1 has substantial special help (and thus a higher expected valuation). This reduces the incentives to enter for other potential bidders. Given that, bidder 1 sees less risk of losing the auction and thus is more motivated to enter a two-stage auction than an English auction.

That the corrupt bidder is more likely but other potential bidders are less likely to enter a two-stage auction implies that the corrupt bidder has a better chance to win in a two-stage auction than in an English auction. In Appendix A.4 we show that under different configurations of his valuation relative to threshold values, the corrupt bidder is at least as likely to win in a two-stage auction and more likely in some configurations, compared to an English auction. Because the corrupt government official can get bribery income only if the corrupt developer wins, ceteris paribus, she is more likely to favor two-stage auctions as the weight, λ, on corruption income rises.

Positive selection

Now we turn to the issue of *positive selection* on unobservables into two-stage auctions. The general idea is that, for hot properties, competition from non-corrupt developers makes it more difficult for the corrupt developer to win an English auction. As discussed above, the corrupt developer can fend off competition more easily in the two-stage auction by making a signaling bid. Therefore, a corrupt government official who cares sufficiently about her bribery payment is more likely to favor a two-stage auction over an English auction when the property to be sold is hotter. This suggests positive selection on unobservables into two-stage auctions.

To formalize this idea, we expect the positive difference in the probability that the corrupt developer wins the land between a two-stage and an English auction to rise with N, so that the gap in $\lambda q\omega$ terms in the land bureau official's objective function between the two auction formats rises. However, this derivation (e.g., deriving $d\hat{V}_{-1}/dN$ and $d\hat{V}_{1p}/dN$ from equations (3) and (4)) turns out to be very difficult for the general case, so we constructed two examples, presented in Appendix A.5, the second of which is quite general. The first example is a special case, where in a two-stage auction no other bidders ever enter, but they do so in an English auction with the chances of a corrupt bidder winning declining as N rises. Then hotter properties are more likely to be assigned to two-stage auction by a highly corrupt official.

We then programmed a general example where non-corrupt bidders have some chance of entering either auction type and λ can take all feasible values, comparing regimes where N=2 versus 3.[xi] Such calculations even just for N=3 are rather complex. In Appendix A.5 we illustrate that, for low values of λ, English auctions are preferred whereas, for high values, two-stage auctions are preferred for both values of N, as discussed above. If the auctioneer cares sufficiently about corruption income and she has a side deal, then she will always choose two-stage auctions. However if she values revenue for the city highly, although she may have a side deal, she will roll the dice by allowing an English auction even if that reduces the chances of her partner winning. In terms of hotness (measured by N), there is an intermediate range of λ where for N=2 English auctions are preferred, whereas for N=3 two-stage auctions are preferred. That is, there is positive selection into two-stage auctions. For comparative statics, as κ rises, the ranges of λ where two-stage auctions are preferred increases for both values of N. Similarly as entry costs rise, the range increases (signaling has a great deterrence effect).

Other considerations of the model

In the model, because the land bureau official as a player chooses the auction format in the first period, her choice may reveal some information about her type (corrupt or not) to potential participants in the auction. If she assigns a hot property to a two-stage auction (an English auction), other potential bidders will update their beliefs and think that she is more (less) likely to be corrupt. This will further enlarge the difference in participation by non-corrupt potential bidders between the two-stage and English auctions, and thus strengthens our argument. Given our focus and space limitation, we do not develop the formal analysis for this first period of the model.

We have two related points concerning interpretation of the model and results. First, in practice, corrupt government officials must walk a fine line between signaling to non-corrupt potential bidders that they should not mess in certain land auctions versus appearing clean and not attracting too much attention from authorities above. Second, equilibrium predictions and econometric analysis are not legal evidence of corruption. Reality is more complicated than in simple economic models, with many factors omitted. However, our theoretical

predictions and the corresponding empirical analysis can suggest certain patterns as likely indictors of corruption, which may improve corruption detection and suggest institutional changes to reduce corruption.

Finally, we do not follow the literature and model bidding rings (e.g., McAfee and McMillian, 1992, Bajari and Ye, 2003, and Athey, Levin and Seira, 2008) in our context for several reasons. First the government's focus on corruption in land markets does not involve collusive bidding, but rather corruption among officials. Specifically, we know of no media reports on the existence of bidding rings, but many on corruption involving officials in league with developers. Correspondingly, as noted later, the instrumental variables for auction type relate to detection of corruption of government officials. Related, in China, it may be less appealing (more dangerous) for individuals to collude against the state per se, as opposed to collude with the state. Another reason is that there seems to be no reason why collusion among bidders would be more successful in two-stage auctions than in English auctions, so collusion among bidders would not explain the substantial difference in the likelihood of non-competitive bidding between the two-stage and English auctions observed in our data. In fact, collusion within a ring might be better enforced in public English auctions. In our analysis, we ignore other factors which would affect the comparison between English and two-stage auctions such as the sequence of land sales in a city. We do not think they would fundamentally affect our analysis and we discuss them in an earlier version of the article (Cai, Henderson and Zhang, 2009).

3. Baseline effect of auction type on sales prices

In this section we explore the reduced form effect of auction type on unit sales prices. We want to know the effect of corruption on sales prices. We can't observe corruption per se, but we do observe auction type. The model suggests that if an auctioneer values corruption income sufficiently and the auction is corrupted (i.e., there is a side deal), the format will be two-stage auction in order to enhance the chances that the corrupt developer wins. Our presumption from the model is that, in the data, in general English auctions are not corrupt, whereas two–stage are. Of course some two-stage auctions may not be corrupt; we will argue that suggests our estimate of the price differential is a lower bound on the effect of corruption. In Sections 4 and 5, we will show that the estimated price difference is explained by the fact that, in comparison to English auctions, two-stage auctions are generally not competitive, with sales mostly at reserve price.

Data for econometric analysis

For econometric analysis, we have data for 2302 completed auctions from 15 cities which held both English and two-stage auctions from 2003-2007.[xii] Details of the drawing of the sample are given in Appendix B. The data are from the Land Bureau of China (or its branches at the city-level). We obtained the geo-economic characteristics of each piece of land for sale through bendi.google.com, locating each piece of land using its street address. We measure the line distance between the property and the CBD of the city and create dummy variables to indicate, whether within a 2.5 km. of the property, there is a railway (including commuter rail) or highway.

For each auction, the land bureau provides detailed information and posts it on its official website www.landlist.cn. Information includes: the address, the area (in square meters), the use restriction (business, residential, mixed), the type of auction, the reserve price, the sales price if the sale is completed, the post date which is the first date bids are accepted, the sale date, and the buyer's identity. Sometimes additional information is given, such as the maximum floor-to-area ratio, the building-density, the green coverage rate, and whether the property is cleared or not. For these additional items, explicit information is only provided in a limited number of cases. For our cities in general, we are missing key information often used in analysis of auctions: the total number of bidders and sequencing of bids. But we have enough information for our specific analyses.

In Figures 1 and 2 we already presented patterns in the raw data, showing the relative concentration of sales at reserve prices for two-stage auctions, indicative of lack of competition. Although properties and buyers are heterogeneous, there should not be a lack of competition in general. Auctions occur in a setting of rapid urban growth, with per capita urban incomes growing at over 10% a year and local population at 2-5 % a year. Given national restrictions on conversion of rural to urban land at the city fringes, this suggests there should be a high demand for land for new development.

Table 1 is summary of basic statistics for the 2302 auctions. The table shows means of key variables with medians in brackets. Compared to English auctions, two-stage auctions have significantly lower mean unit sales prices and are significantly less likely to sell competitively (have a spread greater than 1.005), consistent with

Figure 1. However they have no significant difference in unit sales price, conditional on a competitive sale. This suggests the main effect of two-stage auctions on prices may be through deterring competition. The significant difference in unit sale price for overall sales and the insignificant difference for competitive sales apply to both means and medians. The table also shows that the sizes and locations in terms of distance from the city center are similar for properties sold under the two auction types.

Reduced form price equation

Based on Section 2, consider the specification

$$\ln sale\ price = \ln common\ value + f\,(potential\ number\ of\ bidders,\ auction\ type,\ \tilde{e}) \qquad (7a)$$

This specification follows the model in Section 2 where there is a common value component (v_0) to any bidders' valuation. Given this common component, ex ante sales price then depends on the number of potential bidders and potentially the auction format, with the ex post sales price dependent on the actual drawings of private valuations (which $\tilde{e}$ encapsulates). In the data, the potential number of bidders and certain determinants of the potential number of bidders (e.g. certain property characteristics) are unobserved. For the same common values to two different properties, the number of potential bidders will vary with the city in question (number of active land developers, controlled below by city and time fixed effects) and aspects of the property such as neighborhood. In equation (7a), we assume reserve price is proportional to the common value component. As noted above, reserve price is set by an outside committee, using a formula based upon the valuation of the land parcel carried out by an independent land appraiser. In that sense reserve price is an exogenous valuation of property based on characteristics of the property and general local market conditions; the issue of possible non-exogeneity of reserve price will be addressed at various points below. But it is a strong control for overall quality of a property.

We implement equation (7a) with

$$\ln sale\ price_{ijt} = \ln ask\ price_{ijt} + \tilde{X}_{ijt}\beta + d_{ijt}D + u_j + \delta_t + \varepsilon_{ijt} \qquad (7b)$$

for property i in city j which is sold at time t. $\tilde{X}$'s include observed property characteristics such as use restriction, area, and distance to the city center which may be correlated with the number of potential bidders and

the variance of valuations, as well as seasonal dummies. The terms u_j and δ_t capture city and year fixed effects. The arguments in ε_{ijt} are unobserved time-varying city conditions or property characteristics, which, controlling for common value, may affect the number of potential bidders. Auction type, d_{ijt} , is whether the land bureau chooses a two-stage auction (=1) or not (=0), so that *D* is the effect of auction type on sales price, which we would like to identify**.** Choice of auction format should be related to unobservables. With corruption, we argued that there will be positive selection—the setting aside of "delectable morsels" for corrupt participants; and we argued that absent corruption, there can be negative selection on properties sold by two-stage auction.

Selection problem and instruments.

To deal with auction selection, for our baseline results, we estimate a Heckman (1978) endogenous dummy variable model, as well as regular IV. Instrumental or control function variables are ones which affect selection of auction type by the land bureau, but not sales price conditional on our covariates.

We rely mostly on two sets of instruments. These are two political aspects, which induce the behavior, at particular times, of wanting to "appear clean" by substituting English auctions for two–stage auctions where the latter is "known" to be corrupt. In the model this would correspond to city and time variations in λ in equation (2). Each arises from a pattern in the data analyzed below, but first we discuss the nature of the instruments. In later sections, we will discuss statistical work on validity and strength of instruments.

