Real Estate Boom and Misallocation of Capital in China[*]

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Abstract

We analyze how the ongoing real estate boom in China affects firm investment and efficiency of capital allocation. In addition to the widely documented *collateral channel*, we also uncover two other channels: *the speculation channel*—rapidly rising commercial and residential land prices induce land-holding firms, which have access to financing, to buy more land and reduce other investments and innovation activities; and *the crowding out channel*—in response to rising land prices, banks grant more credit to land-holding firms, crowding out financing to non-land-holding firms. Netting out these channels, a 100-percent increase in commercial land prices leads to an estimated loss of 9.0 percent to aggregate TFP due to misallocation of capital. Our findings caution a widely-held view that real estate booms help to mitigate firms' financing constraints and thus boost the economy by stimulating firm investment.

Keywords: Land Prices, Collateral Channel, Speculation Channel, Crowding Out Channel, Misallocation of Capital

JEL Codes: E44, G21, G31

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It is widely acknowledged that the collapse of the real estate market in mid 2000s triggered the Great Recession in the U.S. and the bursting of the real estate bubble in the early 1990s was a primary culprit of the prolonged stagnation in Japan. Understanding the effects of real estate price fluctuations on firm and household behavior is thus important for understanding long run economic growth and business cycles, e.g., Liu, Wang and Zha (2012), Mian and Sufi (2014), and Kaplan, Mitman, and Violante (2017). It also has important policy implications on how government should restrain real estate bubbles and intervene during real estate cycles.

The literature has documented ample evidence regarding an important collateral channel, through which rising real estate prices affect firm investment by mitigating financial constraints faced by firms. Gan (2007) shows that in Japan after the burst of its real estate bubble in the early 1990s, land-holding firms reduced investment more than non-land-holding firms. Chaney, Sraer and Thesmar (2012) find that in 1993-2007, a representative U.S. firm invested 6 cents in response to a one-dollar increase in its land collateral. Real estate price fluctuations may also affect allocation of capital across firms and the composition of firm investment through two other channels. First, an increase in real estate prices may induce firms, particularly firms with land holdings and thus access to financing, to speculate on future real estate price appreciation at the expense of their other investments, which we call a "*speculation channel*."[1] Second, in response to an increase in real estate prices, banks may grant more credit to land-holding firms, crowding out credit to firms without land holdings, which we call a "*crowding out channel*."[2] Through these channels, a real estate boom may have complex and nuanced effects on different firms—it can not only boost the aggregate investment by relaxing financial constraints of land-holding firms, but also affect the composition of firm investment by inducing land-holding firms to invest more to real estate and crowding out bank financing of non-land-holding firms.

In this paper, we use China's real estate market as a laboratory to systematically examine these channels for real estate shocks to affect firm investment. China provides a unique setting for this

[1] Miao and Wang (2014) argue that a bubble in one sector attracts more capital to be allocated to the sector, and crowds out investment in other sectors. Chen and Wen (2014) build a model to analyze how a self-fulfilling housing bubble can create severe resource misallocation to the housing sector.

[2] Bleck and Liu (2014) emphasize that banks allocate more credit to firms in the bubble sector and less to firms in other sectors. Chakraborty, Goldstein and MacKinlay (2014) provide evidence for a crowding out effect during the recent U.S. housing bubble—when U.S. banks made more mortgage lending, they decreased commercial lending.

purpose due to several reasons. First, investment in the real estate sector has become a crucial part of the Chinese economy, directly accounting for 14% of China's GDP in 2013 and further driving investments in a wide range of peripheral firms. Second, China has experienced rapid housing price appreciations, averaging nearly 400% across the country from 2003 to 2013 according to Fang et al. (2015). This dramatic real estate boom puts the potential effects of real estate shocks under a magnifying lens. Third, there is also substantial heterogeneity in the real estate boom experienced by different types of land in different cities, offering a rich cross-section for analyzing effects of the real estate boom.

By hand-collecting 1.65 million land transactions in 284 cities in China from 2000 to 2015 and by matching the land transaction data with publicly listed manufacturing and service firms in mainland China, we examine the three aforementioned channels for real estate shocks to affect firm investment. Each parcel of land in China is restricted by the local government to be used for exclusive purposes: industrial land designed for industrial and manufacturing facilities, commercial land for commercial and business facilities, and residential land for residential facilities. Due to the rapid demands for commercial and residential facilities during China's urbanization process, commercial land and residential land have experienced substantially more dramatic price appreciations than industrial land. Interestingly, while commercial and residential land cannot be directly used for developing regular businesses of the firms in our sample, they have been actively involved in acquiring commercial and residential land—contributing to over 19% of their gross investments in the sample period.

In our analysis, we first construct a set of land price indices for each city, separately for commercial land, residential land, and industrial land, based on the observed land transaction prices. We first treat land price fluctuations as exogenous and analyze how land price fluctuations affect the investment of each individual firm, with a particular focus on comparing the investments of land-holding and non-land-holding firms. We uncover several interesting findings. First, increases in land value lead to a significant increase in gross investment of land-holding firms, which is consistent with the existing evidence for the collateral channel documented by Gan (2007) and Chaney, Sraer, and Thesmar (2012). We also find an interesting order in the magnitude of this collateral effect, strongest for commercial land, followed by residential land, and weakest for industrial land. This order is also accompanied by the same pattern in the loan-to-value ratio of bank loans collateralized by the three types of land, which indicates banks' collateral preference.

More importantly, by decomposing firm investment into four components, non-land investment, industrial land investment, residential land investment, and commercial land investment, we find strong evidence for both the speculation channel and the crowding out channel. In response to price appreciations of commercial (or residential) land in its headquarter city, a land-holding firm in our sample tends to increase commercial (or residential) land investment, and this effect is particularly strong for firms holding more land and thus having more access to financing. Surprisingly, despite the improved access of land-holding firms to bank financing after land price appreciations, they nevertheless reduce non-land investments, including R&D expenditure and patent applications, to pursue land speculation. This sharp contrast highlights the speculation effect induced by the real estate boom. We also find that the improved bank financing to land-holding firms comes at the expense of reduced bank financing to non-land-holding firms. Consequently, in response to price appreciations of commercial land and residential land, non-land-holding firms substantially decrease investments and innovation activities, as posited by the crowding out effect.

