Collusion in Private Procurement: How Does Mandatory Building Repair Increase Renovation Prices?*

Tin Cheuk Leung	Kwok Ping Tsang	Kevin K. Tsui
Wake Forest University	Virginia Tech	Clemson University
leungtc@wfu.edu	byront@vt.edu	ktsui@clemson.edu

October 6, 2018

Abstract

This paper studies a regulatory change that significantly increases the prices of residential building renovation. In Hong Kong, where most people live in high-density condominiums, owners' corporation arranges tender process to choose contractors on behalf of all homeowners when common areas of a building need maintenance and repair. Since 2012, the government has mandated selected buildings to finish such renovations within a year. Using propensity score matching method, we find that homeowners who received statutory notices to repair their building paid 40 percent more in bid price compared with those who did it voluntarily. After the mandatory scheme was introduced, all homeowners on average paid 40 percent more, and those who received the notices paid even higher prices. Moreover, these increases in prices are more pronounced in districts where condominiums are more expensive and residents are more educated. Finally, the major contractors' bids became more correlated after the introduction of the mandatory scheme, suggesting that the scheme may have helped promote bid rigging and corruption among contractors and owners' corporations.

JEL codes: K21, L12, R21

Keywords: Housing regulations, bid-rigging, private procurement

* Leung is the corresponding author. We thank Factwire for collecting and generously providing the data. We would like to thank Bill Dougan, Sergey Mityakov, Alec Smith and seminar participants at Clemson University, the Competition Commission of Hong Kong, and the University of Texas at El Paso for helpful comments.

1. Introduction

It is widely recognized that building regulations, like zoning and environmental requirements, restrict housing supply and hence increase home prices. Although housing is a durable good, much less attention has been paid to regulations on maintenance and repair. In this paper, we examine how one such regulation imposes substantial costs on homeowners, and we also document how the increased price of building renovation is related to the bid rigging and corruption among contractors and owners' corporations.

In Hong Kong, most people live in condominiums of high density. When common areas (e.g., the external walls) of a building in Hong Kong need maintenance and repair, a contractor from the renovation market is chosen through a tender process arranged by an owners' corporation that represents usually hundreds of homeowners. These homeowners, however, usually have little knowledge of the selection criteria and other technical details of the projects. This private procurement process, therefore, is prone to bid rigging and corruption among contractors and owners' corporations. On the other hand, to protect the public from the effects of aging or even unsafe buildings (e.g., debris fallen on pedestrians), the Hong Kong government recently introduced the Mandatory Building Inspection Scheme (MBIS) that requires selected buildings to complete certain renovations within a specific time limit (usually one year). While we do acknowledge the potential benefits of this regulation, the focus of our paper is on how the requirement affects the prices of such renovation projects through changes in incentives for collusion and corruption when the demand for building renovation becomes less elastic.

To illustrate how collusive arrangements are enforced in private procurement of building renovation contracts, we first consider a case study of the first successful bid-rigging criminal prosecution in the history of Hong Kong. The case study illustrates the contractual arrangement behind the bid-rigging syndicates in private procurement, which consist of renovation contractors as well as members of owners' corporations, property management companies and consulting firms. Moreover, the case shows that bid rigging and corruption among contractors and owners' corporations existed even *before* the MBIS was introduced, and it also suggests that the amount of money involved in these bid-rigging syndicates can be big and is likely to get even bigger over time.

Studies on collusion in private procurement are rare due to the difficulty of collecting the relevant data. We obtain data on 141 building renovation projects from Factwire, an investigative news agency headquartered in Hong Kong, to conduct our empirical exercise. These data include the identity of the contractors and consultants, their bid amounts, the identity of the winner, and some building characteristics. Using propensity score matching method to control for the probability of receiving an MBIS notice, we find that over the period when the MBIS is enforced, homeowners who received notices to repair their building paid 40 percent more in bid prices compared with those homeowners with similar units but did not receive the notice. To the extent that our building characteristics are sufficient to account for the variations in renovation costs, these higher renovation prices paid by the MBIS-homeowners are likely to be driven by either "haste makes a higher cost" or collusive pricing when demand becomes more inelastic.

When we compare all non-MBIS renovation projects before and after MBIS was introduced, the bid price for the post-MBIS projects are also significantly higher than the pre-MBIS ones even after controlling for labor and material costs for construction, suggesting that the "haste makes a higher cost" alone cannot fully explain the price increase. In our full sample, we find that all homeowners on average paid 40 percent more after the MBIS was introduced, and those who received the notices paid even higher prices. We also find that the post-MBIS renovation cost is higher for higher income homeowners, who probably have higher time cost in monitoring the tender process. Finally, to further test our hypothesis that bid rigging spills over, we also examine the bidding behavior of the four most active construction firms in our data before and after the regulatory change. We find that their bids are more correlated after the regulatory change, violating the conditional independence condition in Bajari and Ye (2003) and Bajari and Summers (2002).

The rest of the paper is organized as follows. Section 2 reviews the related literature on regulation and price fixing detection. Background on the MBIS regulation and the building renovation market as well as the bid-rigging case study are presented in Section 3. We present our data and empirical analysis in Section 4. Section 5 concludes.

2. Related Literature

2.1. Regulation and housing prices

By limiting supply response, zoning and environmental regulations increase housing prices. Research on how land use regulations affect house prices dates back to the 1970s. In an early study using data from the San Francisco Bay Area, Katz and Rosen (1987) provided evidence that house prices are between 17 percent and 38 percent higher in regions with city growth moratoria and/or growth control plans. Since then, numerous empirical studies find evidence that more land use regulations would lead to higher housing cost in different cities and in different time periods.[1] Gyourko and Molloy (2015) provided an excellent review of the literature.

This paper differs from the numerous studies in the literature that, instead of studying how regulations affect housing supply and hence house prices, we look at a less common case of regulations affecting the demand for housing renovation and hence the costs of homeownership.

2.2. Detecting collusion

Ever since Stigler (1964), economists have long tried to understand the determinants of successful collusive arrangements. Hay and Kelly (1974) hypothesized several structural characteristics that facilitate collusive behavior, and they include fewness of numbers, concentration, product homogeneity, inelasticity of demand and so on. Most of the implications of these hypotheses have been put to empirical tests by Stigler (1964), Hay and Kelly (1974) and many others.[2] However, the hypothesis that inelasticity of demand provides a higher incentive for collusive behavior has rarely been tested.[3]

[1] See Akee (2009), Gyourko, Mayer and Sinai (2013), Glaeser, Gyouko and Saks (2005), Huang and Tang (2012), and Quigley and Raphael (2005).

[2] Levenstein and Suslow (2006) and Harrington (2005) provide an excellent review on the empirical literature.