The first set of instruments involves the political event of a change in party secretary of a city. The party secretary in a city is the highest ranked city official acting as "chair of the board", whereas the mayor is the chief executive officer more involved in the details of decisions. Party secretaries generally serve in any city for a term of about 5 years. There is routine although not precisely timed turnover as they are rotated (in a parallel move) to another city. There is also turnover due to promotion (to, say, a provincial level secretary), to retirement driven to some extent by age limits, and to demotion for inept or bad behavior, although the reasons occur rarely. A detailed discussion of turnover of provincial level party secretaries is in Li and Zhou (2005) and the situation for cities is essentially the same.

In our data, we observe that in the month before a new party secretary takes office in a city, the land bureau switches to using more English auctions and then a month later it switches back, in fact switching away from English auctions (in effect, catching-up to its usual mix). Figure 3a illustrates for the 17 cases in which a party secretary turns over in our data. Each case is normalized in time, so the month of turnover is zero. We plot the ratio of English to two-stage auctions in our data for 7 months: the month of turnover and then lead and lag for 3 months. In Figure 3a, the ratio of English to total auctions is sharply higher in the month before turnover (and the month of turnover) and is sharply lower in the month after, than in other months. We view the Figure 3a outcome as the land bureau showing "respect": temporarily not using an auction format known to be corrupt just before the new party secretary arrives, and then quickly returning to business as usual. Therefore, our first set of instruments consists of two dummy variables. One dummy indicates whether the land is posted for sale one month before a party secretary turnover; the other indicates whether the land is posted for sale one month after a party secretary turnover.

There are two issues with the use of this instrument, which is intended to create pseudo-randomization, by removing the element of selection in properties' assignment to auction type. First, a change in party secretary should be independent of the month-to-month unobserved conditions affecting land markets and overall hotness of properties in a city (noting we already have city fixed effects as well as year fixed effects in our regressions). Because party secretaries may be evaluated on the basis of how fast their cities grow that could be a concern. In Table 2 we show that monthly reserve prices and implied monthly variation in economic conditions affecting land markets are not related to a change in party secretary. This is consistent with the findings in Li and Zhou (2005). Even when turnover is not routine but due to promotion or demotion, they find promotion or demotion is sensitive to average performance over the party secretary's term, not a particular year, let alone a particular month's performance. Indeed, as we plot in Figure 3b, relative average annual GDP growth in cities which experience turnover is certainly no less in the 2 immediate years before turnover (where growth rates are normalized by all other cities' growth rates in the corresponding years), relative to the two years after. Although it is slightly lower in the year of turnover, this would not be measured until well after the party secretary's departure.

Second, the use of this instrument assumes that the timing of listings is exogenous, so that Figure 3a does not disguise some strategic manipulation of timing of listings of hot versus cold properties over the course of the year in which the party secretary is replaced (saving hotter properties for after the party secretary comes to office). We are assuming that political events just affect auction type choices for properties that would normally come up for listing in each month. To the extent this is not the case we would not be fully correcting for selection of hotter properties into two-stage auctions and our results would still understate the true effect of auction type and corruption. In Table 2 we can show that, whereas the month before and after a party secretary takes office strongly affects choice of auction type, at least it has no effect on the total count of auctions. There is no time pattern in the total count around the party secretary taking office (over the 7 month span), other than total auctions dip in the month a party secretary takes office. That may be explained because nothing much happens in a city during that month with its extensive official and unofficial social requirements. It is not as though there is a shift in the month before to a few token English auctions; the pace of total auctions remains unchanged during the period of turnover.

Similar arguments apply to the second set of instruments, although the timing is different. For the second set, we have cases that relate to *real estate* corruption, reported on Google China. Such cases could involve the removal of a major local government official, the indictment of officials, the execution of officials, or a criminal investigation on land transactions. During a month when a case occurs, officials are more careful not to attract attention and schedule more English auctions. A month later they again revert and catch-up to business as usual. A few months after the case, a sanitized report on the case is announced on state run news agencies and picked up by Google China, with 27 cases in our data. The announcements on Google China appear to occur 3 months after the case, in the sense that 3 months earlier English auctions jump up, followed in the next month by a drop down. This timing of the pattern of one month up followed by one month down is found by experimentation in the data, but it is a clear pattern. Therefore, our second set of instruments consists of two dummy variables. One dummy indicates whether the land is posted for sale three months before a corruption report on Google; the other indicates whether the land is posted for sale two months before a corruption report on Google. As with party secretary turnover, this variable is unrelated to monthly reserve prices or total auctions counts, as we will see in

Table 2. And we expect these corruption investigations are unrelated to month-by-month fluctuations in economic conditions conditional on city and year fixed effects..

We also considered two other types of instruments. One had to do with reports on overall (not just land market) corruption investigations reported the state news agency Xinhua. It is not a strong instrument. Second we had a measure of the pressure on the land bureau to raise more money through land sales—the growth in the relative gap between city public expenditures and on-the-books revenue, where that gap is typically filled with revenue from leasehold sales. This is a strong instrument, but to be valid, this growth must not be connected to city demand conditions that would affect the housing market (given city and year fixed effects). Because this is a questionable assumption, we don't rely on it.

In summary, for the main results, we use just two types of instruments, so our vector of instruments Z consists of 4 variables: dummy variables for any listing which occurs when a new party secretary takes office (one month lead and one month lag) and dummy variables for any listing which occurs when Google reports a land use corruption case (three months lead and two months lead). We now look at first stage results of how instruments affect auction choice.

Choice of auction type

We examine the choice of auction type, both to see the role of the instruments and to analyze the choice itself. Results are in Table 2. Column 1 contains the probit results for the 4 instruments. In column 2, we present linear probability results for the same instruments. In the last two columns, we examine the non-effect of instruments on total auctions per month and setting of reserve price. Focusing on the first two columns, in both, the choice of auction type is unrelated to the reserve price, which is consistent with the idea that the setting of reserve price is independent of auction choice. (Correspondingly, if in the last column of the table where reserve price is the dependent variable we replace our instruments by auction type, the coefficient is insignificant.) Choice of auction type is influenced by land use, where the base case, commercial land, is more likely to be sold in two-stage auction. Sometimes, commercial land consists of smaller plots, which may be of more interest to specialized neighborhood developers within the city; but as we will see below unit reserve prices (quality) are

the same across uses. Also, more likely to be sold at two-stage auction is land near rails (probably land urbanized in the Maoist era) but not near highways (land urbanized more recently).

Of particular interest is how instruments influence auction choice. In columns 1 and 2, the variables for the change in party secretary and for announcements of land corruption cases have the hypothesized patterns and are generally significant. In column 1, the *F*-statistic based on the change in the value of the LLF from adding instruments to the probit is 8.1. For the linear probability model in column 2, the partial-*F* is over 10.0. Although these partial-*F*'s are not as high as one might like, they are reasonable in a context with city fixed effects.

Column 3 of Table 2 shows that the count of auction listings per month is uncorrelated with the instruments. In column 4, we look at what is correlated with unit reserve price. As urban models predict, reserve prices decline with distance from the city center; and they also decline with property size for these very large properties. Conditioning on other covariates, use type does not affect reserve price, so in essence there is equalization in unit valuations across uses. Most critically reserve prices are uncorrelated with the instruments. The number of auction listings and the setting of reserve prices are determined by planning and assessment procedures outside the control of the land bureau. These political instruments affect just auction choice in the relevant months. As such the fact that these political events affect auction choice but not other aspects of the land allocation process itself is an indicator of known corruption in the land bureau.

Sales price results

We estimated the sales price equation by OLS and by Heckman MLE where auction type is an endogenous dummy variable (Heckman, 1978). As specification checks, we also estimated the model by regular 2SLS and LIML IV and experimented with allowing heterogeneous auction effects (Wooldridge, 2008).[xiii] Sales price results are in Table 3. In all specifications, a 1% increase in reserve price raises sales price by just over 0.9%. Why is the elasticity less than 1? A higher reserve price also contains an effect to discourage entry of potential bidders (where we assume appraisers set a reserve price that is common value plus an idiosyncratic error component). Property characteristics are interpreted to affect the number of potential bidders, conditional on reserve price. Sales prices are distinctly lower for larger plots which may be less manageable and have fewer experienced developers who would try to utilize them.

The key variable is choice of auction type. In OLS estimation, prices are lower for two-stage auctions by 17%. With correction for selection, the coefficient has a much larger negative value. The Heckman MLE estimate is about -0.70, about 4 times larger in absolute value. The fact that the treatment effect coefficients are significantly larger than under OLS suggests positive selection: not accounting for selection understates the size of the treatment effect. Correspondingly, for direct evidence on selection, the coefficient on correlation of the error terms in the Heckman MLE results is positive and significant. The theory section suggested positive selection is a marker of corruption, and the empirical results indicate that positive selection into two-stage auctions is a significant force.

Two concerns are the functional restrictions of the Heckman MLE model and sensitivity of results to choice of instruments. In the table we also show LIML IV results, where coefficient with a linear probability first stage is similar to Heckman MLE, -.646. When estimated by 2SLS the coefficient is -.58. In terms of whether the choice of instruments matters, what happens if we use the more thoroughly vetted instruments based on party secretary turnover? With just party secretary instruments alone, the Heckman MLE coefficient is also -.69. All this suggests that the OLS estimate of 17% loss surely serves as a conservative lower bound, with positive selection being clearly indicated.

In terms of validity of instruments, in IV estimation, the Kleibergen-Papp F-statistic on weak instruments is over 11.2. The Sargan p-value of .15 is acceptable but low. We believe the low value is due to model specification error (see next section) rather than unsuitability of instruments per se. We also experimented with several other specifications as double checks of the validity of our instruments. First we note that the IV coefficient (LIML) is almost unchanged at -.67 if all covariates are removed other than fixed effects. That implies that controls for property observables, or conditioning, doesn't affect the IV result, which might lessen the concern that the IV strategy does not deal with property unobservables. Also, if we add to column 1 (the OLS specification) our 4 instruments as covariates, the coefficient on auction type goes from -.1697 to -.1624, a tiny change. If instruments were correlated with unobservables affecting sale prices, assuming that auction type is correlated with unobservables, the added instruments would absorb some of the correlation of unobservables with auction type, affecting its coefficient. That

the coefficient is unchanged is consistent with instruments being orthogonal to unobservables. We also note that instruments have no significant effect on sales price, direct evidence that the instrumented events are not connected with economic events in the city that would influence sales prices.

Finally, we note that, if we drop the reserve price variable and use property characteristics (and city and time fixed effects) to represent both common value and demand considerations, all coefficients become much more negative.[xiv] For example, the OLS coefficient goes from -.17 (with a reserve price control) to -.34 (without a reserve price control); the Heckman MLE coefficient goes -.92; and the LIML IV coefficient is -.80. The *rho* in MLE remains positive and significant, so results without a reserve price control also suggest positive selection.