The usual endogeneity arguments that real estate shocks are potentially correlated with firms' investment opportunities and that land-holding firms have better investment opportunities than non-land-holding firms cannot explain our findings. The former argument implies that both land-holding and non-land-holding firms should increase their non-land investments in response to a real estate boom. While the second argument explains the reduced investments of non-land-holding firms, it makes our finding of reduced non-land investments of land-holding firms even more puzzling. Interestingly, a direct comparison reveals that land-holding firms tend to have lower Tobin's Q and TFPs than non-land-holding firms, further invalidating the second argument.

A more concerning argument is that the government's credit policy, in particular the massive economic stimulus in 2008-2010 might have caused banks to grant excessive loans to inefficient state-owned enterprises (SOEs), which in turn used the funding to speculate on land prices, exacerbating the real estate boom. To address this reverse causality argument, we further employ a difference-in-difference (DID) approach to analyze a quasi-policy experiment in 2010-2011 when 46 cities adopted a housing purchase restriction policy of limiting investment home purchases. This policy generated a negative shock to housing demand and prices of both residential and commercial land prices in the treatment cities relative to the control cities, without any change in the government's credit policy across these cities. The DID analysis reveals that the policy shock led to significant reversal of the aforementioned effects of the real estate boom, strongly supporting the three channels we emphasize.

Due to these three channels, the real estate boom has profound impacts on resource allocation across firms in China. While the real estate boom stimulates firm investment through the collateral channel, it may distort capital allocation in the economy through the speculation and crowding out channels. The rising land prices tend to enlarge the gaps in financial constraints faced by firms with and without land holdings. Furthermore, even for land-holding firms, rising land prices induce them to pursue more land speculation rather than developing their regular businesses. This strategy has been highly profitable during our sample period, and is rationalizable for an individual firm that pursues it. However, such land speculation by firms in aggregate exacerbates inefficient resource allocation of the overall economy.

Motivated by these arguments, we further analyze the impact of the real estate boom on capital misallocation in China. We adopt the measure of capital misallocation proposed by Hsieh and Klenow (2009). Specifically, we treat each city in our sample as a closed economy and measure the aggregate TFP losses of 47 manufacturing sectors in each city relative to the TFP computed from the optimal resource allocation predicted by a structural model. We show that a 100-percent increase in commercial land prices is associated with an estimated loss of 9.0% in aggregate TFP due to misallocation of capital. Given that commercial land prices on average increased more than 6 times from 2000 to 2015, the distortion generated by the real estate boom on the efficiency of capital allocation is substantial.

The paper is organized as follows. Section I introduces the institutional background of China's real estate market and summarize the key data used in our analysis. We describe the empirical hypotheses in Section II and present the empirical results in Section III. Section IV analyzes the impact on resource misallocation. Section V concludes the paper.

I. Institutional Background and Data Summary

Ever since the real estate market reform in 1990s, there has been an enormous real estate boom in China. The government's economic stimulus program of 4 trillion RMB in 2009 against the Global Financial Crisis further fueled the surge in real estate prices. Fang et al. (2015), Wu et al. (2016), and Glaeser et al. (2017) provide detailed account of this real estate boom. This section provides background information regarding this real estate boom and summary statistics related to land prices and firm investment during this boom.

Land Transactions

With China's rapid economic development since the 1980s, Chinese cities gradually sprawled out beyond their original limits, and there was growing demand to "urbanize" more rural land for the city expansion. By constitution, all land in China belongs to the state. In 1998, the 15th National Congress of the Communist Party of China passed a statutory bill granting local governments the *de jure* ownership over land in their geographical jurisdictions (Lin and Ho, 2005; Kung, Xu and Zhou, 2013). The related Land Management Law (1998) also authorizes local government to sell the usufruct right for up to 70 years over the land in their jurisdictions. The land transactions between local governments and private buyers constitute the primary land market. Those private buyers who obtain the usufruct right through a leasehold from local governments can also choose to sell the leasehold to a third party in the secondary land market. However, compared to the primary land market, the size of the secondary land market only accounts for 3.75% of all land transactions in terms of payment from 2000 to 2015. Our study analyzes land purchases by publicly listed firms during this period in both primary and secondary land markets.

There are rigid zoning restrictions confining each parcel of urban land to specific usages.[3] Our analysis focuses on three types of land, which are frequently acquired by firms in our sample: industrial land designated for industrial and manufacturing facilities, commercial land for commercial and business facilities, and residential land for residential facilities. The local government first assigns the usage category to each parcel of land in its annual land development

[3] The Chinese Land Management Law classifies urban land to non-development land and development land, with the latter being further divided into specific usages such as residential (R), administration and public services (A), commercial and business facilities (B), industrial and manufacturing (M), logistics and warehouse (W), road, street and transportation (S), municipal utilities (U), green space and square (G), and so on.

plan, and then sells a leasehold written on the land to private parties.[4] It is difficult for the buyer to change the usage category after acquiring the land from the primary land market.[5] As a result, when a manufacturing firm acquires a parcel of either commercial or residential land, it cannot use the land for developing its regular business. Instead, the purpose of acquiring the land is either for direct speculation of future price appreciation or for profits from selling commercial or residential units after developing commercial or residential buildings on the land. In both cases, the firm aims to profit from the continued real estate boom. This consideration motivates us to examine purchases of commercial and residential land made by manufacturing firms, separately from their purchases of industrial land. Interestingly, many manufacturing firms were heavily involved in acquiring commercial and residential land in recent years.

Our land holding data come from the Ministry of Land and Resources, which keeps record of all land transactions in China. We first obtain a complete land transaction dataset covering all 2.42 million land transactions between 2000 and 2015 in 284 cities across the whole country from the website of the Land Transaction Monitoring System maintained by the Ministry (http://www.landchina.com/). This dataset contains detailed information on land buyers, land area, total payment, land usage, location, and transaction prices.