[3] For instance, in all the Department of Justice memoranda they examine, Hay and Kelly (1974) find little or no evidence to support the hypothesis. Studies have used prior information of appropriate events, such as formation of trade association (Funderburk 1974) and sudden increase in entry (Levenstein and Suslow 2001) as candidate breakpoints to identify suspicious collusive behavior. However, events leading to drastic change in industry's demand elasticity and firms' collusive behavior have not been studied much. To the best of our knowledge, ours is the first paper that studies this.

Although in theory the effect of demand elasticity on the likelihood of collusion is ambiguous, what is clear is that the collusive price is higher the more inelastic the demand is. A significant portion of the collusive agreements has been found in industries with inelastic demand. Public construction market (Porter and Zona 1993) and school milk market (Porter and Zona 1999) are two such examples. Four of the industries studied in Hay and Kelly (1974), which overlapped with another study on industries' elasticities, all had short-run elasticities that were less than one. While it is hardly a coincidence that many of these collusive agreements are found in industries with inelastic demand, this is at most indirect evidence that corroborates with the hypothesis. A more direct and rigorous test requires a "structural break" in the industry's demand elasticity and firms' behavior.

There is also a growing literature on detecting cartels and distinguishing collusion from competition. Harrington (2005) provides an excellent review. The key to detect cartels is to compare a suspected group of firms with a competitive benchmark. There are several ways to find such a benchmark. First, one might be able to find geographic markets for the same goods and firms are suspected of colluding in some but not all those markets.[4] Alternatively, one might have prior information on the identities of cartel members and the cartel is not totally inclusive.[5] This paper follows a third approach: we identify collusion by looking for a structural break in firm behavior.[6] In particular, we analyze an increase in demand inelasticity due to a change in government policy. Moreover, our case of private procurement for renovation contracts also features how the success of bid rigging depend upon the ability of the buyers to monitor the tender process.

[4] Porter and Zona (1999) adopt this approach to detect collusion in school milk contracts, and Zona (2011) uses a structural approach to estimate overcharges of price-fixing.

[5] Porter and Zona (1993), Bajari and Summers (2002) and Bajari and Ye (2003) use this approach to examine the different bidding behaviors of cartel members and non-cartel members in a first-price sealed bid procurement auction setting.

[6] Hay and Kelley (1974) use horizontal price fixing cases in the 1960s and early 1970s to categorize a set of product and product market characteristics associated with price fixing, which includes existence of trade associations, fewness in number of firms, demand inelasticity and so on. The literature has empirically investigated a few factors that can lead to a structural break in several such characteristics: (i) Creation of trade associations. For instance, Funderburk (1974) finds that the Oklahoma Highway Department started to receive identical bids at procurement auctions some time after the formation of the Asphalt Refiners Association; (ii) A sudden increase in entry. Levenstein and Suslow (2001) document that the market for vitamin C started to collapse after the growing expansion of Chinese manufacturers in the market; (iii) A government price-fixing investigation. Froeb, Koyak and Werden (1993) and Abrantes-Metz, et al. (2006) find a significant decrease in price and price variation in the frozen seafood market after reports of the existence of an investigation into the bid-rigging scheme. Clark and Houde (2014) and Erutku and Hildebrand (2010) find that the prices and margins fell after the collapse of collusion in Quebec's retail gasoline market following a Competition Bureau investigation.

3. Background: Government Intervention in the Building Renovation Market

3.1. The Mandatory Building Inspection Scheme

Partly for improving building safety and the cityscape, and partly for preserving jobs in the construction sector after the global financial crisis, the Hong Kong government had launched several programs to encourage building renovations since 2009.[7] The Mandatory Building Inspection Scheme (MBIS) was introduced in June 2011 as part of the enactment of relevant amendments to the Building Ordinance 2011, which was then enforced in June 30, 2012.[8]

Under the MBIS, the Building Authority can issue statutory notices to owners of buildings aged 30 years or above requiring them to carry out inspections and repairs if deemed necessary. In particular, the Buildings Department would take advice from a selection panel, comprising representatives from various professionals, to select the target buildings each year.[9] The selection panel would consider several factors, including (i) the maintenance condition of the buildings and windows, (ii) repair records of the buildings, (iii) traffic and pedestrian flows around the buildings, (iv) location of the buildings, (v) building clusters, and (vi) nominations by the District Councils. Generally speaking, higher priority is given to those dilapidated buildings abutting areas of heavy traffic and pedestrian flows for their relatively higher risk posed to the public. According to the Building Department, buildings that have received comprehensive building renovation (i.e., repair works in the common areas and on the external walls) in recent years would not be selected within a "certain period" after the completion of the renovation.

[7] The first one is the HK$1-billon (approximately USD130 million) "Operation Building Bright" initiated by the Financial Secretary in collaboration with the Hong Kong Housing Society and the Urban Renewal Authority. The aim of the program is to provide subsidies and one-stop technical assistance to owners of about 1,000 old buildings. However, most of these subsidies are either small in terms of the amount (the cap of HK$3,000 per unit under the Common Area Repair Works Subsidy is less than 3 percent of the renovation cost per household in our sample) or in terms of scale because of the stringent criteria (the Operation Building Bright only aimed to provide subsidies to owners of about 1,000 old buildings). None of these programs has a more comprehensive impact on the building renovation market as the MBIS.

[8] According to the Buildings Department, the first MBIS notice was issued on November 12th, 2012. A total of 19 MBIS notices were issued in 2012, significantly less than approximately 2,000 notices issued per year between 2013 and 2016.

[9] The selection panel includes representatives from professional institutions, non-government organizations, property management professionals, District Councils and relevant Government departments. Currently, including the Chairman from the Building Department, there are 26 members. Professional institutions representatives are from the Hong Kong Institutes of Architects, the Hong Kong Institute of Engineers, and the Hong Kong Institute of Surveyors. Non-government organizations and property management professional representatives are from the Hong Kong Housing Society and Hong Kong Association of Property Management Companies.

Once selected, the Buildings Department issues pre-notification letters to the homeowners before the serving of statutory notices to alert them to get prepared and organized for carry out the required prescribed inspection and repair. Within 6 months after the pre-notification letters are issued, the Buildings Department may serve statutory notices to the owners of the target buildings. For buildings with (resp. without) an owners' corporation,[10] homeowners are required to (i) appoint a registered inspector within 3 (resp. 6) months of the date of the statutory notice to carry out the prescribed inspection, (ii) complete the prescribed inspection within 6 (resp. 9) months of the date of the statutory notice,[11] and (iii) complete the prescribed repair within 12 (resp. 15) months of the date of the statutory notice if renovation is found necessary.

Homeowners have statutory obligation to arrange for a prescribed inspection and prescribed repair when they are served with a statutory notice. Those who fail to comply with the statutory notice for mandatory inspection may be prosecuted and liable on conviction to (i) a fine of HK$50,000 and imprisonment for 1 year and (ii) a fine of HK$5,000 for each day during which it is proved to the satisfaction of the court that the offense has continued. Thanks to the high population density, most of the residential buildings in Hong Kong have multiple households. To address the free-rider problem, the Building Ordinance states that it would be an offence if one of the homeowners, without reasonable excuse, "refuses to contribute to the cost of inspection, investigation, works or other action in relation to the common parts of the building that is required to be carried out by the owners' corporation of the building for the purpose of complying with the statutory notice served by the Building Authority, the owner commits an offence."