Other evidence

In this section, we turn to a variety of other evidence we have collected about the corruption process and the effect of auction type on prices, before turning to the more nuanced question of whether the effect of auction type is just through the degree of competition, or whether for the same degree of competition, there is still an auction effect on price.

Prices on ex-post housing developments of auctioned land.

For our 15 cities, for residential land we were able to match 499 of our auctions with ex post residential developments called *loupan* developments, where that data was collected from www.soufang.com in April 2009. The match requires that the auctioned property was for residential development (about 700 of our auctions) and that development of the land had been both initiated and still is on-going, or has new property for sale in April 2009.

For 342 properties, we have detailed information on floor to area ratio restrictions, prices and type of residential development. For these we looked at the determinants of the premium: the log of the 2009 price per square meter of residential space in the development minus the log of auction sales price per square meter of land. Controls are land reserve price and year of land auction sale, city fixed effects, and type of residential property, with the simple model and details in the footnote.[xv] Premiums are significantly higher by 19.3% for land that was sold at two-stage auction compared to English auction. This is consistent with the OLS reduced

form land price result of a 17% reduction in land price by two-stage auction. Given the very limited sample size, our instruments were too weak to pursue IV work, but the OLS result makes the point.

With the same data, it is possible to obtain corroborating evidence on three other issues. First for the same data we looked at the determinants of unit housing sale price rather than the premium, using the same covariates (but now with no need to know final land sales price on the LHS). For this sample of 342, unit house prices are significantly higher by 9.6% for properties where land was sold at two-stage auction. This is consistent with the idea of positive selection of land properties into two-stage auction.

Second, the variances (based on residuals) for the unit housing price equation just discussed are significantly higher for the two stage part of the sample ($\hat{s}^2_{2-stage}$ =.0683, n=221) compared to the English ($\hat{s}^2_{english}$ =.0308, n=113). Average unit housing prices are also higher for two-stage auctions and the normalized variances are similar. As detailed in Cai, Henderson and Zhang (2009), price differentials by auction type might be explained if the land bureau assigned riskier properties to English auction.[xvi] Part of the reason for having extensive controls in the estimated price equation was to control for riskiness. However there is no evidence that properties assigned to English auction are riskier.

Finally, we noted earlier that there is evidence that development restrictions on floor to areas are more likely to be violated under two-stage as opposed to English auctions, indicating more ex post "special help" from land bureaus. For our residential development properties, we observe a key type of special help: FAR violations by April 2009 in on-going developments. We expect less chance for a development to be in violation for land that is sold later, so we want to distinguish year effects. We start with a sample with relevant information of 342 developments; but, because of tiny cell sizes (under 10 by auction type or by violation by year), we drop 2003, 2004 and 2008. Controlling for ask price, the floor to area ratio limit, and city and year of sale fixed effects, for land sold in 2005, a property is significantly more likely to be in violation by April 2009 if it was sold at two-stage auction (compared to English), as estimated by a logit. The effects for 2006 and 2007 are positive but t-statistics are only 1.37 and 1.63. We then looked at a Tobit for the extent of violation – the actual floor to area ratio by April 2009 over the

limit set at auction—with truncation at a ratio of 1. We find significant increases in the extent of violation for properties sold by two-stage (over English) auction in both 2005 and 2006.

Special data for Beijing on the nature of two-stage auctions

In the econometric work, we know only sales and reserve prices and nothing about the bidding process itself—sequence and number of bids. However for Beijing, which is not part of the sample used in our econometric analysis, we have a sample of 195 two-stage auctions during our sample period, where we know the number of bids each day in the first stage. From that sample, we learn several things. First, and most critically from Table 4a, bidders do not signal valuations with jump bids, as theory says they would in the absence of corruption. In all auctions with just one bid, almost all bids are within 0.5% of reserve price, consistent with our corruption story. Once we have 2 or more bids then a spread develops. This also supports the formulation in the next section where we define whether an auction is competitive (has more than one bid) or not based on spread.

Columns 1 and 2 of Table 4b show that conditional on property characteristics, having a first day bidder is negatively correlated with the number of bids, which is consistent with first day bids (at reserve price) deterring entry in two-stage auctions as in the theory. Having a first day bid, given 10 days to bid, would mechanically raise the number of bids (and a first day bid could indicate selection into better properties). Yet having a first day bid is associated with fewer bids. Similarly, in columns 3 and 4, having a first day bidder makes it less likely that the auction will be competitive, consistent with the signaling story. [xvii] We also note auctions can be highly contested if more than one bidder does enter: in 26 of the cases with 3 or more bids, there are reported to be over 65 bids in each of the auctions.

Finally we observe that in Beijing there are not strong patterns of repeat winners, where such patterns might be expected if bidding rings are prevalent. From 2004 to 2007, 171 of 258 auctions involve non-repeat winners over the four years. Twenty-one buyers repeat once, but most of those occur in the same and last year (2007), just before the Olympics at the height of construction frenzy. There are 7 buyers who win 3 times over 4 years, 2 who win 4 times, 1 who wins 5 and1 who wins 11 (all in 2004). We note in 2007 there were 2688 registered "real estate developers" in Beijing, a more than fourfold increase since 1999 (Beijing Statistical Yearbook). These basic facts suggest there are lots of potential bidders in the Beijing market but properties are

heterogeneous, each with a particular clientele. Because project land areas are extremely large, one development is a huge undertaking.

What is missing in the reduced form approach?

In the data, if an auction is non-competitive, price equals reserve price; a spread only emerges with competition. Price is bounded below by reserve price, which is not accounted for in the continuous specification. Further, we believe that if multiple entrants emerge in the second stage of a two-stage auction, the outcomes for English and two-stage auctions for that property will be similar. In both cases once into the English auction portion, the sales price will simply be the valuation of the second highest valuation bidder. Of the 2302 auctions, only 1235 are ex post competitive, or have more than one bidder as inferred from the degree of spread. We already saw in Table 1 that raw unit price differences between English and two-stage auction are insignificant for competitive auctions.

To understand the nature of workings of corruption in auction choice better, we examine the two components. How does auction type affect the probability that an auction will be competitive or not? Implicitly we are assuming again that two-stage auctions tend to be corrupt (whereas English are not), potentially leading to understatement of the effect of corruption. Second, if auctions are competitive does the choice of auction format still affect sales price?

4. The effect of auction type on competition

What is the effect of auction type on whether an auction will be competitive or not, defined as whether there appears to be more than one bidder because spread exceeds 1.005? A simple probit of competitive or not with auction type as a potentially endogenous dummy variable faces the same selection problem as in the sales price estimation. Properties may be negatively or positively selected into two-stage auctions, and such selection itself will affect the potential for competition. The literature handles this in different ways. One is to use the bivariate recursive probit (Greene, 1998, Evans and Schwab, 1995), as an MLE solution. Another is to estimate a linear probability model (Angrist, 1999), where we instrument for auction type with Z's. We do both.

The bivariate recursive probit is a two equation MLE model where action is a dummy endogenous variable which is a function of X and Z. Auction type affects the event: competition or not. That is,

$$d_{ijt}^{*} = Z_{ijt}\alpha + X_{ijt}\theta + u_{ijt}, \qquad (8)$$

$$s_{ijt}^{*} = X_{ijt}\eta + d_{ijt}\gamma + v_{ijt}, \qquad (9)$$

$$d_{ijt} = \begin{cases} 1 & if\ d_{ijt}^{*} > 0 \\ 0 & o.w. \end{cases}, \qquad (10)$$

$$s_{ijt} = \begin{cases} 1 & if\ s_{ijt}^{*} > 0 \\ 0 & o.w. \end{cases} \qquad (11)$$

d_{ijt} denotes whether an auction is two-stage (1), or not (0), and s_{ijt} denotes whether an auction is competitive (=1) or not (=0). *X*'s include city fixed effects, year and seasonal dummies, and ln(*ask price*) and observed property characteristics in all equations. The recursive structure allows identification in a standard bivariate probit framework (Greene, 1998). In Section 5 where we add a continuous equation for the sales price in competitive auctions we detail specifics of estimation.

Results are in Table 5 which shows marginal direct and indirect effects for the bivariate recursive probit. The variable of interest, two-stage auction, has only a direct effect. In the ordinary probit in column 1, the marginal effect of two-stage auction on the probability of being competitive is -.34, consistent with the raw data in Table 1. In the recursive formulation that marginal effect in column 3 is 26% stronger, at -.43. This is again suggestive of positive selection into two-stage auctions: the two-stage auction's negative effect on competition is understated because properties with better unobservables are selected into two-stage auctions. Consistent with this, the *rho* measuring the degree of correlation between the error terms is positive (.38), and significant.

The auction effect when estimated by LIML IV in column 4 using a linear probability model (both first and second stages) suggests an even bigger auction effect of -.650; the 2SLS coefficient is -.649. This might suggest that the -.43 in the bivariate probit is a conservative estimate.

In terms of other variables, in columns 2 and 3, relative to the base case of commercial use, sales of residential and mixed use land are likely to be more competitive, whereas large properties away from the city center are less likely to have competitive bidding. Total marginal effects on competition or not include direct [xviii] and indirect effects[xix] through the effect of covariates on auction type and hence competition. Indirect effects

seem strongest for land use variables. Removal of reserve price as a covariate in both equations has little effect on results, consistent with the fact that its coefficient is insignificant in Table 5.

5. Effect of auction type on sales prices, for competitive sales

If properties sell competitively, is there a remaining effect of auction type on sales price? Examination of this question faces two problems. First there is the auction selection problem discussed earlier. Second being competitive is endogenous, and there is selection on unobservables into competition that are surely correlated with price. Because such selection is mediated by the auction process, it is not the standard problem in Lee, Maddala and Trost (1980), but rather one modeled in the labor literature (Fraker and Moffitt 1988, Goux and Maurin, 2000) and in firm growth models (Reize, 2001).

We tackle the problem in two ways. We do estimate a parametric specification modeling the two selection issues using MLE with a trivariate normal, as in the literature cited above. But such structure is highly restrictive. As a less parametric approach, we wanted to do identification-at-infinity (Heckman, 1990), by examining auction effects for samples where the predicted probability of a non-competitive sale is small (less than 0.2 or 0.15). This isolates a sample where, ex ante, we expect sales to be competitive regardless of auction type, so we only need to worry about selection into auction type not competition. The problem is that in this sample, as we will see, we lack cities with competitive sales in both auction formats. So instead we focus on the raw data and ask whether, conditional on the predicted probability of being competitive, prices diverge between auction types.