Figure 1 depicts the total size of China's primary land market in terms of both total land payment (upper panel) and total area (lower panel) for each year in 2000-2015, separated into the three categories of land. Land sales by local governments gradually rose in the first half of this period, with sharp rises in 2009 and 2010, which were stipulated by financial pressure faced by local governments across China to implement the massive economic stimulus mandated by the central government.[6] Land sales eventually peaked in 2013 with a total revenue of over 4 trillion

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[4] According to the Land Management Law, the typical lease term is 70 years for residential usage, 40 years for commercial usage and 30 years for industrial usage. The leasehold sales can take the form of open auctions or case-by-case negotiation. To restrain corruption in the primary land market, in 2002 the Ministry of Land and Resource issued the No. 11 regulation "Regulation on the Transaction Method of Leasehold Sale of Land by Local Government", which requires leasehold sales for commercial and residential developments should use open auctions. Some argue that the mandatory open auctions of commercial and residential land further fueled the skyrocketing increase of the land price (Cai et al., 2009).

[5] According to the Land Administration Law published in 1998, to change the usage category requires permission from both the local government and the Bureau of Real Estate Administration in the central government.

[6] In response to the disruption of the world financial crisis, the central government in China promptly announced in November 2008 an economic stimulus program, which contained investment projects of 4 trillion RMB (12.5% of China's GDP at the time). The central government funded only 1.18 trillion RMB of this massive investment program,

RMB, and then dropped in 2014 and 2015 to slightly below 3 trillion RMB. Among the three types of land, residential land contributed most to the sale revenue, followed by commercial land, and industrial land. In terms of area of sales, industrial land was the largest, followed by residential land, and commercial land. As we will discuss later, this difference in order is due to the fact that industrial land tends to be substantially cheaper than commercial land and residential land.

We match the land transactions with all publicly listed firms (including their subsidiaries). In total, we find 72,763 land transactions by 2,174 firms publicly listed in China. The total area of land involved in these transactions is 3,488,076,032 square meters, and the total payment is 3427.69 billion RMB (which is equal to 536.37 billion US dollars at an exchange rate of 6.387 RMB/dollar), accounting for 12.37% of the total land sale revenue during this period.

Land Price Indices

To separately estimate price fluctuations and values of commercial, residential, and industrial land parcels held by firms, we construct three sets of price indices for each of the 284 prefectural cities in our sample, covering commercial land, residential land, and industrial land, respectively. Following Deng, Gyourko and Wu (2012), we adopt the hedonic price regression approach to generate a set of quality-free land price indices for each city by running the following regression on the sample of publicly auctioned land parcels of type k (commercial, residential, or industrial) in the city: [7]

$$lnP_{i,k,c,t} = \beta_{k,c,0} + \sum_{s=1}^{T} \beta_{k,c,s} \cdot 1_{s=t} + \theta_{k,c} X_i + \varepsilon_{i,t},$$

where $lnP_{i,k,c,t}$ is the logged price of land parcel i in the sample of type-k land transactions in year t in city c, $\beta_{k,c,t}$ is the time dummy for year t capturing the quality-free land price appreciation

with the rest financed by local governments and banks. Revenues from land sales are a key source of financing for local governments.

[7] We also follow Deng, Gyourko and Wu (2012) to use land parcels sold through public auctions (either through listing bidding or English auction). Due to the well-known rent-seeking behavior and the resulting preferential land prices in land transactions through bilateral agreements or by local government financing vehicles, prices in those transactions may not reflect the true market values. We also exclude transactions through invited bidding as it is usually used for public projects and only accounts for a tiny fraction of the total transactions (0.09%).

during the year, the vector X_i is a set of land parcel characteristics to control for the parcel-level heterogeneity, including 1) street/township dummy (9-digit administrative unit); 2) the size of the land parcel; 3) subcategories of land usage (54 types, e.g. public housing); 4) the method of transaction (an indicator for transaction through listing bidding, or English auction); and 5) a subjective evaluation of land quality (20 ranks).[8] To minimize the influence of outliners, we remove observations, for which either per unit land price or size of land parcels is above 95th or below 5th percentile for each city year. In addition, following Deng, Gyourko and Wu (2012), we also remove observations in city-years when there are less than 15 transaction observations. The base year ($t=0$) for each city is the year when we have sufficient transaction observations in our sample. Thus, the price index $LandPriceIndex_{k,c,t}$ for the k-th type of land in year t in city c is simple given by:

$$LandPriceIndex_{k,c,t} = \begin{cases} 1 & if\ t = 0 \\ \exp(\beta_{k,c,t}) & if\ t = 1,2,\ldots \end{cases}$$

We fill in all missing values for years without transaction observations using linear interpolation and extrapolation.

Figure 2 Panel A depicts the appreciations of national land prices for the three categories from 2000 to 2015. The line with circles represents the price index for commercial land by taking the weighted average by the total payment of commercial land transactions across the 284 cities in our sample, the line with crosses the price index for residential land, and line with dots for industrial land. The plot shows that commercial land has experienced an enormous price appreciation from a level of 1 in 2004 to over 6.11 in 2015, residential land has a more moderate, yet nevertheless dramatic, appreciation from a level of 1 to about 4.75 over the same period, while industrial land price remains almost flat from 1 to about 1.5.[9] This substantial price heterogeneity motivates us to separately treat commercial land, residential land, and industrial land in our analysis.

[8] The quality score of each land parcel is rated by the official in charge of the land transaction based on the surrounding infrastructure, e.g. whether the land parcel is in area with supply of water, electricity, and road, etc.

[9] It is a common practice for local governments across China to offer industrial land at low nominal prices to support and stimulate local industries. That is, enterprises can often get industrial land at low costs as incentives to expand their operations in a city. The city government benefits from the increased tax revenue in the future. As a result, industrial land did not experience as much price appreciations as commercial and residential land.

There is also substantial heterogeneity across different cities in the price appreciations of each type of land. Panel B of Figure 2 depicts the magnitude of one standard deviation of land price changes across cities in each year. The plot starts in 2005. The cross-city price variation of commercial land and residential land is mostly above 40% throughout our sample years. The price variation of industrial land is at high levels near 80% in 2006 and 2007 and then comes down to around 20% after 2010. This large cross-city variation allows us to examine how firms in different cities change their investments in response to land price fluctuations.