The selection of the contractor is done in two stages.[12] First, the homeowners, through the owners' corporation, appoint a consultant to advise them on the exact renovations needed to be done and oversee the selection process for bidders. The consultant, which is usually a firm, must

[10] Owners' corporations are institutions through which owners can jointly manage and maintain their Complexes. Their main functions include appointing property management companies and commission of maintenance works, the latter of which is the focus of this paper.

[11] The inspection shall cover the following building elements: (i) external elements and other physical elements; (ii) structural elements; (iii) fire safety elements; (iv) drainage system; and (v) identification of unauthorized building work in common parts of the building, on the exterior other than the common parts of the building (such as external wall, roof or podium, yard or slope adjoining the building) or on the street on which the building fronts or abuts.

[12] For the description of the bidding process, we rely on the report by the Hong Kong Competition Commission (2016) and various media reports.

have a professional individual registered under the Buildings Ordinance (typically an engineer, architect, or surveyor). After that, the homeowners vote on the proposals selected by the consultant, after some proposals are eliminated by the consultant and hence not available for voting.

3.2. The first bid-rigging conviction in Hong Kong

Before we provide further statistical evidence on collusive bidding behavior, we describe in this section the first successful bid-rigging criminal prosecution in Hong Kong.[13] We believe that this case study can illustrate how bid-rigging syndicates in private procurement are different from their counterparts in public procurement and how large-scale big-rigging corruption existed even before the implementation of the MBIS. We hope that such details will make it easier to understand and interpret the empirical results in the following sections.

On September 29, 2016, Yau Shui Tin, a sub-contractor, was sentenced to 35 months' imprisonment for four charges of conspiracy to offer advantages to agents. This sentence by the District Court marks the first successful criminal prosecution of bid-rigging in Hong Kong. Yau was involved in the renovation projects at Garden Vista and Ravanna Garden in the Shatin district, where the former fetched an eye-catching price of HK$262,000,000 (equivalent to over US$33,500,000), averaging HK$300,000 (equivalent to over US$38,000) per household.

Yau pleaded guilty for offering bribes to building managers and owners' corporation members in order to secure renovation contracts for several private residential estate renovation projects between 2010 and 2014, all of which were arranged *before* the implementation of the MBIS.

In 2005 a member of the committee (Ho) established for Ravana Garden's renovation project asked Yau to assist in contacting responsible officers of Universal Housing Engineering Consultants Limited and two other contractors, who at that time already submitted tenders to bid the consultancy contract for the same project.

[13] This section is largely translated from the original Reasons for Verdict (case number DCCC 552/2015) in Chinese, available here:

Yau got in touch with the director (Wong) of Universal, and in a dinner meeting with all these parties present, HK$600,000 “tea money”, an electrical works contract and an external wall redecoration sub-contract were offered to Ho in return for securing the consultancy contract for Universal. Wong also offered HK$200,000 to Yau personally as an award for introducing Ho to him. Later, Universal won the bid for the HK$30,000,000 consultancy contract as planned. Notice that the only bribe involved (HK$800,000) takes up about 2.7% of the contract price.

The much bigger project for Garden Vista was manipulated in a similar manner. In 2010, the property manager (Hui) at Synergis Management Services Limited asked Yau to find contractors for the renovation tender at Garden Vista. Yau then arranged a dinner with Hui and the following five parties: Chung (a shareholder of T. S. Tam Architects Limited), Lai (the chairman of Garden Vista’s incorporated owners), Fan (the then executive director of management firm Synergis Holdings Limited), Wong (the director of consultancy firm Wong Pun and Partners Limited), and Yeung (the director of engineering firm Hong Dau Construction Co. Limited).

During the dinner the parties reached an agreement to give Fan, Hui and Lai 6%, 1% and 10% respectively of the total costs of the renovation project for assuring that Wong Pun and Partners Limited and Hong Dau Construction Co. Ltd would successfully win the bid of Garden Vista’s renovation project. It was agreed that Lai would recommend to the incorporated owners to select the consultancy with the third highest bid and the contractor with the third lowest bid, while Wong, Yeung and Chung would be responsible for arranging “dummy firms” to submit bids. Later, Wong Pun and Partners Limited got the consultancy contract and Hong Dau Construction Co. Ltd won the bid for the renovation project as planned. The bribe involved in this case already takes up 17% of the contract price, on top of the likely inflated prices charged by the consultant and engineering firms.

Yau was convicted under the above four charges of conspiracy to offer advantages to agents. Interestingly, although Yau also reported other parties involved, there was not enough evidence showing that the parties concerned actually received the proceeds of bribes and none of them were prosecuted.

The details behind these two renovation projects highlight the following facts: (1) bid-rigging existed before the MBIS, (2) the amount of money involved in such projects is large, and our data will show that it is getting even larger, (3) the bribe, which is also the minimum markup to be imposed on the homeowners, takes up a significant fraction of the total project cost, and (4) the owners' corporation plays a crucial role in this private procurement process.

4. Empirical Analysis

4.1. The data

We use data from various sources to conduct our analysis. The main source of our data comes from Factwire (www.factwire.org), an investigative news agency headquartered in Hong Kong. Since June 2016, Factwire has been assembling information on tenders for building renovations from difference sources, including the Property Owners' Anti Bid-Rigging Alliance, consulting firms, owners' corporations and the public. The information includes the identity of the consultants and contractors, their bid amounts, the identity of the winner of each tender (if there is one), and other building characteristics. Factwire then made this data public in April 2017 as part of their news report.[14] In this paper, we do not analyze the bid-rigging behavior of consultants, and therefore we only use tenders that involve contractors.[15] The data include the information of 223 buildings' projects, of which 141 are with fully matched information on buildings characteristics.

Information on whether a building had received an MBIS notice is obtained from the Buildings Department. The Buildings Department maintains a list of target buildings under the MBIS which can be assessed on its website.[16] We obtain information on the construction cost index from the Census and Statistics Department. The Census and Statistics Department compiles report on the index numbers of the costs of labor and materials used in public sector construction projects in each month. The labor costs include the composite labor wages for civil

[14] The data can be accessed online here.
[15] We experimented with using the consultant information in some of our specifications. We found that projects associated with consultants that appeared in the sample many times did receive a much higher bid (more than 10%) than other projects. However, we do not want to over-interpret the results because only approximately half of the sample has information on the identity of consultants.
[16] The list can be obtained online here.

engineering contracts and composite labor wages for building contracts. The material costs include costs of selected materials for standard public construction projects, such as bitumen, concrete blocks, hardwood, paint, and sand etc. Overall, these indexes for labor and material costs are compiled for working out the change of payment to the main contractors of public sector construction projects in Hong Kong. Due to the lack of data on the cost of construction, these indexes represent the best proxy for the production cost in the building renovation industry. Information on the buildings' housing price and owners' demographics is from Centaline, one of the largest property agencies in Hong Kong. Its website provides information on historical transaction prices of houses and demographics of homeowners in the neighborhood of buildings obtained from the Census and Statistics Department.