Comparative prices under competition: the data

For each auction type *separately*, we estimate the probability that an auction is competitive; specifically that the spread (ratio of sales to reserve price) is greater than 1.005 (cf, Mulligan and Rubinstein, 2007). The covariates in these simple predictive probits are the *X*'s including reserve price and city fixed effects, but not the instruments. Given estimation is separate by auction type, for two-stage auctions for example, the predicted probability of competition is made in the context of signaling and selection. We then look at the raw data on spread and unit prices in two ways. First, for each auction type, we order the predicted probabilities and break the two-stage auction rankings into 40 equal size bins and the English (with the smaller sample) into 20. For each bin, we calculate the average predicted probability and the median and mean spread and price.

Results for the mean and median are similar and Figure 4 shows the plots for medians. Over the whole range of predicted probabilities, for spread in Figure 4a, in the relevant interval of predicted probabilities, the plots for two-stage and English auction spreads overlap each other. There is no difference in spread for the same probability of being competitive, consistent with our hypothesis. Note a key difference between two-stage and English auctions is the lack of points for English auctions at low probabilities of being competitive and the lack at very high probabilities for two-stage auctions. Thus spread is 1 (price equals reserve price) until predicted probabilities hit about 0.5 and then spread rises with predicted probabilities. For unit prices, the plots for two-stage auction are actually higher than for English, but those price differences are not significant.

For the second analysis of raw data, in Table 6, we divide predicted probabilities into 0.05 intervals and ask whether there are significant differences in spread and prices between the two auction types. As Figure 4 suggests, we need to truncate the exercise in the lower half and at very upper end of the predicted probability range because of lack of observations for one of the auction formats. Note the extreme differences in counts of the two auction types in the tails of the predicted probability range. In general in Table 6, differences in median spread and price are insignificant. Conditional on the predicted probability of being competitive, English auctions do not bring better prices.

For implementing identification at infinity, the problem is apparent from Table 6. There are just too few two-stage auctions to use a typical cut-off of greater than 0.8 probability of being competitive. With too few cities left in the sample which use both auction types, our instruments (for auction type) loose their power. Thus we turn to a traditional parametric approach.

Trivariate MLE estimation of selections into competitive and two-stage auctions

To the model in equations (8) – (11), we now add a third equation for price

$$y_{ijt} = X_{ijt}\beta + d_{ijt}D + \varepsilon_{ijt} \quad if \ s_{ijt} = 1, \tag{7c}$$

where y_{ijt} is sales price in logs. The structure imposes a trivariate normal error

$$\sum = Var\begin{pmatrix} \varepsilon \\ u \\ v \end{pmatrix} = \begin{pmatrix} \sigma_\varepsilon^2 & \rho_{\varepsilon u} & \rho_{\varepsilon v} \\ \rho_{\varepsilon u} & 1 & \rho_{uv} \\ \rho_{\varepsilon v} & \rho_{uv} & 1 \end{pmatrix}, \tag{12}$$

so as to estimate the parameter set $\Theta = (\beta\; D\; \alpha\; \theta\; \lambda\; \gamma\; \sigma_\varepsilon\;\; \rho_{\varepsilon u}\; \rho_{\varepsilon v}\; \rho_{uv})$. The LLF is in Appendix B and we estimate the model by MLE.

In Table 7, we present simple OLS price equation and MLE results for the 1235 competitive auctions. The OLS coefficient on auction type in column 1 is -0.03 and insignificant. Column 2 gives the MLE results for the price equation, along with the covariance structure. Estimates for the discrete choice part of the three-equation MLE model are almost identical to those in Table 5. In column 2, the coefficient for the auction type effect on price in competitive auctions is small and insignificant as hypothesized. In the covariance structure, as before, there is strong positive selection into two-stage auctions. The error term on the price equation has low correlation with the error terms in the discrete events.

Summary. Whether we approach the problem as a parametric one with strong assumptions or use a non-parametric look at the raw data, it seems that, once auctions become competitive, price is not affected by auction format. Auction format matters at the margin of whether auctions are competitive or not, consistent with the corruption signaling hypothesis for two-stage auctions

6. Conclusions

To the best of our knowledge, this article is the first to investigate empirically corruption in auctions beyond simple price-fixing among bidders, to allow corrupt auctioneers and signaling activity, which we believe has relevance in other contexts. The article also builds a case based upon indirect evidence using both theory and empirics to argue that corruption exists in a particular form. Consistent with corruption, two-stage auctions have first bids at reserve price, rather than the jump bids expected absent corruption and there is positive rather than negative selection of properties into two-stage auctions. We also see that officials switch to English auctions in contexts where it is important to appear clean. Two-stage auctions lead to less competitive bidding and thus substantially smaller revenue than English auctions in China's land market.

The obvious policy recommendation is that the option to use two-stage auctions should be eliminated. Local officials resist such a reform. One repeatedly cited objection in our survey of land bureau officials is that English auctions yield irrational biding and too high prices. We have a different interpretation to such objections by local officials.

What would be the revenue gains if properties sold at two-stage auction were instead sold at English auction (ignoring any general equilibrium effects of the resulting increases in prices paid for land)? The reduced form price equation in Section 3 suggested revenues would be 17% higher in OLS and 65-70% higher in IV results if properties sold at two-stage auction were shifted to English auction, but that equation is misspecified. Thus we also use the full MLE model in Section 5 with its modeling of selection effects to generate an estimate.

In our data, for properties sold at two-stage auctions, the model predicted revenue is 227.7 billion Yuan.[xx] The predicted revenue from switching to English auction for these properties is the (enhanced) predicted probability of these properties selling competitively if switched to English auction times the predicted price when sold competitively, plus the predicted probability of not selling competitively if switched to English auction times the reserve price.[xxi] The predicted revenue is 299.6 billion Yuan. This is 32% higher than the predicted revenue if sold by two-stage auction. Given MLE gives a relatively low increase in predicted probability of being competitive when switching to English auction, we see this number as a lower bound on the expected revenue gain. The gain in revenue for these properties is illustrated in Figure 5. The 45^{o} line is for model predicted prices if sold still by two-stage auction, whereas the scatter plot is for the predicted prices if sold at English auction.

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Appendices

Appendix A. Theory

1. Two-stage auctions without corruption

In a non-corruption context, entrants, in arbitrary sequence, have a first opportunity to submit a bid. Sequencing could be based on the arbitrary times at which potential bidders learn the auction has started and decide to enter in the first stage, and have had their application to bid approved. Solving the general case with endogenous first stage entry is daunting—whether an early entrant signals with what bid function, whether later entrants with higher valuations enter or not, and the complicated interactions between early and later signalers. We work with a special case where of the *N* potential bidders, only one randomly selected person, labeled bidder 1, has the option to enter and bid early. This case models the general situation in which *N* = 2 as typically formulated in the jump-bid literature (e.g., Daniel and Hirshleifer, 1997). Here we give highlights of solving for a separating, signaling equilibrium, where bidder 1 signals his true valuation.

Bidder 1 chooses to enter in stage 1 by using a strictly increasing bidding schedule $B(V_1)$ when his valuation is $V_1 \in [\tilde{V}, \bar{V}]$. For $V_1 < \tilde{V}$, bidder 1 will choose to not enter the auction. Suppose his valuation is exactly $\tilde{V}$. Based on the Riley argument in the signaling literature, bidder 1 will use the lowest possible signal, the reserve price r. Once bidder 1 bids r and reveals that his valuation is $\tilde{V}$, other potential bidders will enter only if their valuation is above $\hat{V}_S(\tilde{V})$, which is the solution to equation (2) with $\tilde{V}$ replacing r and $N-2$ replacing $N-1$. That is, for the other potential bidders*, the effective reserve price increases to* $V_1 = \tilde{V}$. Bidder 1 can win the auction only if no other potential bidders enter, so $\tilde{V}$ satisfies

$$F(\hat{V}_S(\tilde{V}))^{N-1}(\tilde{V} - r) = C. \qquad \text{(A1)}$$

Note that because $\hat{V}_S(\tilde{V}) > \tilde{V} + C$, comparing (A1) and (2) reveals that $\tilde{V}$ is smaller than $\hat{V}$, so bidder 1's threshold entry level is lower in a two-stage than English auction. If bidder 1 does not enter in the first stage, the

other $N-1$ potential bidders play the same game as in an English auction, with a threshold for entry, denoted by $\hat{V}_{NS} = \hat{V}(r, C, N-1, \bar{V})$. Note that $\hat{V}$ is increasing in N, thus $\hat{V}_{NS} < \hat{V}(r, C, N, \bar{V})$, which is the equilibrium entry threshold in the case of an English auction with N potential bidders. So overall the two-stage auction has a greater chance of any sale.

What happens if bidder 1's evaluation V_1 exceeds $\tilde{V}$? When bidder 1 has valuation $V_1 \in [\tilde{V}, \bar{V}]$, he has a bidding function that is strictly increasing in V_1 and truthfully reveals his valuation. Such a bidding function satisfies the single crossing property, so it isn't beneficial for lower valuation bidders to pretend to be higher types.

When bidder 1 enters in stage 1 with a bid B_1, the other potential bidders can infer bidder 1's valuation $V_1 > B_1 + C \geq r + C$ from his bidding schedule $B(V_1)$. Except for this, the same game is played by the other $N-1$ potential bidders as in the case of an English auction. The valuation threshold for entry can be solved as $\hat{V}_S(V_1) = \hat{V}(V_1, C, N-1, \bar{V})$. Because $V_1 > r$, we have $\hat{V}_S(V_1) = \hat{V}(V_1, C, N\text{-}1, \bar{V}) > \hat{V}(r, C, N\text{-}1, \bar{V}) = \hat{V}_{NS}$, given the entry deterrence effect of bidder 1's signaling.

For $V_1 \in [\tilde{V}, \bar{V}]$, suppose for a bid of B, other potential bidders believe his valuation is $\vec{V}_1$. Then his expected payoff is

$$U(V_1, \vec{V}_1, B) = F(\hat{V}_S(\vec{V}_1))^{N-1}(V_1 - B) - C.$$

Clearly this payoff function is increasing in bidder 1's true valuation V_1 and the belief of the other potential bidders $\vec{V}_1$, but decreasing in his bid B. In equilibrium, bidder 1 should "tell the truth" by bidding his equilibrium bid $B(V_1)$ and we can show that this truth-telling constraint satisfies the single crossing condition, so lower valued bidders have no incentive to misrepresent their valuations. From the truth-telling constraint, the differential equation that characterizes the strictly increasing bidding schedule is

$$\frac{dB}{dV_1} = \left(\frac{(N-1) f(\hat{V}_S(V_1))(V_1 - B)}{F(\hat{V}_S(V_1))} \right) \cdot \left(\frac{F(\hat{V}_S)}{F(\hat{V}_S) + (N-2) f(\hat{V}_S)(\hat{V}_S - V_1)} \right). \qquad \text{(A2)}$$

where the second bracketed expression comes from applying the implicit function theorem to equation (2) and $\hat{V}_S(V_1) = \hat{V}(V_1, C, N-1, \overline{V})$. Along with $B(\tilde{V}) = r$, equation (A2) characterizes the strictly increasing signaling schedule.