To further illustrate land price fluctuations in different cities, Figure 3 depicts the land price indices for the three types of land across selected tier-1, tier-2, and tier-3 cities. There are four so-called tier-1 cities in China, namely Beijing, Shanghai, Guangzhou, and Shenzhen, which are the four largest metropolitan centers. The first row of Figure 3 depicts the land price indices of all tier-1 cities in the first panel and each of the four cities in the subsequent four panels. On average, commercial land had greater price appreciations than residential land, which had similar price appreciations as commercial land until a sharp drop occurred in 2011. This drop was due to the housing purchase restriction policy adopted initially by Beijing in April 2010 and then by 45 other large cities in 2010 and 2011. This policy aimed to cool off the soaring residential housing prices in these cities, which in turn caused residential land prices to fall as well. While it is common for industrial land to have small price appreciations in these four cities, commercial land and residential land have followed rather different paths across these cities. Commercial land tends to have substantially smaller price appreciations than residential land in Beijing, opposite to the patterns in the other cities, especially in Shenzhen, where commercial land had steady price appreciations without any decline while residential land had a sharp boom and bust around 2009, when the world financial crisis hit hard on the center for China's export industries.

The second panel of Figure 3 illustrates land prices in 35 tier-2 cities, which are either provincial capital or regional industrial and commercial center. The first panel depicts the land price indices of all tier-2 cities, and the subsequent four panels show four selected tier-2 cities, Chongqing, Suzhou, Changsha, and Xiamen. On average, commercial land had greater price appreciations than residential land, although this pattern is not so sharp in the selected cities. While these tier-2 cities had all adopted the housing purchase restriction policy in 2010 and 2011, there is not a sharp decline in the average residential land price index because these cities adopted the policy at different times, smoothing out the price effects. Nevertheless, residential land had visibly smaller price appreciations than commercial land after 2010, likely due to the housing purchase restriction policy.

The third row of Figure 3 illustrates land prices in all other cities in our sample, which we generically call tier-3 cities, specifically with the land price indices for all tier-3 cities in the first panel and for four selected cities in the following four panels. Residential land on average had slightly greater price appreciations than commercial land, and, in particular, did not show a slowdown after 2010 relative to commercial land, in contrast to that in tier-1 and tier-2 cities. This contrast is possibly due to the fact that few tier-3 cities had adopted the housing purchase restriction policy. Overall, it is common for industrial land to have flat price appreciations across all cities in our sample, but there is substantial heterogeneity in the price appreciations of commercial land and residential land.

By using the land price indices for each city, Table 1 provides the correlation matrix of land price changes among the three types of land (Panel A) and summary statistics for land price changes (Panel B). The correlation matrix in Panel A indicates a strong correlation of 0.41 between commercial and residential land price changes across cities and over time. Our indices are also highly correlated with those provided by Deng, Gyourko and Wu (2012), which have a correlation of 0.41 and 0.34 with our residential and commercial land indices. Interestingly, the price change on industrial land is negatively correlated with that of commercial land and the land price index by Deng, Gyourko and Wu (2012).

Panel B shows that the average commercial land price growth per year is 13.63%, modestly higher than the average price growth of residential land of 10.46%, and substantially higher than the average price growth of industrial land of 1.74%. Over the sample period, the annual land price growth also has substantial variations in our city-year observations—the standard deviation is 44.22% for commercial land, 49.03% for residential land, and 26.49% for industrial land.

To quantify the effect of the real estate boom on firm investment, it is useful to measure the value of each firm's land holdings over time. Rather than assuming that a firm's land holdings are all in its headquarter city, we take advantage of our detailed information of each land parcel held by the firm in different cities and the constant-quality land price indices in the respective cities to directly measure the value of the firm's land holdings.[10] Specifically, we compute the value of landing holdings by firm i in year t, $LandValue_{i,t}$, by

$$LandValue_{i,t} = \sum_j \sum_k \sum_{h=1}^{t-1} LandPayment_{i,j,k,h} \times \frac{LandPriceIndex_{j,k,t}}{LandPriceIndex_{j,k,h}},$$

where $LandPayment_{i,j,k,h}$ is the payment firm i made to acquire a land parcel of type k (commercial, residential, or industrial) in city j in year h, which was held to year t; $LandPriceIndex_{i,k,h}$ and $LandPriceIndex_{i,k,t}$ are the price indices of type-k land in city j in years h and t, respectively. Year 1 represents the initial year in our sample. In this expression, we estimate the market value of each land parcel by using the corresponding land price index to adjust its initial acquisition cost.[11]

Firm Investment

We focus on investments of firms publicly listed inside mainland China.[12] We obtain the financial information of each publicly listed firm from the China Stock Market & Accounting Research Database (CSMAR), which is maintained by GTA Information Technology. Following the literature, we exclude firms in real estate, mining, construction and financial sectors to have a sample of manufacturing and service firms[13]. The annual sample for our analysis covers 26,214 firm-year observations from 2000 to 2015, representing 2,687 unique firms.

We scale a firm's investment by its lagged net fixed assets. We further classify the gross investment into four components: 1) non-land investment, which refers to investment not directly related to land acquisition, 2) commercial land investment, i.e., the expenditure on acquiring new commercial land, 3) residential land investment, namely the expenditure on acquiring new residential land, and 4) industrial land investment, namely the expenditure on acquiring new industrial land. The second to fourth components of firm investment are directly obtained from

[10] Our data show that a significant fraction of the Chinese firms' land holdings is in non-headquarter locations (about 77% in terms of area of land transactions or 74% in terms of initial cost of land acquisition.) Given the substantial land price heterogeneity across cities, it is important to account for the location of a firm's land holdings.

[11] In this calculation we implicitly assume that firms' land holdings before the start of our sample were zero. As a result, our analysis under-estimates their actual land holdings.

[12] Our sample does not cover Chinese firms publicly listed outside China, such as Hong Kong, New York, and London.

[13] The industry classification of a firm is defined based on its core business, which is provided by China Securities Regulatory Commission (CSRC).

our land transaction data,[14] while the first component is measured as the difference between a firm's gross investment and the sum of all land investments.