Table 1 reports the summary statistics. Over the sample period, the winning bid per household is HKD118,241 (approximately USD15,000). There is a significant difference in the winning bid before and after the implementation of the MBIS. As the first and second columns of Table 1 show, the winning bid per household increased by HKD53,449 (approximately USD6,900) after the implementation of the MBIS.

Some of the buildings' characteristics are similar before and after the MBIS. For instance, the average age of the buildings is approximately 39 years, although those received the MBIS notice are a little younger compared with those who did not after the MBIS was introduced. The proportion of buildings located in the New Territories and Kowloon are 18% and 34% respectively, and it is interesting to note that relatively more MBIS notices were issued to households in Kowloon. The quality (proxied by the housing price in 2016) and the demographic characteristics of the neighborhood are also similar before and after 2012. However, the buildings are slightly bigger (average number of units increased from 192 to 266), and are equipped with more facilities (percentage of buildings equipped with shopping mall or club house increased from 10% to 21% and from 3% to 8%) after the implementation of the MBIS.

While demand for renovation was increased by the MBIS, cost did not seem to have responded significantly. While the implementation of the MBIS might have led to higher demand for construction labor and material through the more stringent capacity constraints in the building renovation industry, this sub-industry is only a small portion of the whole construction industry that includes construction of public infrastructure projects (such as high speed railroads)

and new apartment complexes. Figure 1 shows that the overall construction cost index had increased more rapidly between 2005 and 2011, compared to after 2012 when the Building Departments started to issue the MBIS notices. Also, in Figure 2 we plot the time series of proxies of construction cost and the winning bid per household between 2010 and 2016. While the construction cost (using the overall construction cost index and construction worker wage index as proxies) had increased at approximately the same rate both before and after 2012, the winning bid per household had increased at a faster rate during the 2 years after 2012, the year in which the MBIS was enforced.

The possibility of phantom bidding is consistent with our data. Table 2 shows that the 4 most active firms (each of which had submitted a bid in at least 60 out of 141 tenders in the data) regularly "bid against" each other. The table shows the number of times in which a firm bid against another both before and after the implementation of the MBIS. For instance, the upper panel of Table 2 shows that on the 37 occasions in which firm 1 submitted a bid before the MBIS, 19 bids were also submitted by firm 2. As the table suggests, these four firms became slightly more active after the MBIS. They also "bid against" each other more often after the MBIS.

4.2. Post-MBIS matching estimation

While Table 1 suggests that there is no significant difference between the buildings that received MBIS notice and those that did not in terms of their observable characteristics, there might still be concern that the small difference would lead to selection bias. To address such a concern, we use the propensity score matching (PSM) estimator to evaluate the effect of MBIS notice by comparing the bid prices for the buildings that received MBIS notice to those of similar buildings as a comparison group. Denote $P(Z) = P(D = 1|Z)$ as the probability for a building to receive MBIS notice ($D = 1$) given its observed characteristics Z, which include a set of building characteristics, construction cost index, and time trend.[17]

The PSM estimator for the population average treatment effect (ATE) of MBIS notice is:

$$\pi_{ATE}^{PSM} = E_{P(Z)}\{E[Y(1)|D = 1, P(Z)] - E[Y(0)|D = 0, P(Z)]\},$$

[17] The building characteristics include the number of units within the building, building age, facility dummy variables, and location dummy variables that may affect renovation costs.

where $Y(1)$ and $Y(0)$ are the natural log of the winning bid per household of building that did and did not receive MBIS notices, respectively. The PSM ATE estimator answers the question: "What is the expected effect on the bid price if buildings in the population were randomly sent the MBIS notice?" However, as Heckman (1997) notes, the estimate might not be policy relevant because it includes the effect of MBIS notice on buildings for whom the MBIS was never intended. Therefore, we also estimate the average treatment effect on the treated (ATT), where the PSM estimator is defined as:

$$\pi_{ATT}^{PSM} = E_{P(Z)|D=1}\{E[Y(1)|D=1, P(Z)] - E[Y(0)|D=0, P(Z)]\}.$$

Table 3 reports the results of our matching estimation, using the post-MBIS subsample. For comparison, column 1 shows the OLS estimate with the full set of controls. The OLS result suggests that the MBIS-households paid 25 percent more compared with the non-MBIS-households, although the estimate is not precisely estimated. The rest of the table shows that there is a more robust and significant relationship between MBIS-status and renovation prices. After the MBIS was enforced, the MBIS-households paid more than 40 percent more compared with the non-MBIS-households. To the extent that there is selection on observables, the selection tends to bias the effect of MBIS downward. In other words, at least in our sample, there is no evidence that MBIS notices were systematically issued to buildings that were too expensive to repair. Focusing on the post-MBIS subsample, however, we are not able to differentiate if the increase in renovation price paid by MBIS-household is driven by "haste makes a higher cost" or collusive pricing when demand becomes more inelastic.

4.3. Before-After comparison

Another way to examine the price effect of MBIS is to do a before-and-after comparison. We consider the following regression model:

$$Y_{it} = \gamma_0 PostMBIS_{it} + \gamma_1 MBISNotice_{it} + X_{it}'\gamma_2 + \gamma_3 Trend_t + \gamma_4 Cost_t + \epsilon_{it},$$

where Y_{it} is the natural log of the winning bid per household of building i in year t.[18] The first variable of interest $PostMBIS$ is a dummy variable that equals 1 if the renovation was conducted on or after 2013, and equals 0 otherwise. Therefore γ_0 measures the overall impact of the MBIS

[18] The results using the actual winning bid per household as the dependent variable are shown in the Appendix.

on all buildings. The second variable of interest $MBISNotice$ is a dummy variable that equals 1 if the building received a notice from the Buildings Department for the MBIS, and equals 0 otherwise. Therefore γ_1 measures the direct impact of the MBIS on those buildings that received the notice. X'_{it} represents a set of control variables for the buildings characteristics, including the number of units within the building, building age, facility dummy variables, and location dummy variables that may affect renovation costs. In addition to the buildings characteristics, there might be other time-varying factors that affect the costs. We control for that using $Trend_t$, which is the quadratic time trend, and $Cost_t$, which controls for the cost of construction project.