2. Comparing the assignment of hot versus cold properties to auction type, without corruption: a numerical example

Because a general comparison of the expected revenue between English and two stage auctions with heterogeneous properties is too difficult absent corruption,[xxii] we constructed numerical examples to show that the expected revenue can be higher for a two stage auction than for an English auction when the land is "cold," and vice versa, which suggests negative selection. We compare two situations, the first where N=2 (cold property) and the second where N is very large (hot property) so we can use limit calculations as $N \to \infty$. We derived the expected revenues from English vs. two-stage auctions for N=2 and for $N \to \infty$. The derivations are very complicated and take several pages to show, so we do not present the derivations here but they are available from the authors on request. We then solved a variety of examples. As an illustration for one set we assume C=5, $r = 2$ and each bidder's private valuation is uniform on $[0, \overline{V}]$. In this example for both values of N, two stage auctions yield higher expected revenue than English auctions for low $\overline{V}$ (< 9), whereas for high $\overline{V}$ (>11) English auctions dominate. However there is a range of intermediate $\overline{V}$ values where English auctions dominate for $N \to \infty$, but not for N=2. This illustrates a situation where cold properties are assigned to two-stage auctions. We note however if we change parameter values so that C is small compared to r, then the opposite is the case: in the intermediate range two-stage auctions dominate for $N \to \infty$, but not for N=2.

3. The snapping strategy by a non-corrupt developer does not work: an example

The issue is whether a non-corrupt bidder would be tempted to mimic the behavior of bidder 1 to scare away other bidders. Even if this snapper could manage to bid at the reserve price before the true corrupt developer, the latter is likely to make a higher bid in order to reclaim the land as long as κ is relatively large. In such a case, the snapper will lose the auction and waste his entry cost; an example in the next paragraph shows snapping will not be an equilibrium strategy if κ is large. When κ is not sufficiently large, a non-corrupt bidder may try snapping when his valuation is very high with less fear of being outbid by a corrupt bidder. It is possible that in equilibrium, a non-corrupt bidder with very high valuation and a corrupt bidder are pooled in using the same strategy of bidding at the reserve price at the start of the auction (whoever manages to be the first is immaterial). In that equilibrium, a corrupt bidder who does not get the chance to submit a first bid will try to outbid the non-corrupt bidder only when he also has a quite high valuation. What is important, however, is that in such a pooling equilibrium, other bidders are seriously discouraged to enter, either by a very high valuation non-corrupt bidder or by a corrupt bidder.

For the example assume V is uniformly distributed on $[0,\overline{V}]$. Suppose κ is sufficiently large so that other bidders will not enter if they see a bid at the reserve price at the start of the auction. Suppose a non-corrupt bidder plays the snapping strategy by mimicking the corrupt bidder when his valuation is above $\breve{V}$. We consider the bidder with the threshold valuation. A corrupt bidder will outbid him if $V_1 \geq 0.5(\breve{V}+\overline{V})+C-\kappa$, which happens with probability of $p^* = p[0.5(\overline{V}-\breve{V})-C+\kappa]/\overline{V}$. With the remainder probability, he succeeds and obtains a payoff of $\breve{V}-r-C$. Thus, playing the snapping strategy yields an expected payoff of $(1-p^*)(\breve{V}-r)-C$. Now suppose this bidder who contemplates the snapping strategy plays the equilibrium strategy of waiting to see whether there is a corrupt developer who submits a bid at reserve price at the start of the auction. It is reasonable to suppose that when no corrupt developer submits a bid at reserve price at the start of the auction, this bidder is the first one to submit a signaling bid in the two stage auction without corruption. For simplicity, let us consider the case of low valuation scenario when $\overline{V} \leq r+2C$ in the previous example. In such a case, the non-corrupt

bidder with valuation $\breve{V}$ who plays the equilibrium strategy obtains an expected payoff of $(1-p)(\breve{V}-r-C)$, because in the low valuation scenario he can prevent competition by bidding at the reserve price (see the previous section).

For the threshold valuation $\breve{V}$, it must be that $(1-p^*)(\breve{V}-r)-C=(1-p)(\breve{V}-r-C)$. Simplifying terms yields $(0.5\overline{V}+0.5\breve{V}+C-\kappa)(\breve{V}-r)=C\overline{V}$. Clearly $\breve{V}$ increases in κ. It can be checked that when $\kappa \geq \overline{V}+C-\frac{C\overline{V}}{\overline{V}-r}$, then $\breve{V} \geq \overline{V}$, in other words, it does not pay for a non-corrupt bidder to play the snapping strategy.

4. Comparing English and two-stage auctions under corruption

Here we show that in all relevant cases the corrupt bidder has at least as good a chance of winning a two-stage auction as an English auction, and sometimes a better chance. When the corrupt bidder's valuation, V_1, is smaller than the entry threshold in the two-stage auction, $\tilde{V}_C$, then the corrupt developer will not enter no matter what auction format is chosen. For the case where $V_1 \geq \tilde{V}_C$ but $V_1 \leq \hat{V}_{1P}$ (the entry threshold in the English auction), so the corrupt developer will enter only if the corrupt government official chooses the two-stage auction, the corrupt developer can win only if a two-stage auction is chosen. Then there is the case where $V_1 > \hat{V}_{1P}$ so that the corrupt developer enters no matter what the auction format is. Let X_1^{N-1} denote the highest valuation of all N-1 non-corrupt potential bidders. The probability of the corrupt developer wining the auction depends on the realized value of X_1^{N-1}. If $X_1^{N-1} \leq \hat{V}_{-1} < \tilde{V}_0$, where we recall $\hat{V}_{-1}$ ($\tilde{V}_0$) is the entry threshold of a non-corrupt bidder in the English (two-stage) auction, then none of the non-corrupt bidders will enter either auction format in this event and the corrupt developer wins the auction without contest. If $\hat{V}_{-1} < X_1^{N-1} < \tilde{V}_0$, then the non-corrupt bidder with the highest valuation will enter the English auction but not the two-stage auction. In this event, the corrupt developer wins without contest if the two-stage auction is chosen, but may face competition from some non-corrupt bidders and may lose the auction if $X_1^{N-1} \geq V_1+\kappa$. Finally, if $\tilde{V}_0 \leq X_1^{N-1}$,

then the non-corrupt bidder with the highest valuation will enter to contest the corrupt developer under either auction format. No matter what the auction format is, whether the corrupt developer wins depends on whether $V_1+\kappa$ is greater than X_1^{N-1}. In summary, in all relevant cases, the probability of the corrupt developer winning the auction is not less and sometimes greater under the two-stage auction than under the English auction. Therefore, when λ is close to one, a corrupt government official will choose the two-stage auction over the English auction.

5. Comparing the assignment of hot versus cold properties to auction type, with corruption: examples

Example 1. First is a special case to illustrate the principle that hot properties are more likely to be assigned to two-stage auction under corruption. Assume λ is close to 1 so that the land bureau official is focused almost exclusively on corruption income and that κ is sufficiently large, so that we are at or near a corner solution for two-stage auctions where $\tilde{V}_0$ is near or greater than the upper bound on valuations, $\overline{V}$. In this case, non-corrupt bidders will not enter the two-stage auction once they believe that a corrupt developer has secured an agreement with the corrupt government official. In this case, $\tilde{V}_C = C + r - \kappa$, and the corrupt developer wins the land with probability one as long as his valuation is above $\tilde{V}_C$. The value of the official's objective function under two-stage auctions doesn't vary with N (for $\lambda = 1$).

However things are different for English auctions. Note, from the analysis above that $\hat{V}_{-1} < \tilde{V}_0$, so that non-corrupt bidders' entry point into English auctions may be well below $\overline{V}$. Assuming $V_1 > \hat{V}_{1P}$ so that the corrupt developer is motivated to enter the English auction despite potential entry by other bidders, when $V_1 < \hat{V}_{-1} - \kappa$, the corrupt developer wins the land in the English auction with probability of $F^{N-1}(\hat{V}_{-1})$. It can be shown that this is decreasing in N. When $\hat{V}_{-1} \le V_1 + \kappa$, the corrupt developer wins the land with probability of $F^{N-1}(V_1+\kappa)$ in the English auction. Clearly, as N becomes larger, the corrupt developer is less likely to win the land in the English auction. Thus the gap in corruption income for two-stage auctions over English auctions

will grow as N grows and there is positive selection on unobservables (the number of potential bidders) into two-stage auctions.

Example 2. For this example, for English auctions, equations (3) and (4) are used to solve for threshold values of $\hat{V}_{-1}$ *and* $\hat{V}_{1p}$. Equation (5) and (6) for two-stage auctions are used to solve for $\tilde{V}_0$ and $\tilde{V}_C$. For N=3, the expressions for equations (4) and (6) must account for the possibilities that any of the three bidders may have the highest bid, that either of the remaining two may be the 2nd highest bidder, and that either or both of the remaining two bidders may enter. Once we have solved for threshold values, then the auctioneer's objective function under each auction format must be evaluated. In the comparison, we examine the situation where the corrupt bidder 1 enters if it is a two-stage auction ($V_1 > \tilde{V}_C$) (but may or may not enter the English auction given $\tilde{V}_C < \hat{V}_{1p}$). The auctioneer only gets bribe income if bidder 1 wins and the auction income depends on who enters and has the second highest bid if there are multiple entrants. For N=3, the expressions are very long, because they have to account for all the ways the corrupt developer can win and lose and all the relevant winning valuation and 2nd highest valuation possibilities.

We solve the example where $\overline{V} = 9;\ r = 2;\ \kappa = 1.9,\ 2$ and $2.1;\ p = .8;\ C = .75,\ 1$ and $1.25;\ q = 2.45,$ and λ lies between 0 and 1. Figure A.1 shows the solution when $C = 1$ and $\kappa = 2$. The horizontal axis is λ and the vertical is the value of the land bureau official's objective function under English auction minus that under two-stage auction. As one can see, for low λ, English auctions maximize the auctioneer's objective function, whereas, for high λ, two-stage auctions dominate for both values of *N*. However for a small interval of λ values in the neighborhood of .7, English auctions are preferred if N=2 (see where the N=2 line intersects the horizontal line at 0), but two-stage are preferred if N=3, indicating positive selection.

Appendix B. Data and technical appendix

1. Data

Our base data for 15 cities consists of 4016 listings for 2003-2007, where a listing is a property put up for auction whether the auction is completed and results in a sale, or not. Our 4016 listings exclude industrial use

land (about 7% of total listings). As in the USA, industrial land use has a low and highly variable unit price; regressions using USA data which examine the determinants of sales prices for industrial land have low explanatory power (DiPasquale and Wheaton, 1996). More critically in China, such properties are often sufficiently far from the city center stretching into peri-urban areas, that we couldn't get location characteristics from bendi.google.com.