Figure 4 plots the average investment by the firms in our sample for each year between 2000 and 2015, and further divides the investment into four components: non-land investment, commercial land investment, residential land investment, and industrial land investment. The total firm investment experienced a rapid increase from a level around 106 million RMB in 2000 to a level slightly above 553 million RMB in 2011, and then flattened out at this level after 2011. Interestingly, while there was almost no land investment before 2006, commercial land investment grew to a substantial level around 192 million RMB in 2010 (39.83% of total investment), and then gradually stabilized to 41 million RMB in 2015. At the same time, residential land investment also grew substantially and peaked at around 69.7 million RMB in 2011. In contrast, while industrial land investment also grew during this period, it remained small with an annual share less than 7%. The substantial investments in commercial land and residential land by these manufacturing and service firms are the key focus of our analysis.

Table 2 reports summary statistics of various firm-level variables, with the variable definitions given in Appendix A. It covers all publicly listed firms in our sample with 24,685 firm-year observations. About 67.54 percent (1,866 out of 2,763) of these firms acquired at least one land parcel in the sample period.[15] The average firm investment in a year is 448 million RMB, with land investment accounting for 18.93 percent. Land value accounts for 23.96 percent of a firm's fixed asset. This number is a lower bound, as we set firms' initial land holding at year 2000 to be zero. Commercial land is the largest part of land value held by these firms, accounting for 45.36 percent of the total land value, residential land for 28.83 percent, and industrial land for only 26.01 percent. Firm investment scaled by their lagged net fixed asset has an average value of 0.22. The Tobin's Q is on average around 2, and the total firm asset is around 6.7 billion RMB.

We measure a firm's innovation activities by its R&D expenditure and its number of patent applications. We scale the R&D expenditure by the firm's lagged net fixed assets. The data for

[14] For land parcels acquired through subsidiaries of publicly listed firms, we scale the acquisition cost of a land parcel by the fraction of shares of the listed firm in the subsidiary to count the land investment of the listed firm.

[15] The majority of the firms in our sample acquired land after 2006. If we define land ownership at the firm-year level, the percentage of land holding is 43.75%.

new patents in 1985-2015 are obtained from Patent Reference Database, which are released by the State Intellectual Property Office. There are three types of patents: invention patents, utility model patents, and design patents. As suggested by the literature, we do not count design patents because they involve limited technological advancements (e.g. Tan et al., 2016). Our results remain robust to including all three types of patents. We then match the firm data with the patent data using a firm's full name, including the names of its subsidiaries. Specifically, we measure a firm's innovation activities by the logarithm of the number of successful new patent applications (i.e., applications that are eventually granted) submitted by the firm in a given year. In total, we have 57,234 patents granted to 1,330 publicly listed firms in our sample from 2000 to 2015. Our analysis also employs some other data, which we will describe when we use them.

II. Empirical Hypotheses

This section introduces a series of empirical hypotheses organized to examine three distinct channels for real estate shocks to affect firm investment. First, the aforementioned literature has documented strong evidence for the *collateral channel* of real estate shocks: an increase in land value will increase the collateral value of real estate assets and thus enhance the debt capacity of land-holding firms. Motivated by this literature, we expect real estate shocks to have a similar effect on Chinese firms, as stated in the following hypothesis.

Hypothesis 1 (the Collateral Channel): Greater land values allow land-holding firms to borrow more and invest more.

In testing this hypothesis, we follow the empirical methodology of Chaney, Sraer, and Thesmar (2012) by taking each firm's lagged land-holdings as given and examining how the lagged land-holding value affects the firm's investment. As motivated by the substantial differences in the price appreciations of different types of land, we also separately examine the effects of commercial land, residential land, and industrial land.

A real estate boom not only allows land-holding firms to increase their investment through the collateral channel, but may also induce firms with financing (such as land-holding firms) to speculate in real estate. That is, firms may increase investment in the real estate sector even when their regular businesses are not related to real estate, aiming to gain from future real estate price appreciations. We call this channel the speculation channel.[16] If this speculation channel is sufficiently strong, land-holding firms may even reduce their non-land investments, such as R&D expenditure and patent applications, despite their improved access to financing during the real estate boom. We summarize the speculation channel in the following hypothesis:

Hypothesis 2 (the Speculation Channel): A real estate boom not only gives land-holding firms more financing but may also induce them to pursue more housing speculation. When their speculation incentives are sufficiently strong, they may even reduce their non-land investments despite their improved access to financing during the boom.

In testing this hypothesis, we take the spectacular real estate boom across Chinese cities as given, without taking a stand on what has caused the boom. As suggested by Fang et al. (2015), rapid urban developments, precipitated by the spectacular economic growth of China, have played a key role in driving the real estate boom. Investment demands or speculative motives of households and enterprises may have also contributed to the boom. As recognized by the literature, it is difficult to identify a real estate bubble. This is because a real estate boom may reflect either rational learning of agents and firms regarding future real estate fundamentals in the presence of realistic uncertainty, e.g., Pastor and Veronesi (2003, 2006), or their behavioral biases in over-extrapolating past price increases into the future, e.g., Case and Shiller (2003), Gennaioli, Shleifer and Vishny (2015), Barberis, Greenwood, Jin and Shleifer (2016). It is even more challenging to determine whether the real estate boom in China is a bubble, as the boom is still ongoing, even though many argue that current housing prices are too high relative to household income, e.g., Fang et al. (2015), Glaeser et al. (2017), and Wu, Gyourko, and Deng (2016).

The objective of our analysis is not to identify whether there is a housing bubble in China. Instead, we are primarily interested in analyzing how the real estate boom affected firm investment. Anchored on this objective, we examine not only the gross investment made by land-holding firms in response to a positive real estate shock, but more importantly specific types of investment taken by them. In particular, we examine whether firms take more investments to further develop their

[16] The macro literature has also developed theoretical models to show that a bubble in the real estate sector may attract more capital to be allocated to the sector, e.g., Miao and Wang (2014), and Chen and Wen (2014).

regular businesses, or buy more land, and if they buy more land, whether they buy more industrial, residential, or commercial land. Note that residential and commercial land cannot be used for building manufacturing facilities. While an individual firm may choose to transform its business models over time for idiosyncratic reasons, one would not expect non-real estate firms to systematically increase real estate investments in response to real estate shocks except for speculation over future price appreciations.