First, we report in Table 4 the results using the subsample of buildings that did not the MBIS notice. Interestingly, even when renovations were done on a voluntary basis, households paid significantly higher prices after the MBIS was enforced. In the specification that include the full set of controls, post-MBIS households paid 46 percent more to renovate their buildings. Because these none of these households faced a deadline to get their renovation done, the premium the post-MBIS households paid is likely to be driven by bid rigging. But why the post-MBIS households face a less elastic demand for renovating their buildings when they were not mandated to do so? We do not think the increase in demand for renovation and hence the construction costs alone can explain the sudden increase in renovation price, because we do control for the cost of construction, and building renovation is only a part of the construction sector in Hong Kong. One possibility is that some non-MBIS households might now have higher incentive to renovate earlier to avoid receiving an MBIS notice. To the extent that there are fixed costs for contractors in forming a bid-rigging syndicate, there will be spillover when collusion becomes more profitable when some households are mandated to renovate. Our case study indeed revealed that the same middleman can participate in different renovation projects. Moreover, when a few bid-rigging syndicates become the dominant firm in the renovation market, other contractors may as well set their prices as price-followers.

When we include both $MBISNotice$ and $PostMBIS$ dummies (Table 5), the spillover effect of the MBIS is still positive and statistically significant in most specifications, but its magnitude is smaller than the specifications when we do not control for $MBISNotice$. With the full set of controls, the cost of renovation per household increased by HKD49,608 (USD6,360), or 41.86 percent, after the implementation of the MBIS. In addition to this, we find that the effect

of the MBIS on buildings that did receive an MBIS notice is more pronounced. While the estimates of the $MBISNotice$ dummy are not statistically significant due to the small sample size, it is important to note that the cost difference between buildings with and without notice is economically significant. Households in buildings that received an MBIS notice had to pay an extra of HKD28,205 (USD3,616), or 25.48 percent, compared to other buildings after the implementation of the MBIS.

Some owners are more prone to bid rigging than others. We divided our sample into subsamples by buildings' characteristics (housing price) or owners' demographics (income and education). We then re-estimated the main specifications on the subsamples. Table 6 suggests that the post-MBIS renovation cost is higher for more expensive buildings (columns 1 and 2), higher income owners (columns 3 and 4), and more educated owners (columns 5 and 6) who might have higher time cost in monitoring the tender process, though the results are not statistically significant.

We conduct a placebo test by moving the cutoff year from 2012 to the year before and the year after. We consider the following regressions:

$$Y_{it} = \gamma_0 Post2011_{it} + X_{it}'\gamma_1 + \gamma_2 Trend_t + \gamma_3 Cost_t + \epsilon_{it},$$

and

$$Y_{it} = \gamma_0 Post2013_{it} + X_{it}'\gamma_1 + \gamma_2 Trend_t + \gamma_3 Cost_t + \epsilon_{it},$$

where the only difference from the main regression is that we replace $PostMBIS$ with $Post2011$ and $Post2013$. Table 7 shows that the estimates for $Post2011$ and $Post2013$ are almost always statistically insignificant and much smaller in magnitude. The only specification that yields a statistically significant result is that when no other controls are included in 2011, but the coefficient becomes insignificant once other controls are included.

4.4 Further evidence on collusion

Tables 4-6 show that the effect of the MBIS is not limited to buildings that received notice. One might argue that the increase in demand inelasticity could explain the increase in overall renovation cost, even in the absence of bid rigging. However, the magnitude of the

increase in the cost (more than 40%) is too large to be explained by the increase in demand inelasticity alone. In addition to analyzing the effect of the MBIS on the overall cost of renovation, we also test if the bidding behavior of construction contractors had changed after the MBIS. We follow Bajari and Summers (2002) and Bajari and Ye (2003) to test if the conditional independence condition holds before and after the MBIS.

Conditional independence implies that, once we have controlled for information about costs that is publicly available to all bidders, the bids should not be correlated. The intuition behind is simple: if there is no collusion, each firm would estimate the cost of the project independently, and therefore the bid, after controlling for publicly available information, should be independent as well.

We first estimate the following regression:

$$Y_{ijt} = \beta_{0,i} + X'_{it}\beta_{1,j} + \beta_2 Trend_t + \epsilon_{ijt},$$

where Y_{ijt} is the natural log of the bid from bidder j to tender in building i at time t, $X'_{it}, Trend_t$ are buildings' characteristics and time trend, and $\beta_{0,i}$ is a building fixed effect that captures other unobservable building characteristics that may affect renovation costs and thus bid prices of building i. The subscript j takes one of the five values, where 1 to 4 indicates the 4 most active bidders in the sample, and 5 indicates other bidders. To test for conditional independence of firm j's bid and firm k's bid, we test whether the correlation between the residuals of the bid functions for the two firms, ϵ_{ijt} and ϵ_{ikt}, is zero. We perform this test for the 4 most active bidders before and after the implementation of the MBIS.

The results for the conditional independence test are reported in Table 8. We find that the bids of the most active bidders, even after controlling for observables, became more correlated after the MBIS. The upper panel shows the correlation of the bid residuals for the 4 most active bidders before the MBIS, and the lower panel shows their correlations after the MBIS. Before the MBIS, only two firm-pairs (firm 2 and firm 3), and (firm 3 and firm 4) have significantly correlated bid residuals. However, the number of firm pairs with significantly correlated bid residuals increased to 5. The only pair of firms which did not have significantly correlated bid is

(firm 1 and firm 2). Also, the magnitude of correlation increased after the MBIS for most of the firm-pairs, though the correlation of only one pair of firms (firm 2 and firm 4) has statistically significant difference.

5. Conclusion

Thanks to some unique data and a drastic change in housing regulations, we are able to look at the rarely studied issue of collusion in private procurement in this paper. We have shown that there are economically and statistically significant differences in price and bidding behavior between buildings that received MBIS notice and buildings that did not, and also between buildings that conduct the tender process for renovation before and after the MBIS. One possible extension is to collect data on renovation projects prior to 2009 and analyze whether the MBIS encouraged the firms to begin rigging bids or merely exacerbated the bid rigging arrangement already in place.

References

Abrantes-Metz, Rosa M., Luke M. Froeb, John Geweke, and Christopher T. Taylor. 2006. "A Variance Screen for Collusion." *International Journal of Industrial Organization* 24 (3): 467-486.

Akee, Randall. 2009. "Checkerboards and Coase: The Effect of Property Institutions on Efficiency in Housing Markets." *Journal of Law and Economics* 52: 395-410.

Bajari, Patrick, and Garrett Summers. 2002. "Detecting Collusion in Procurement Auctions." *Antitrust Law Journal* 70 (1): 143-170.

Bajari, Patrick, and Lixin Ye. 2003. "Deciding Between Competition and Collusion." *Review of Economics and Statistics* 85 (4): 971-989.

Clark, Robert, and Jean-Francois Houde. 2014. "The Effect of Explicit Communication on Pricing: Evidence from the Collapse of a Gasoline Cartel." *Journal of Industrial Economics* 62 (2): 191-228.

Erutku, Can, and Vincent A. Hildebrand. 2010. "Consipiracy at the Pump." *Journal of Law & Economics* 53 (1): 223-237.

Froeb, Luke M., Robert A. Koyak, and Gregory J. Werden. 1993. "What is the Effect of Bid-Rigging on Prices?" *Economics Letters* 42: 419-423.