Of the 4016 listings, 607 have no recorded sales data. Another 1107 record sales but do not have information on either reserve price or sales price, or both. We focus on the remaining 2302 which are completed auctions with full price information. Does this sample differ from those with missing data or no recorded sale? First from Table B.1, a comparison of columns I and III (with tests of differences given in column V) suggest sales with missing sale or reserve price data are similar to those in our estimating sample. They have similar auction type and use proportions and when data is available have similar reserve and sales unit prices. Properties without full price information tend to be older listings and (related) nearer the city center. We view these differences in samples for sales with full versus limited price information as "innocent," as city officials get better with time at fulfilling reporting requirements.

However, properties with no listed sale compared to our working sample of 2302 show distinct differences. A comparison of columns I and II (with tests of differences given in column IV) suggests these properties are more distant from the CBD (related to listing date), have a lower reserve price; and are more likely to have been offered at English auction. A probit of auction type on sale listed or not, with controls for property characteristics including reserve price and city and year fixed effects, suggests two-stage auctions have a .076 higher probability of a listed sale, potentially evidence of positive selection into two-stage auctions. In terms of sales dates, unsold properties are more recent listings, and many could have been sold but the data not entered yet. For those that are truly unsold, we suspect they are eventually removed from public listing on the internet, perhaps rebundled, and then relisted, which makes statistical analysis of sale versus no sale difficult, because we don't know which properties are being offered for the first versus second time. We think unsold properties are not evidence of a lack of demand per se, but more of heterogeneity and thinness in parts of the market.

2. Likelihood function for trivariate MLE, controlling for selections into competitive and two-stage auctions

The LLF is[xxiii]

$$\ln L = \begin{cases} \ln(\Phi_2[-Z_{ijt}\alpha - X_{ijt}\theta, -X_{ijt}\eta - d_{ijt}\gamma, \rho_{uv}]) & \text{if } d_{ijt}=0, s_{ijt}=0 \\ \ln(\Phi_2[Z_{ijt}\alpha + X_{ijt}\theta, -X_{ijt}\eta - d_{ijt}\gamma, -\rho_{uv}]) & \text{if } d_{ijt}=1, s_{ijt}=0 \\ \ln(\Phi_2[-p_{dijt}, p_{sijt}, -\rho_{ds}]) - \frac{1}{2}\ln(2\pi) - \ln(\sigma_\varepsilon) - \frac{1}{2}\left(\frac{y_i - X_{ijt}\beta - d_{ijt}D}{\sigma_\varepsilon}\right)^2 & \text{if } d_{ijt}=0,\ s_{ijt}=1 \\ \ln(\Phi_2[p_{dijt}, p_{sijt}, \rho_{ds}]) - \frac{1}{2}\ln(2\pi) - \ln(\sigma_\varepsilon) - \frac{1}{2}\left(\frac{y_i - X_{ijt}\beta - d_{ijt}D}{\sigma_\varepsilon}\right)^2 & \text{if } d_{ijt}=1,\ s_{ijt}=1. \end{cases}$$

$\Phi_2(.)$ is the cumulative density function of the bivariate normal distribution. And

$p_{dijt} = \dfrac{Z_{ijt}\alpha + X_{ijt}\theta + \frac{\rho_{\varepsilon u}}{\sigma_\varepsilon}(y_i - X_{ijt}\beta - d_{ijt}D)}{\sqrt{1-\rho_{\varepsilon u}^2}}$, $p_{sijt} = \dfrac{X_{ijt}\eta + d_{ijt}\gamma + \frac{\rho_{\varepsilon v}}{\sigma_\varepsilon}(y_i - X_{ijt}\beta - d_{ijt}D)}{\sqrt{1-\rho_{\varepsilon v}^2}}$, and

$$\rho_{ds} = \frac{\rho_{uv} - \rho_{\varepsilon u}\rho_{\varepsilon v}}{\sqrt{(1-\rho_{\varepsilon u}^2)(1-\rho_{\varepsilon v}^2)}}.$$

For the expected revenue calculation, the price equation is $\hat{y}_{ijt} = X_{ijt}\hat{\beta} + d_{ijt}\hat{D} + \hat{c}_{u,ijt}\hat{\rho}_{\varepsilon u} + \hat{c}_{v,ijt}\hat{\rho}_{\varepsilon v}$, where $\hat{c}_{u,ijt}, \hat{c}_{v,ijt}$ are the predicted values for the expressions

$$\begin{aligned} c_{u,ijt} &= \phi[Z_{ijt}\alpha + X_{ijt}\theta]\frac{\Phi[X_{ijt}\eta + d_{ijt}\gamma - \rho_{uv}(Z_{ijt}\alpha + X_{ijt}\theta)]/(1-\rho_{u\upsilon}^2)^{1/2}}{\Phi_2[Z_{ijt}\alpha + X_{ijt}\theta, X_{ijt}\eta + d_{ijt}\gamma, \rho_{uv}]} \text{ if } d_{ijt}=1 \\ &= \phi[-Z_{ijt}\alpha - X_{ijt}\theta]\frac{\Phi[X_{ijt}\eta + d_{ijt}\gamma - \rho_{uv}(Z_{ijt}\alpha + X_{ijt}\theta)]/(1-\rho_{u\upsilon}^2)^{1/2}}{\Phi_2[-Z_{ijt}\alpha - X_{ijt}\theta, X_{ijt}\eta + d_{ijt}\gamma, -\rho_{uv}]} \text{ if } d_{ijt}=0 \\ c_{v,ijt} &= \phi[X_{ijt}\eta + d_{ijt}\gamma]\frac{\Phi[Z_{ijt}\alpha + X_{ijt}\theta - \rho_{uv}(X_{ijt}\eta + d_{ijt}\gamma)]/(1-\rho_{u\upsilon}^2)^{1/2}}{\Phi_2[Z_{ijt}\alpha + X_{ijt}\theta, X_{ijt}\eta + d_{ijt}\gamma, \rho_{uv}]} \text{ if } s_{ijt}=1 \\ &= \phi[X_{ijt}\eta + d_{ijt}\gamma]\frac{\Phi[-Z_{ijt}\alpha - X_{ijt}\theta + \rho_{uv}(X_{ijt}\eta + d_{ijt}\gamma)]/(1-\rho_{u\upsilon}^2)^{1/2}}{\Phi_2[-Z_{ijt}\alpha - X_{ijt}\theta, X_{ijt}\eta + d_{ijt}\gamma, -\rho_{uv}]} \text{ if } s_{ijt}=0 \end{aligned}$$

Figure 1. Distribution of spread, the sale/reserve price ratio, by auction type

Orange (solid) is two-stage auction; white (blank) is English auction

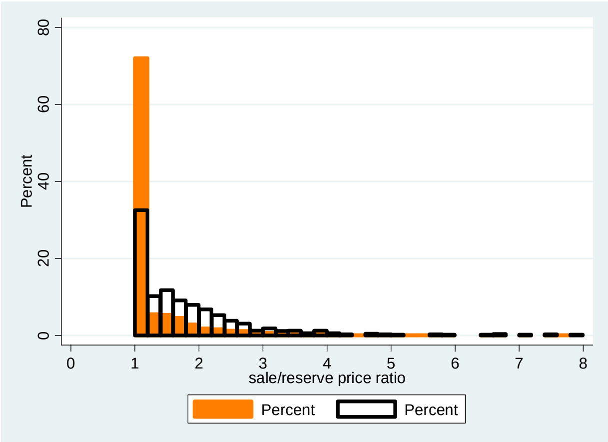


Figure 2. Distribution of unit sales prices (in 10,000 yuan), by auction type

Orange (solid) is two-stage auction; white (blank) is English auction

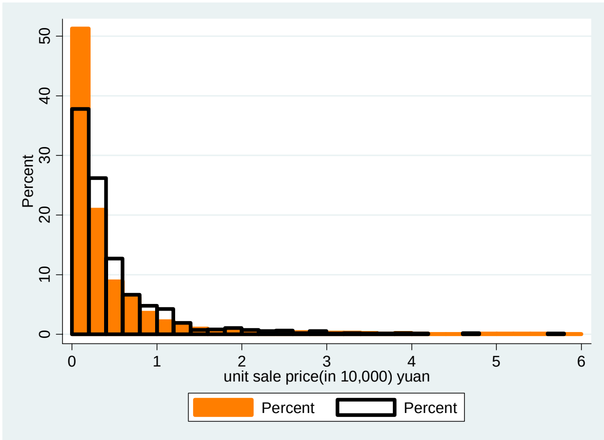
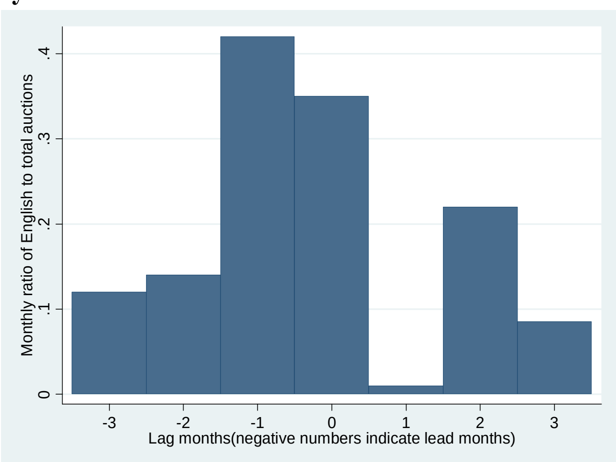


Figure 3. Party Secretary

a. Timing of party secretary turnover and auction choice

Ratio of English to total auctions, by month



b. Timing of party secretary turnover and GDP growth

Growth relative to the nation, by year

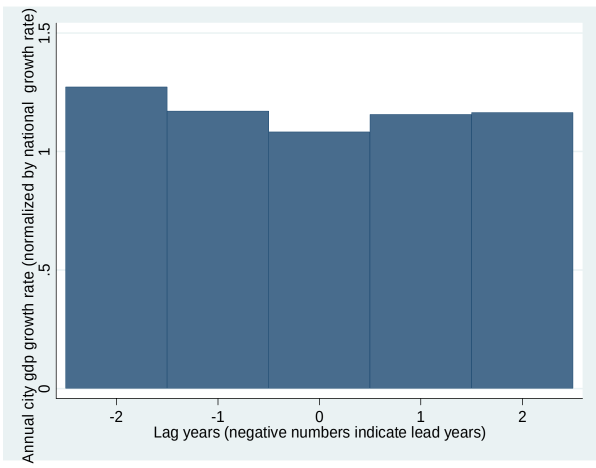
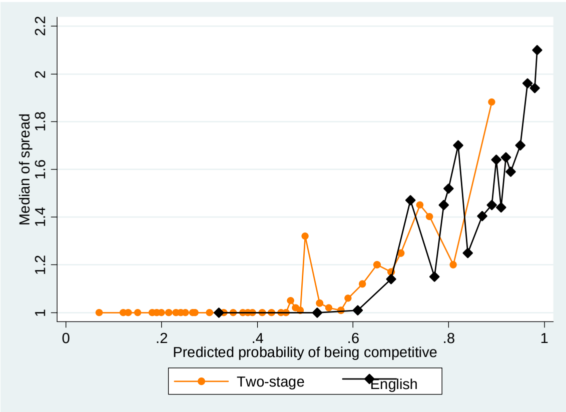