To make this effect as clear as possible, we also examine whether firms expand or reduce their innovation activities in response to positive real estate shocks. Note that the literature has argued that if firm managers are myopic, a real estate bubble may lure firms to direct more resources away from innovation activities into the real estate sector (Aghion et al., 2013; Kaplan and Minton, 2006; Stein, 1989, 2003). While our study does not aim to identify whether the real estate boom in China is a bubble, any evidence of the real estate boom inducing firms to reduce innovation activities would indicate inefficient capital allocation from the perspective of allocation efficiency.

In our analysis, we treat price changes in the price indices of the three types of land in each city as different shocks, which is consistent with the aforementioned, relatively small correlations among the land price changes. We examine whether in response to a price shock to one type of land, say commercial land, in its headquarter city, a firm acquires more commercial land.[17] As the firm needs financing in order to carry out the land acquisition, we examine the speculation effect as a joint effect of the firm's land holdings and the land price shock, with the price shock as the stimulus for land speculation and its land holdings as a proxy for its financing capacity.

When a land-holding firm invests a sufficiently large amount on land speculation, it may have to cut down its non-land investment. That is, the firm may reduce its regular investments, such as its R&D expenditure and innovation activities, despite that more financing becomes available after a positive real estate shock. As part of the speculation effect, this effect also shows up as a negative joint effect of the firm's land holdings and the land price shock.

Furthermore, the improved access of land-holding firms to financing comes at a cost to non-land-holding firms. When banks make more loans to land-holding firms after a positive real estate

[17] This test builds on an assumption that the past price shock causes the firm to expect greater land price appreciation going forward. This assumption is potentially consistent with both rational and irrational learning.

shock, there is less financing available to non-land-holding firms. Through this crowding out channel, a real estate boom may affect the allocation of capital across firms:

Hypothesis 3 (the Crowding Out Channel): A real estate boom reduces bank financing to non-land-holding firms and thus their investments.

In what follows, we exploit China's real estate boom in the past 15 years to examine these three distinct channels for real estate shocks to affect firm investment. With these three channels, real estate shocks may have profound impacts on the efficiency of capital allocation across the economy. Through the collateral channel, a positive real estate shock may mitigate the financial constraints faced by land-holding firms and thus improve allocation efficiency. However, through the speculation channel and the crowding out channel, the shock may divert limited capital to housing speculation, away from real production. The net effect of the shock on allocation efficiency is thus undetermined. We will examine this issue at the end of the paper.

III. Firm Investment

This section reports empirical findings on how real estate shocks affect firm investment through the three economic channels highlighted by Hypotheses 1-3. We first treat land price changes as exogenously given and study how firm investment reacts to price changes of the three types of land. We then discuss potential endogeneity arguments and finally present additional results from a quasi-policy experiment, which helps to address the key endogeneity concern.

A. The Collateral Channel

We first examine the collateral channel, as hypothesized in Hypothesis 1. Following Chaney, Sraer, and Thesmar (2012), we use the following regression specification to examine how real estate shocks affect firms' gross investment:

$$\frac{I_{i,t}}{K_{i,t-1}} = \alpha + \beta \cdot \frac{LandValue_{i,t-1}}{K_{i,t-1}} + \theta X_{it} + \mu_i + \delta_t + \epsilon_{it} \quad (1)$$

The dependent variable $\frac{I_{i,t}}{K_{i,t-1}}$ is firms' gross investment in year t normalized by its total fixed asset in year $t-1$. The key explanatory variable $\frac{LandValue_{i,t-1}}{K_{i,t-1}}$ is the firm's total land value in year $t-1$ normalized by its total fixed asset in year $t-1$. The coefficient β measures the effect of an increase in the firm's land value on its gross investment. The control variables X_{it} include Tobin's Q, end-of-year cash flow normalized by lagged fixed asset, total sale (logged), total firm asset (logged), and the firm's share of state ownership. We also include firm fixed effect μ_i and year fixed effect δ_t. The standard errors are clustered at the firm level.

Table 3 reports the regressions results. Column (1) uses firms' total land value (lagged) as an explanatory variable. Similar to Chaney, Sraer and Thesmar (2012), we find a significant positive effect of land value on gross investment. This effect is not only statistically significant at 1 percent level, but also economically large. The estimated coefficient of total land value shows that if the land value increases by ￥1, the gross investment increases by ￥0.037. This estimate is somewhat smaller than the collateral effect estimated in the U.S. data by Chaney, Sraer and Thesmar (2012), who find that a $1 increase in land collateral value raises corporate investment by $0.06.

We also separately examine the effect from firms' holdings of commercial, residential, or industrial land in Columns (2) to (4), respectively. Column (2) shows that if the value of a firm's commercial land holding increases by ￥1, its gross investment increases by ￥0.140, which is statistically significant and substantially bigger than (more than four times) the collateral effect associated with the firm's total land value. In Column (3), the effect associated with the firm's residential land is 0.072, which is also statistically significant and modestly larger than that of the total land value. On the other hand, Column (4) shows that the effect associated with the firm's industrial land is insignificant. Overall, Table 3 provides evidence in support of the collateral channel—land-holding firms substantially increase their gross investment in response to increases in the values of their land holdings, consistent with Hypothesis 1, and this effect stems primarily from the values of their commercial land and residential land holdings.

To address the endogeneity concern of land value being correlated with firms' investment opportunities, Chaney, Sraer and Thesmar (2012) adopt a land supply elasticity variable as an instrument variable. We have also followed their procedure to implement an IV test. The IV estimates yield qualitatively and quantitatively similar results as the OLS estimates, confirming that firms' land holdings have a significantly positive effect on corporate investment. As we do not view confirming the collateral channel in China as a main contribution of this paper, we omit the results from this IV estimation. Our later analysis on the composition of land-holding firms' investments shall provide further evidence inconsistent with the real estate boom being correlated with firms' investment opportunities.