Funderburk, Dale R. 1974. "Price Fixing in the Liquid-Asphalt Industry: Economics Analysis versus the 'Hot Document'." *Antitrust Law and Economics Review* 7: 61-74.

Glaeser, Edward L., Joseph Gyourko, and Raven Saks. 2005. "Why is Manhattan So Expensive? Regulation and the Rise in Housing Prices." *Journal of Law and Economics* 48: 331-369.

Gyourko, Joseph, and Raven Molloy. 2015. "Regulation and Housing Supply." *Handbook of Regional and Urban Economics* 5: 1289-1337.

Gyourko, Joseph, Christopher Mayer, and Todd Sinai. 2013. "Superstar Cities." *American Economic Journal: Economic Policy* 5 (4): 167-199.

Harrington, Jr., Joseph E. 2005. "Detecting Cartels." *working paper* .

Hay, George A., and Daniel Kelley. 1974. "An Empirical Survey of Price Fixing Consipiracies." *Journal of Law & Economics* 17 (1): 13-38.

Heckman, James J. 1997. "Instrumental variables – a study of the implicit behavioral assumptionsused in making program evaluations." *Journal of Human Resources* 32 (3): 441-462.

Hong Kong Competition Commission. 2016. *Report on Study into Aspects of the Market for Residential Building Renovation and Maintenance.* Research Report, Hong Kong: Hong Kong Competition Commission.

Huang, Haifang, and Yao Tang. 2012. "Residential land us regulation and the US housing price cycle between 2000 and 2009." *Journal of Urban Economics* 71: 93-99.

Ihlandfeldt, Keith R. 2007. "The effect of land use regulation on housing and land prices." *Journal of Urban Economics* 61: 420-435.

Katz, Lawrence, and Kenneth Rosen. 1987. "The Interjurisdictional Effects of Growth Controls on Housing Prices." *Journal of Law and Economics* 30: 149-160.

Levenstein, Margaret C., and Valerie Y. Suslow. 2001. "Private International Cartels and Their Effect on Developing Countries." *working paper* .

Levenstein, Margaret C., and Valerie Y. Suslow. 2006. "What Determines Cartel Success?" *Journal of Economic Literature* 44: 43-95.

Porter, Robert H., and J. Douglas Zona. 1993. "Detection of Bid Rigging in Procurement Auctions." *Journal of Political Economy* 101 (3): 518-538.

Porter, Robert H., and J. Douglas Zona. 1999. "Ohio School Milk Markets: An Analysis of Bidding." *The RAND Journal of Economics* 30 (2): 263-288.
Quigley, John, and Steven Raphael. 2005. "Regulation and the High Cost of Housing in California." *American Economic Review* 95 (2): 323-328.
Stigler, George J. 1964. "A Theory of Oligopoly." *Journal of Political Economy* 72 (1): 44-61.
Zona, J. Douglas. 2011. "Structural Approaches to Estimating Overcharges in Price-Fixing Cases." *Antitrust Law Journal* 77 (2): 473-494.

Table 1: Summary Statistics

	On or before 2012	After 2012	With MBIS Notice	Without MBIS Notice	Whole Sample
Bid per Household	90,948 (69,306)	144,397 (121,866)	162,132 (116,765)	109,238 (97,928)	118,241 (102,878)
Number of Bids	9.26 (4.21)	11.21 (6.98)	9.42 (5.52)	10.43 (5.92)	10.26 (5.85)
MBIS Notice	0 (0)	0.33 (0.47)	1	0	0.17 (0.38)
Number of Units	191.67 (405.19)	266.14 (559.15)	186.79 (292.84)	238.50 (521.37)	229.70 (489.59)
Building Age	39.90 (10.03)	38.85 (10.53)	37.46 (10.09)	39.75 (10.30)	39.36 (10.26)
Facility (Mall)	0.10 (0.30)	0.21 (0.41)	0.29 (0.46)	0.13 (0.34)	0.16 (0.36)
Facility (Club)	0.03 (0.17)	0.08 (0.28)	0.08 (0.28)	0.05 (0.22)	0.06 (0.23)
New Territories	0.16 (0.37)	0.19 (0.40)	0.17 (0.38)	0.18 (0.39)	0.18 (0.38)
Kowloon	0.35 (0.48)	0.33 (0.47)	0.5 (0.51)	0.31 (0.46)	0.34 (0.48)
Hong Kong Island	0.49 (0.50)	0.47 (0.50)	0.33 (0.48)	0.51 (0.50)	0.48 (0.50)
Housing Price 2016	10,628 (3,168)	11,252 (3,507)	11,644 (3,427)	10,795 (3,325)	10,943 (3,342)
Median Income	24,861 (16,116)	26,067 (16,965)	26,735 (11,846)	25,219 (17,339)	25,477 (16,507)
College Attainment	0.29 (0.12)	0.31 (0.14)	0.34 (0.13)	0.29 (0.13)	0.30 (0.12)
N	69	72	24	117	141

Note: Standard deviations in parenthesis.

Table 2: Simultaneous Bids by the Most Active Firms on Buildings' Tenders

	Pre-MBIS			
	Firm 1	Firm 2	Firm 3	Firm 4
Firm 1	37	19	22	22
Firm 2	19	28	16	15
Firm 3	22	16	35	23
Firm 4	22	15	23	34
	Post-MBIS			
	Firm 1	Firm 2	Firm 3	Firm 4
Firm 1	47	29	25	26
Firm 2	29	36	19	19
Firm 3	25	19	38	23
Firm 4	26	19	23	36

Table 3: Effect of Receiving the MBIS Notice on Housing Complex Renovation Prices from Propensity Score Matching Estimation (log)

	(1)	(2)	(3)	(4)
MBIS Notice (ATE)		0.4226*	0.4773**	0.4424**
		(0.2263)	(0.1912)	(0.1813)
MBIS Notice (ATT)		0.3162	0.4634*	0.4150
		(0.2092)	(0.2815)	(0.2815)
MBIS Notice	0.2538			
	(0.2279)			
		Treatment Model Controls		
Housing Complex Attributes	Yes	Yes	Yes	Yes
Construction Cost Index	Yes	No	Yes	Yes
Time Trend	Yes	No	No	Yes
Sample	Post MBIS	Post MBIS	Post MBIS	Post MBIS
Treatment Model		Logit	Logit	Logit
N	72	72	72	72

Note: Column 1 reports the OLS result, with the full set of controls. For columns 2 to 4, ATE stands for average treatment effect and ATT stands for average treatment effect for the treated. Standard errors in parenthesis.

Table 4: Effect of the MBIS on Housing Complex Renovation Prices (log) (No MBIS Notice Sample)

	(1)	(2)	(3)	(4)
Post MBIS	0.2880*	0.3539**	0.2758*	0.4559*
	(0.1655)	(0.1443)	(0.1609)	(0.2598)
Housing Complex Attributes	No	Yes	Yes	Yes
Time Trend	No	No	No	Yes
Construction Cost Index	No	No	Yes	Yes
Adjusted R^2	0.0170	0.2652	0.2665	0.2632
N		117		

Note: Standard errors in parenthesis.