Figure 4. Conditional on the predicted probabilities of being competitive, spreads and prices for English versus two-stage auctions

a. Spreads: sale/reserve prices (gold: two-stage; blue: English)



b. Unit sale prices (10, 000 yuan; gold: two-stage; blue: English)

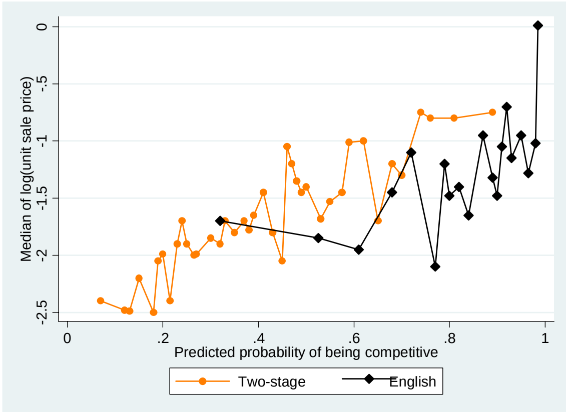


Figure 5. For two-stage auction sales: predicted unit price (in 10, 000 yuan) if sold by two-stage (45^{o} line) versus switching to English auction

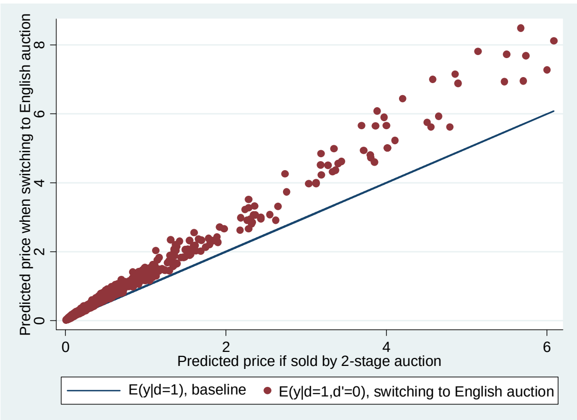


Figure A1. English versus two stage auctions

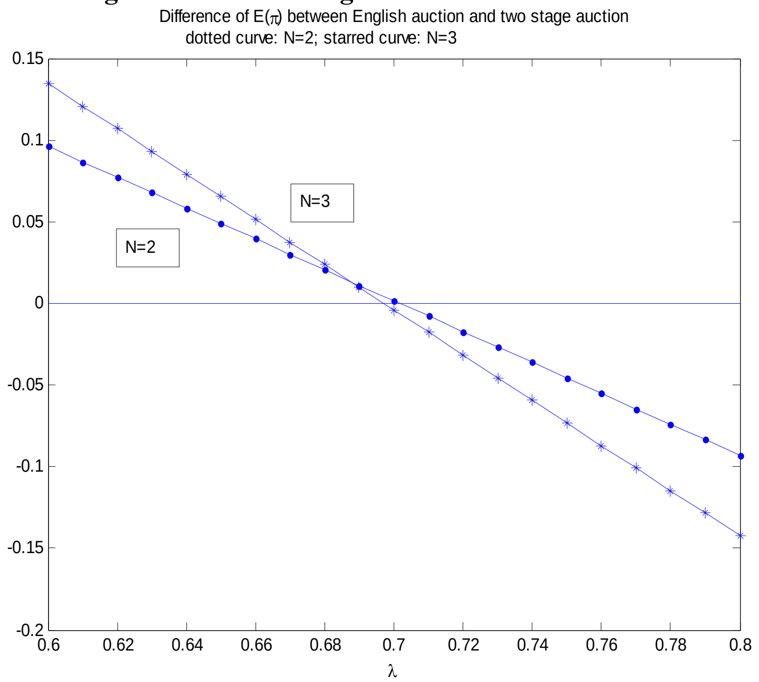


Table 1. Data on two-stage vs. English auctions

	Two-stage auction: Mean {median} (N=1661)	English auction: Mean {median} (N=641)	Difference in means	t-stat.
Unit sales price (10,000 yuan)	.47 {.17}	1.0 {.30}	-.53	-2.64
Proportion non-competitive	.57	.18	.39	-20.4
Unit price if competitive (10,000 yuan)	.73 {.30} (N =708)	1.13 {.32} (N = 527)	-.40	-1.62
Area (in sq. meter)	55290 {20754}	53751 {27256}	1539	.30
Distance to CBD (in km)	19.9 {10.6}	17.8 {9.3}	2.1	1.86

Table 2. Two-stage auction, or not[1]

	Probit: (marg. effects)	Linear probability	Poisson count: Total listings/month	OLS, Ln (reserve price)
Ln (reserve price)	-.040 (.031)	-.031 (.026)		
Dummy: Residential use	-.255** (.058)	-.167** (.058)		.050 (.083)
Dummy: Mixed use	-.245** (.064)	-.160** (.055)		.193* (.101)
Ln (dist. To CBD)	-.044 (.038)	.-033 (.029)		-.571** (.043)
Ln (area)	-.0015 (.013)	-.0026 (.011)		-.145** (.043)
Dummy: railway within 2.5 kms.	.055* (.028)	.038* (.021)		.127 (.129)
Dummy: highway within 2.5 kms.	-.066** (.021)	-.044** (.015)		-.158* (.084)
Party secretary turnover, 1 month lead	-.300** (.127)	-.215** (.092)	.051 (.399)	.035 (.116)
Party secretary turnover, 1 month lag	.157** (.022)	.161** (.045)	-.253 (.253)	-.084 (.253)
Google report, Land corrupt. ca month lead	-.212* (.136)	-.211* (.112)	-.165 (.230)	.051 (.220)
Google report, Land corrupt. ca month lead	.183** (.040)	.150** (.070)	.207 (.215)	.238 (.177)
Season, year, city dummies	Yes	Yes	Yes	Yes
N	2302	2302	283	2302
(Pseudo) Rsq	(.37)	.41		.40
Implied *F*-Statistic From adding instruments	8.1	10.0		

* significant at 10% level; ** significant at 5% or higher level.
All standard errors are robust clustered by city-code, except for LIML where errors are robust.

Table 3. Baseline case: Unit sales prices [ln (sales price/area)]

	OLS	Heckman MLE	LIML-linear prob. 1st stage
Dummy: two-stage auction [2SLS]	-.170** (.037)	-.707** (.217)	-.646** (.267)
Ln (reserve price)	.923** (.028)	.907** (.025)	.909** (.018)
Dummy: Residential use	.023 (.049)	-.068 (.078)	-.058 (.056)
Dummy: Mixed use	.078** (.034)	-.0091 (.059)	.0008 (.054)
Ln (dist. To CBD)	.0083 (.037)	-.010 (.037)	-.0083 (.021)
Ln (area)	-.069** (.011)	-.070** (.013)	-.070** (.011)
Dummy: railway within 2.5 kms.	-.025 (.035)	-.0034 (.035)	-.0059 (.028)
Dummy: highway within 2.5 kms.	-.067 (.038)	-.089* (.046)	-.087** (.025)
Season, year, city dummies	Yes	yes	yes
N	2302	2302	2302
Rsq	.85		.94
***rho* {Sargan *p*-value}**		.641** (.235)	{.15}

* significant at 10% level; ** significant at 5% level or higher.
All standard errors are robust clustered by city-code, except for LIML where are errors are robust

Table 4. Beijing two-stage auctions

a. **Spread and the number of bids**

Number of bids	Number of cases: Sales-reserve price ratio ≤ 1.005	Number of cases: Sales-reserve price ratio > 1.005
1	**104**	**1**
2	**3**	**6**
3 or more	**0**	**75**

b. **First day bids deter entry and competition**

	Poisson: Number of bids (robust s.e.'s)		Probit: Sales/reserve price ratio > 1.005: marginal effects	
Bidder on first day, or not (167 of 195)	-.731** (.344)	-8.28** (.310)	-.142 (.103)	-.224* (.117)
Residential use		1.04** (.352)		.272** (.106)
Mixed use		.772* (.429)		.213** (.105)
Ln (area)		.131 (.085)		.027 (.035)
Ln (distance to CBD)		-.735** (.186)		-.186** (.079)
Ln (reserve price)		-.487** (.130)		-.045 (.059)
Property is cleared, prior to auction		1.63** (.591)		.292** (.135)
N	195	155	189	155
Pseudo Rsq	.030	.260	.007	.129

* significant at 10% level; ** significant at 5% level or higher

Table 5. Probability of competitive sale

	Ordinary probit	Bivariate recursive probit MLE		LIML, Linear probability
	Marginal effects	Marginal indirect effects	Marginal direct effects	
Dummy: two-stage auction	-.338** (.079)	n.a.	-.427** (.085)	-.650** (.191)
Ln (reserve price)	.-016 (.027)	.085 (.067)	-.023 (.024)	-.028** (.012)
Dummy: Residential use	.216** (.055)	.405** (.131)	.172** (.062)	.126** (.041)
Dummy: Mixed use	.205** (.049)	.405** (.156)	.161** (.069)	.117** (.041)
Ln (dist. To CBD)	-.028 (.021)	.094 (.085)	-.035* (.022)	-.036** (.014)
Ln (area)	.-045** (.012)	.002 (.028)	-.045** (.011)	-.035** (.0070)
Dummy: rail within 2.5 kms.	.013 (.036)	-.123* (.076)	.023 (.039)	.027 (.025)
Dummy: highway within 2.5 kms.	-.019 (.029)	.137** (.067)	-.028 (.029)	-.025 (.023)
Season, year, city dummies	Yes	Yes	Yes	Yes
N	2297		2297	2297
Rho			.383** (.157)	
Rsq {Sargan p-value}	.22			{.20}

* significant at 10% level; ** significant at 5% level or higher. All standard errors are robust clustered by city-code, except for LIML where are errors are robust

Table 6. Auction price differences under competition: data

Probability of being competitive	No. of 2-Stage	No. of English	Spread: Difference in Medians: Chi sq p-value*	Price: Difference in Medians: Chi sq p-value*
<0.40	805	20	.67	.83
0.4 - 0. 45	120	10	.74	.74
0.45 - 0.50	142	10	.33	.74
0.50 – 0.55	122	16	.06	.18
0.55 – 0.60	91	23	.16	.64
0.60 – 0.65	89	12	.38	.38
0.65 – 0.70	76	20	.80	.80
0.70 – 0.75	60	41	.93	.75
0.75 – 0.80	63	56	.92	.002
0.80 – 0.85	40	78	.01	.33
0.85 – 0.90	35	88	.21	.21
>0.90	14	240	.78	.78

*Yates continuity corrected

Table 7. Sales prices: "Competitive" sales only

All sales where spread > 1.0005		
	OLS	**MLE (selection on auction type and competition)** (eqs. 7a – 11)
Dummy: two-stage auction	-.031 (.071)	-.137 (.414)
Ln (reserve price)	.870** (.041)	.867** (.051)
Dummy: Residential use	-.157* (.075)	-.162 (.103)
Dummy: Mixed use	-.061 (.042)	-.065 (.068)
Ln (dist. To CBD)	.025 (.048)	.020 (.047)
Ln (area)	-.097** (.027)	-.098** (.032)
Dummy: there is railway within 2.5 kms.	-.049 (.052)	-.049 (.053)
Dummy: there is highway within 2.5 kms.	-.102 (.064)	-.110 (.077)
Season, year, city dummies	Yes	Yes
N	1235	1235
σ_{ε}		.510** (.060)
$\rho_{u\varepsilon}$		.114 (.437)
$\rho_{v\varepsilon}$		.088 (.212)
ρ_{uv}		.374** (.186)
Rsq	.82	

Significant at 10% level; ** significant at 5% level or higher. OLS s.e.'s are robust, city clustered.