Table 3 shows a decreasing pattern in the magnitude of the collateral effect across commercial land, residential land, and industrial land. This curious order indicates that banks may have preferences over accepting different types of land as collateral. To further understand this issue, we construct a dataset of over 0.35 million land-collateralized loans between 2002 and 2014, from the same Ministry of Land and Natural Resource website (www.landchina.com). In the dataset, for each land-collateralized bank loan, we have information on the land value and the land collateral value (evaluated by the bank), as well as the land location.

We pool together the land-collateralized bank loans to run the following regression:

$$LTV_{ikct} = \alpha + \beta \cdot Com + \delta \cdot Res + \gamma \cdot \Delta PriceIndex_{ct}^{k} + \kappa_1 \cdot Com \cdot \Delta PriceIndex_{ct}^{k} + \kappa_2 \cdot Res \cdot \Delta PriceIndex_{ct}^{k} + \mu_c + \delta_t + \epsilon_{ikct} \quad (2)$$

where LTV_{ikct} is the loan-to-value ratio of a loan, Com is a dummy to indicate whether the collateral is commercial land, Res is a dummy to indicate whether the collateral is residential land, and $\Delta PriceIndex_{ct}^{k}$ is the price index change of type-k land in the city, where the land collateral is located. We also include both city and time fixed effects. In this regression, we treat industrial land collateral as the base effect, with the coefficients of the two land type dummies capturing the additional effects of commercial land and residential land on the loan-to-value ratio. We also include $\Delta PriceIndex_{ct}^{k}$ and its interaction term with the corresponding land type dummy.

Table 4 reports the regression results. We include only the dummies of commercial and residential land in column (1), which shows that both types of land have significantly higher loan-to-value ratio than industrial land. Specifically, commercial land has a higher loan-to-value ratio by 9.1%, and residential land by 2.0%. In columns (2) and (3), we also include the commercial land price change and its interaction term with the commercial land dummy. The results indicate that the loan-to-value ratio to loans collateralized by commercial land increases with the price increase of commercial land. Column (4) and (5) also show similar results for residential land, although Column (6) shows that industrial land price change has no effect on the loan-to-value ratio of loans collateralized by industrial land. Taken together, Table 4 confirms that banks' lending preference is affected by the type of land collateral and land price fluctuations, with commercial land as the most desirable collateral, followed by residential land, and industrial land.

B. The Speculation Channel and the Crowing Out Channel

We now examine the speculation and crowing out channels posited by Hypotheses 2 and 3 by analyzing different components of each firm's investment in response to lagged land price fluctuations in its headquarter city. We take the lagged land price changes as given for now, and will later address potential endogeneity issues. Specifically, we pool together all firm-year observations in our sample and run the following regression:

$$Y_{i,t} = \alpha + \gamma \cdot \Delta PriceIndex_{i,k,t-1} + \beta \cdot \frac{LandValue_{i,t-1}}{K_{i,t-1}} + \eta \cdot \frac{LandValue_{i,t-1}}{K_{i,t-1}} \cdot \Delta PriceIndex_{i,k,t-1} + \kappa_0 \cdot I_{Non-owner} + \kappa_1 \cdot I_{Non-owner} \cdot \Delta PriceIndex_{i,k,t-1} + \theta X_{it} + \mu_i + \delta_t + \epsilon_{it} \quad (3)$$

where $Y_{i,t}$ measures firm i's investment in year t in each of the five types (gross, non-land, commercial land, residential land, or industrial land investment), scaled by the previous year fixed asset K_{it-1}. On the right-hand side, $\Delta PriceIndex_{i,k,t-1}$, the lagged percentage change of type-k land price index, is the key explanatory variable, which induces land-holding firms to engage in land speculation (Hypothesis 2) and crowds out the financing of non-land-holding firms (Hypothesis 3). We include $\frac{LandValue_{i,t-1}}{K_{i,t-1}}$ to represent the availability of financing and its interaction term with $\Delta PriceIndex_{i,k,t-1}$, which may have a positive coefficient on land investment and a negative coefficient on non-land investment according to Hypothesis 2. To capture the crowding out effect on non-land-holding firms (Hypothesis 3), we include $I_{Non-owner}$, which is a dummy that takes a value of 1 for firm-year observations without any land holding, and its interaction term with $\Delta PriceIndex_{i,k,t-1}$. This regression specification separates the effects of the land price fluctuation on land-holding firms and non-land-holding firms. Specifically, for land-holding firms, $\Delta PriceIndex_{i,k,t-1}$ captures the base effect on a firm holding a small quantity of land, while $\frac{LandValue_{i,t-1}}{K_{i,t-1}} \cdot \Delta PriceIndex_{i,k,t-1}$ captures the incremental effect from having more land. The term $I_{Non-owner} \cdot \Delta PriceIndex_{i,k,t-1}$ captures the crowding out effect on non-land-holding firms, relative to the base effect of $\Delta PriceIndex_{i,k,t-1}$ on land-holding firms.

Table 5 reports the regression results with the dependent variables being the gross investment and the four components of firm investment, all scaled by the lagged fixed asset. We separately examine the effects associated with shocks to different land price indices, with Panel A using commercial land price change as the key explanatory variable, Panel B residential land price change, and Panel C industrial land price change. As commercial land is the largest component in firms' aggregate landing holdings and has the strongest collateral effect, we use the value of each firm's commercial land holdings, rather than its total land holdings, paired with different land price shocks in our analysis. We also include the same control variables as in regression (1), including Tobin's Q, end-of-year cash flow normalized by lagged fixed asset, total sale (logged), total firm asset (logged), and share of state ownership, together with firm fixed effect ε_i and year fixed effect δ_t. The standard errors are clustered at the firm level.