Table 5: Effect of the MBIS and Receiving the Notice on Housing Complex Renovation Prices (log)

	(1)	(2)	(3)	(4)
Post MBIS	0.2880*	0.3680**	0.3074*	0.4186*
	(0.1639)	(0.1474)	(0.1634)	(0.2386)
MBIS Notice	0.2411	0.2258	0.2092	0.2548
	(0.2187)	(0.2004)	(0.2015)	(0.2040)
Housing Complex Attributes	No	Yes	Yes	Yes
Time Trend	No	No	No	Yes
Construction Cost Index	No	No	Yes	Yes
Adjusted R^2	0.0376	0.2364	0.2349	0.2380
N		141		

Note: Standard errors in parenthesis.

Table 6: Effect of the MBIS on Housing Complex Renovation Prices (log) for Sub-Groups

	Housing Price		Income		Education	
	High	Low	High	Low	High	Low
Post MBIS	0.4103	-0.1086	0.7187*	0.0751	0.4078	0.1158
	(0.4133)	(0.6066)	(0.4314)	(0.2170)	(0.3858)	(0.2860)
Housing Complex Attributes	Yes	Yes	Yes	Yes	Yes	Yes
Time Trend	Yes	Yes	Yes	Yes	Yes	Yes
Construction Cost Index	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.1395	0.3381	0.2053	0.3621	0.0658	0.5148
N	51	52	70	71	71	70

Note: The sample grouped by house price is smaller due to missing price data. Standard errors in parenthesis.

Table 7: Placebo Test (Dependent Variable: Natural Log of Winning Bid per Unit)

	2011			2013		
Post 2011/2013	0.3170*	0.0996	0.0637	0.0127	-0.1548	-0.1587
	(0.1624)	(0.2138)	(0.2173)	(0.1818)	(0.3431)	(0.3431)
Housing Complex Attributes	No	Yes	Yes	No	Yes	Yes
Time Trend	No	Yes	Yes	No	Yes	Yes
Construction Cost Index	No	No	Yes	No	No	Yes
Adjusted R^2	0.0196	0.2137	0.2129	-0.0071	0.2136	0.2137
N	141			141		

Note: Standard errors in parenthesis.

Table 8: Correlation of Bid Residuals for the 4 Most Active Firms

	Pre-MBIS			
	Firm 1	Firm 2	Firm 3	Firm 4
Firm 1	1.000			
Firm 2	0.1710	1.000		
Firm 3	0.2203	0.7446*	1.000	
Firm 4	0.3254	0.1900	0.4687*	1.000
	Post-MBIS			
	Firm 1	Firm 2	Firm 3	Firm 4
Firm 1	1.000			
Firm 2	0.1820	1.000		
Firm 3	0.4097*	0.4768*	1.000	
Firm 4	0.4161*	0.6243*	0.4837*	1.000

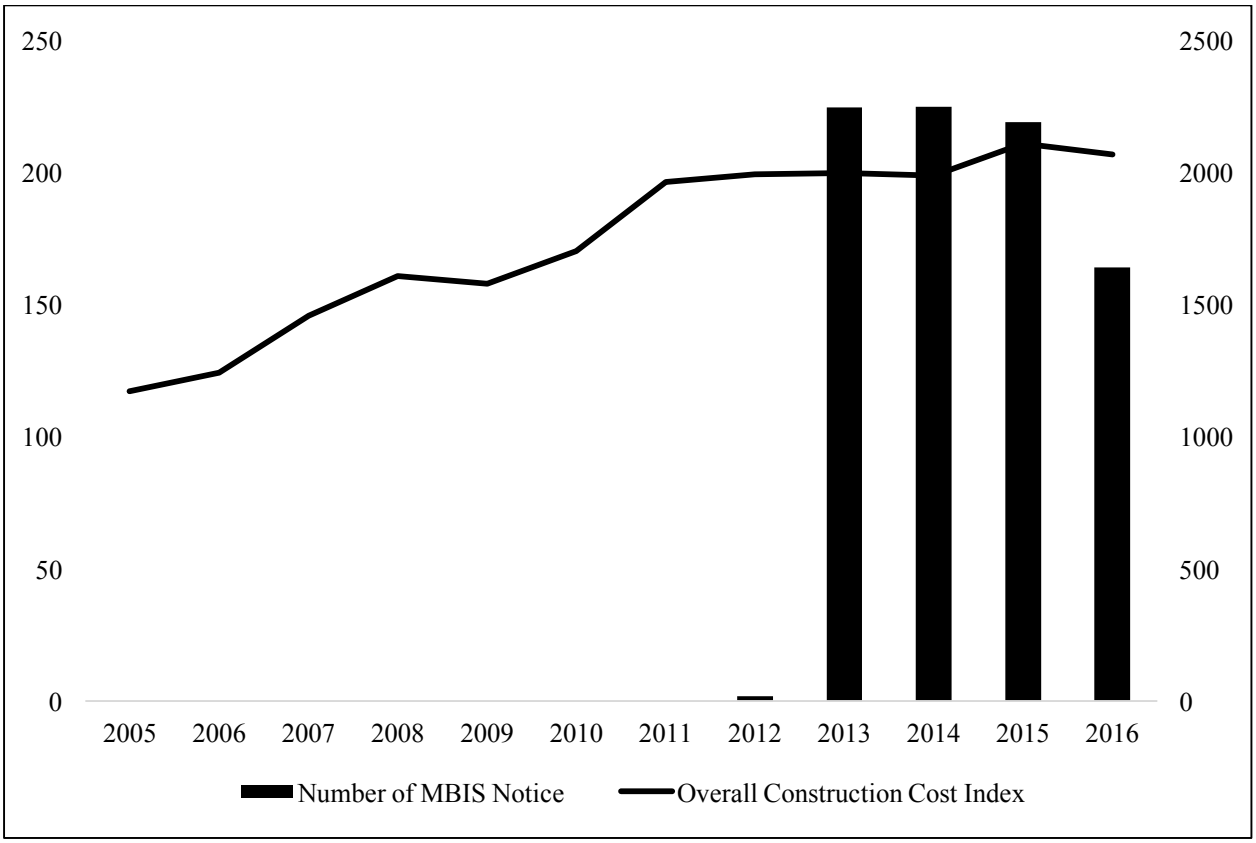
Note: * indicates 5% significance level. The four firms (names withheld) are the most active participants in the market.