Table B.1 Comparing the estimating sample with samples of unsold properties and of properties with missing information

	I. Base sample N = 2302	II. Unsold N = 607	III. Sold: missing price data. N= 1107	IV. Unsold Diff: t-stat. I-II	V. Missing price Data. Diff: t-stat I-III
Two-stage auction	.72	.61	.69	5.11	1.66
Area (sq. m.)	54861	54113	53831	-.09	.25
Distance (km.)	19.3	46.4	13.4	-13.6	7.68
Unit sale price (10,000 yuan)	.62	n.a	.58 (n=824)	n.a.	.53
Unit reserve price	.37	.21	.31 (n=200)	5.01	.50
Mixed use	.38	.52	.39	-6.03	-.54
Commercial use	.31	.27	.28	1.99	1.76
Residential use	.31	.21	.33	4.99	-1.14
No. quarters since listing until Dec. 2007	8.17	4.74	9.31	19.8	-6.25

Endnotes

[i] The central government (National Asset Committee) and the military may control portions of city land in particular cases, as for example the national capital Beijing.

[ii] In the public finance literature on the Henry George tax, land rents in a city in principle will fund an efficient level of local public expenditures (e.g., see Atkinson and Stiglitz,1980). If leasehold sales had been at market prices since the early 1990's and that money had been put into a public investment fund, it could have funded most local public expenditures into the future. That unusual opportunity was clearly squandered.

[iii] Bulow and Klemperer (2009) and Roberts and Sweeting (2011) also compare English auction with an auction with sequential pairwise elimination. Both types differ from the two-stage auction in China's land market auction, based on whether bidders know their valuations ex ante or observe signals about their valuation, as well as assuming sequential pairwise elimination.

[iv] The third type is sealed bid, or *zhaobiao* auction. Sealed bids are submitted to the land bureau. The winner is determined by a score function, in which the magnitude of a submitted bid has only a 20-30% weight. The remaining weight goes to reputation, financial capacity, and "social responsibility."

[v] In addition to cash deposits, qualification involves things like being a China-based firm, not having a criminal record, and not having a record (complaints) of shady development practices in dealing with consumers.

[vi] The entry fee consists of (i) cost of making cash deposit to qualify, (ii) cost of preparing documents to meet the qualification requirements, (iii) other transaction costs (e.g., time, consulting fee).

[vii] We assume the reserve price is exogenous to the auction format choice, because it is set by an independent appraiser and empirically (below) it is not correlated with auction format. In similar setting without corruption, McAfee, Quan and Vincent (2002) analyze the setting of reserve price. With endogenous reserve price, our corruption story is likely strengthened because the corrupt official is more likely to lower reserve price for two stage auction, and the expected revenue loss to the city would be larger. In an English auction, a lowered reserve price would attract more participation by non-corrupt

bidders and reduce the chance of winning by the corrupt bidder. In contrast, a lowered reserve price would have little effect on the chance of winning by the corrupt bidder in a two-stage auction, given his first day bid at the reserve price as a signal to prevent entry by other bidders. A lower reserve price would mostly increase the net profit of the corrupt developer (and thus the bribe to the corrupt official).

[viii] This assumption holds when ex ante no one knows the identity of the potentially corrupt bidder. If everyone knows that bidder 1 is the potentially corrupt one, he is more likely to enter than other bidders, even if he does not have a deal. This is because only bidder 1 himself knows that he is not corrupt and all other bidders are worried that bidder 1 may be corrupt. Our analysis will not change much if we allow for this possibility.

[ix] That $\hat{V}_{1P} < \hat{V} < \hat{V}_{-1}$ can be shown as follows. Given equation (2) holds, by comparing equations (3) and (4), we have $\hat{V}_{1p} < \hat{V}_{-1}$. If $\hat{V}_{-1} \geq \hat{V}_{1p} + \kappa$, then for equation (2) to hold, equation (4) implies that $\hat{V}_{-1} > \hat{V}$ (note then that all $\hat{w}_m$'s are zero). If $\hat{V}_{-1} < \hat{V}_{1p} + \kappa$, then for equation (2) to hold, equation (3) implies that $\hat{V}_{-1} > \hat{V}$ (note that the first term in the bracket is zero). Comparing equations (2) and (4) reveals that if $\hat{V}_{-1} \geq \hat{V}$, then $\hat{V}_{1p} < \hat{V}$.

[x] Because equation (2), (4) and (6) hold, if $\tilde{V}_0 > \hat{V}_{-1}$, then $\hat{V}_{1p} > \tilde{V}_C$. Suppose counterfactually $\tilde{V}_0 \leq \hat{V}_{-1}$, then it can be shown that the left hand of equation (5) is less than that of equation (3), which yields a contradiction (right hand sides are the same).

[xi] Note that in the model we have held the bribe payment q fixed. However, it is likely that q is higher for hotter properties (greater gain in expected price paid, or greater gain from deterred entry). In such a case, the corrupt official would have even more incentive to direct a hotter property to two-stage auction (positive selection).

[xii] These are Xiamen, Guangzhou, Shenzhen, Nanning, Changchun, Suzhou, Wuxi, Nanchang, Shenyang, Taiyuan, Chengdu, Tianjin, Hangzhou, Ningbo, and Chongqing.

[xiii] We experimented with adding interactions of auction type with covariates to the IV specification, allowing auction effects to vary with covariates. But the effects are not instructive, especially given we already have a reduced form specification. In OLS the interactions are not significant. In the IV (2SLS)

results, the interactions are somewhat statistically stronger and the average treatment effect is larger. However there is little variation in treatment responses as covariates go from low to high values.

[xiv] These reported results done earlier in the project use 7 instruments, our current four plus the other two sets discussed above and later rejected. Throughout results with 4 or 7 instruments are always almost identical.

[xv] Consider a Cobb-Douglas production function where land has a quality *g*, and the shift factor, *A* contains housing type and technology by city (terrain, weather) information. Assume zero profits apply to housing of each quality sold by English auction, whereas land sold by two-stage is effectively subsidized at a rate *t.* The prices of housing, land of quality *q,* and capital are respectively $\boldsymbol{p}, \boldsymbol{p}_{l,g}$ **and** $\boldsymbol{p}_k$. The ratio of unit house price in the market to land price paid in two stage auction is given by $[(p_{l,g})^{\alpha} p_k^{1-\alpha} A^{-1} \alpha^{-\alpha} (1-\alpha)^{\alpha-1}] / (p_{l,g}(1-t)]$. We use reserve price to control for price by land quality and have city dummies (to control for *A* differences for example) and controls for 4 house types and the extent to which the interior is finished. In the double- log formulation, on the RHS, ln(*1-t)* is represented by a dummy variable for the treatment effect of two-stage auction.

[xvi] If so, English auctions might have less chance of a sale (bid above reserve price), but yield higher prices for sales that occur. Of course the land bureau might assign risky properties to two-stage auctions without corruption to try to ensure any sale.

[xvii] In Beijing sometimes properties are sold which, contrary to national policy, have not been cleared for redevelopment. For Beijing, unlike other cities, we have good data on clearance, with 155 of the observations having an entry for this variable.

[xviii] Marginal direct effects are calculated based on the estimated coefficients in the second equation of the bivariate recursive probit, as well as the predicted probability of being competitive at the mean level of covariates, i.e., P=0.4817. For a continuous variable, its marginal effect is equal to the product of the density of normal distribution at P=0.4817 and its estimated coefficient. For a discrete variable, its

marginal effect is equal to $\Phi(\Phi^{-1}(0.4817)+\theta)-0.4817$, where $\Phi(\cdot)$) is the cdf of the normal distribution and θ is the estimated coefficient.

[xix]The marginal indirect effect of each covariate is obtained from the product of the estimated coefficient of two-stage auction in the second equation of the bi-probit regression, the estimated coefficient of this covariate on auction type in the first equation, and the two pdf's. We calculate the standard errors using the delta method approach. The variance-covariance matrix is obtained through post-estimation of the bi-probit model.

[xx] In this MLE calculation, the unit sales price calculation is based on the predicted probability of selling competitively at two-stage auction ($\text{prob}\left(s_{ijt}=1 \mid d_{ijt}=1\right)$) times the predicted price if sold competitively, plus the predicted probability of selling non-competitively at two-stage auction times the reserve price. The predicted price if sold competitively is from the price equation adjusted for the two selection terms from Appendix B.2. Revenues are based on predicted prices multiplied by quantities. The actual revenue from properties sold at two-stage auctions is 239.6 billion, about 5% higher than predicted.

[xxi] Let us denote the probability of selling competitively under the switch as $\text{prob}[s_{ijt}=1 \mid d_{ijt}=1, d'_{ijt}=0]$.

Then $\text{prob}[s_{ijt}=1 \mid d_{ijt}=1, d'_{ijt}=0]=\Phi\left(\Phi^{-1}(\text{prob}[s_{ijt}=1 \mid d_{ijt}=1])-\hat{\gamma}\right)$.

[xxii] In part the complication comes from the fact that the relationship between expected revenue and the number of potential bidders in auctions with costly entry is quite complex, see, e.g., Samuelson (1985), Milgrom (2004) and Ye (2007).

[xxiii] We thank Frank Reize for access to his STATA code on MLE estimation of the model, to check ex post against our STATA code, although in the end we reprogrammed the model in MATLAB. There seems to be a minor error in Reize (2001) in specification of the LLF.