Table 9: Effect of the MBIS Notice on Housing Complex Renovation Prices (log)

	(1)	(2)	(3)	(4)
MBIS Notice	0.4458**	0.2128	0.2782	0.2538
	(0.1836)	(0.2265)	(0.2239)	(0.2279)
Housing Complex Attributes	Yes	Yes	Yes	Yes
Time Trend	No	No	No	Yes
Construction Cost Index	No	No	Yes	Yes
Sample	Whole	Post MBIS	Post MBIS	Post MBIS
Adjusted R^2	0.2061	0.1835	0.2200	0.2073
N	141	72	72	72

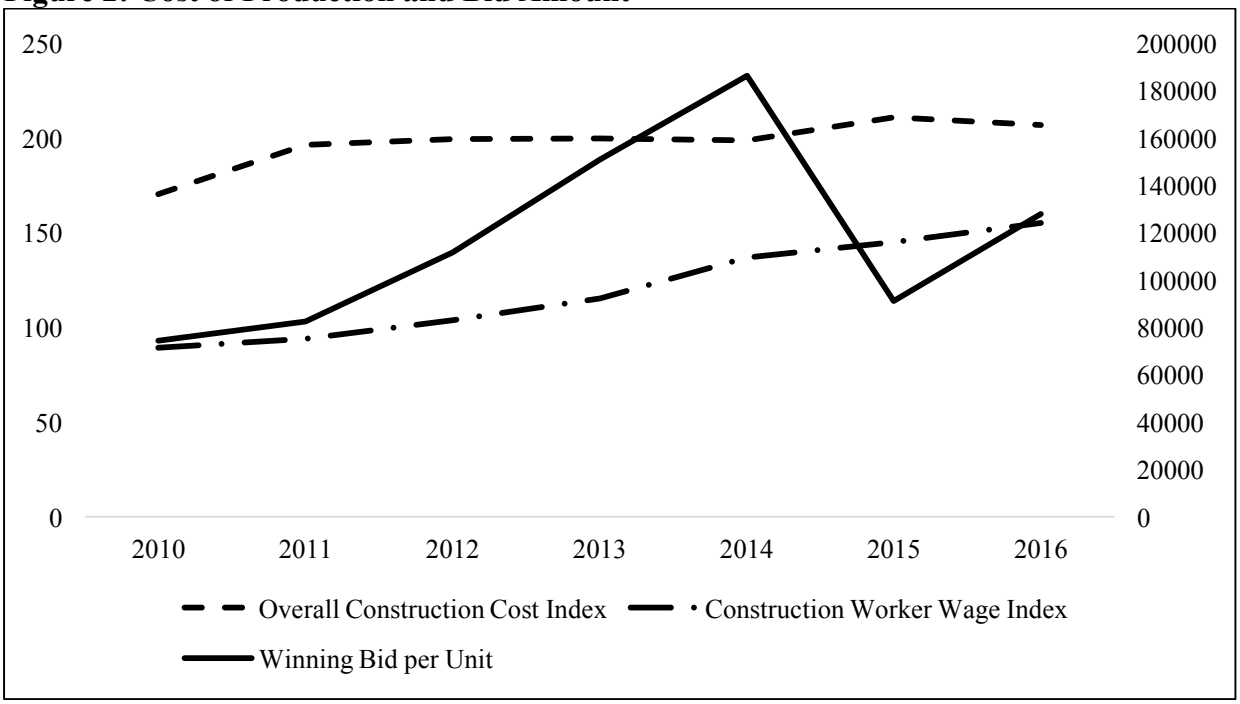
Note: Standard errors in parenthesis.

Figure 1: Cost of Production and Number of MBIS Notice



Note: There are several things to note. First, the MBIS notices were issued to buildings of all types, including residential, commercial, industrial, and educational buildings. Second, a housing Complex with multiple buildings might get multiple notices from the Buildings Department. Third, there were 19 MBIS notices in 2012, all of them issued after November.

Figure 2: Cost of Production and Bid Amount



Appendix: Additional Results

Table A1: Effect of Receiving the MBIS Notice on Housing Complex Renovation Prices (Dependent Variable: Winning Bid per Unit)

	(1)	(2)	(3)	(4)
MBIS Notice	49,417**	53,687**	44,530*	33,978
	(23,885)	(23,548)	(24,573)	(26,336)
Housing Complex Attributes	No	Yes	Yes	Yes
Time Trend	No	No	No	Yes
Construction Cost Index	No	No	Yes	Yes
Adjusted R^2	0.0227	0.0400	0.0444	0.0495
N	141			

Note: Standard errors in parenthesis.

Table A2: Effect of the MBIS on Housing Complex Renovation Prices (Dependent Variable: Winning Bid per Unit)

	(1)	(2)	(3)	(4)
Post MBIS	47,327***	55,041***	51,620***	54,097*
	(17,730)	(16,991)	(19,656)	(30,629)
Housing Complex Attributes	No	Yes	Yes	Yes
Time Trend	No	No	No	Yes
Construction Cost Index	No	No	Yes	Yes
Adjusted R^2	0.0416	0.0756	0.0695	0.0599
N	141			

Note: Standard errors in parenthesis.

Table A3: Effect of the MBIS and Receiving the Notice on Housing Complex Renovation Prices (Dependent Variable: Winning Bid per Unit)

	(1)	(2)	(3)	(4)
Post MBIS	38,460*	46,714**	44,407**	49,608
	(19,794)	(18,917)	(21,022)	(30,900)
MBIS Notice	26,602	25,764	25,131	28,205
	(26406)	(25,724)	(25,936)	(26,422)
Housing Complex Attributes	No	Yes	Yes	Yes
Time Trend	No	No	No	Yes
Construction Cost Index	No	No	Yes	Yes
Adjusted R^2	0.0417	0.0757	0.0690	0.0610
N		141		

Note: Standard errors in parenthesis.

Table A4: Effect of the MBIS on Housing Complex Renovation Prices for Sub-Groups (Dependent Variable: Winning Bid per Unit)

	Housing Price		Income		Education	
	High	Low	High	Low	High	Low
Post MBIS	72,180	-33,321	78,948	10,372	80,275	12,046
	(55,486)	(45,119)	(55,780)	(27,261)	(59,119)	(27,996)
Housing Complex Attributes	Yes	Yes	Yes	Yes	Yes	Yes
Time Trend	Yes	Yes	Yes	Yes	Yes	Yes
Construction Cost Index	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.0311	0.0227	0.0078	0.1863	0.0194	0.2210
N	51	52	70	71	71	70

Note: Standard errors in parenthesis. The sample grouped by house price is smaller due to missing price data.

Table A5: Placebo Test (Dependent Variable: Winning Bid per Unit)

	2011			2013		
Post 2011/2013	51,676***	30,700	25,797	12,464	-37,712	-38,295
	(19,425)	(27,504)	(27,943)	(21,972)	(44,221)	(44,155)
Housing Complex Attributes	No	Yes	Yes	No	Yes	Yes
Time Trend	No	Yes	Yes	No	Yes	Yes
Construction Cost Index	No	No	Yes	No	No	Yes
Adjusted R^2	0.0413	0.0436	0.0435	-0.0048	0.0398	0.0428
N	141					

Note: Standard errors in parenthesis.