In Panel A, Columns (1) and (3) show that an increase in land value causes land-holding firms to increase both gross investment and non-land investment, consistent with the collateral effect. The lagged commercial land price appreciation significantly increases land-holding firms' commercial land investment (Column 5) and significantly decreases their non-land investment (Column 3). The interaction term of the lagged commercial land price appreciation and land value is also significantly positive for commercial land investment (Column 6) and significantly negative for non-land investment (Column 4). These coefficients show that commercial land price appreciation in the previous year leads land-holding firms to invest more in commercial land and crowd out their non-land investments, and these effects are particularly strong for firms holding more land and thus having more access to financing. The magnitudes of these effects are substantial. The coefficient of $\frac{LandValue_{i,t-1}}{K_{i,t-1}} \cdot \Delta PriceIndex_{i,k,t-1}$ is 0.171 for commercial land investment and -0.098 for non-land investment, implying that a commercial land price increase of 44.22% (one standard deviation from Table 1) leads land-holding firms to increase commercial land investment by 7.6% of their current commercial land value and at the same time to reduce non-land investment by 4.3% of their current commercial land value, in same order of magnitude to the collateral effect discussed earlier. This reduction in non-land investment is particularly surprising as the land price appreciation gives land-holding firms better access to financing. The sharp contrast between the positive effect on commercial land investment and the negative effect on non-land investment thus strongly supports the speculation effect posited by Hypothesis 2, highlighting the important effect of the real estate boom on the composition of firm investment.

Note that the commercial land price appreciation also leads to a significant increase in the land-holding firms' investment in residential land (Column 8) but not in industrial land (Column 10). As commercial land prices are largely correlated with residential land prices, it is natural for the commercial land price appreciation to induce speculation in residential land as well.

The coefficient of the interaction term of the non-owner dummy with $\Delta PriceIndex_{i,k,t-1}$ measures the additional effect of the land price change on the investment of non-land-handing firms relative to that on land-handling firms. Columns (3) and (4) of Panel A show that this coefficient is negative for non-land investment, indicating that commercial land price appreciation has a stronger effect on non-land investment of non-land-holding firms, relative to the substantial, negative effect on non-land investment of land-holding firms. The lack of statistical significance of this coefficient is not a particular concern because the base effect on land-holding firms is highly significant. In Column (3), the sum of the coefficient of $\Delta PriceIndex_{i,k,t-1}$ and the coefficient of $\Delta PriceIndex_{i,k,t-1}$ interacting with the non-owner dummy, is -0.077, which measures the net effect of the commercial land price change on non-land investment of non-land-holding firms. This value implies that a commercial land price increase of 44.22% (one standard deviation) leads non-land-holding firms to reduce their non-land investment by an amount equal to 3.4% of their fixed-asset value, which is substantial. This result strongly supports the crowding out effect posited by Hypothesis 3 and shows that the real estate boom has an important effect on the allocation of capital across firms.

Panel B reports similar speculation effect and crowding out effect induced by residential land price appreciation. Columns (4) and (8) show that residential land price appreciation induces land-holding firms to increase residential land investment and decrease non-land investment. The coefficient of $\frac{LandValue_{i,t-1}}{K_{i,t-1}} \cdot \Delta PriceIndex_{i,k,t-1}$ is 0.058 for residential land investment and -0.074 for non-land investment, implying that a residential land price increase of 49.03% (one standard deviation from Table 1) leads land-holding firms to increase residential land investment by 2.8% of their current commercial land value and at the same time to reduce non-land investment by 3.6% of their current commercial land value. Furthermore, Column (4) shows that the additional effect of residential land price appreciation on non-land investment of non-land-holding firms, relative to land-holding firms, is also significant with a coefficient of -0.056. This value implies that a residential land price increase of 49.03% (one standard deviation) leads non-land-holding firms to reduce their non-land investment more than the already substantial crowding out effect on land-holding firms by an amount equal to 2.7% of their fixed-asset value.

Overall, Table 5 finds supporting evidence for both the speculation channel and the crowding out channel—an increase in commercial (or residential) land price induces land-holding firms to increase investment in commercial and residential land, and to reduce non-land investments; and the land price increase also reduces the investments of non-land-holding firms. To verify the robustness of the results in Table 5, we also examine a sample of private firms covered by the National Taxation Statistics in 2008-2011. These firms tend to be substantially smaller than the sample of publicly listed firms covered in Table 5. The results reported in Appendix B replicate Panel A of Table 5 and confirm the same set of effects. Interestingly, the crowding out effect on non-land-holding firms in this sample is even stronger.

Given the dramatic price appreciations for commercial and residential land across China, the land speculation strategy has been highly profitable in terms of financial returns. However, the resulting capital allocation across firms is potentially inefficient as capital is channeled away from real production of both land-holding and non-land-holding firms. To further explore the consequence of this capital allocation, we also examine how real estate shocks affect firms' innovation activities by replacing the investment variables with two innovation measures in Table 6. Specifically, we use the R&D expenditure scaled by lagged fixed asset and natural logarithm of one plus the number of patent applications to measure a firm's innovation activities. Panel A shows that commercial land price appreciation significantly reduces firms' R&D expenditure and number of new patents, interacting or not interacting with commercial land value. The coefficient of the non-owner dummy and commercial land price appreciation is also significantly negative, indicating that commercial land price appreciation further reduces R&D expenditure and number of patent applications of non-land-holding firms, in addition to the already negative effects on land-holding firms. Panel B shows that residential land price appreciation has similar crowding out effects on the innovation activities of both land-holding and non-land-holding firms.

To further understand how real estate shocks affect allocation of capital across firms, we investigate how banks allocate credit when land prices rise. If banks tilt their lending toward borrowers with land collateral, they have to cut down loans to other firms. This behavior by banks naturally leads to a crowding out effect against non-land-holding firms. To examine this crowding out effect, we collect a loan-level dataset for the publicly listed firms in our sample from the firms' public statements. The data is obtained from RESSET and CSMAR. It covers 81,872 loans made to 2,862 Chinese publicly listed firms from 2000 to 2015. For each bank loan, we collect information on collateral and bank branch of the lender.

We adopt the following specification to examine conditional on offering a loan to firms in our sample, how land price fluctuations affect the type of loan banks prefer:

$$Collateral_{i,b,t} = \zeta + \lambda * \Delta LandPriceIndex_{b,c,t} + \theta X_{i,t} + \mu_{ct} + \iota_{bt} + \tau_{bc} + \pi_{i,b,c,t} \quad (4)$$

The dependent variable is the collateral characteristics for loan i lent by bank branch b in year t. The key explanatory variable is the land price change in year t for the city where the bank branch b is located. All regressions have controlled for a set of firm-level variables X_{it} including Tobin's Q, firm's end-of-year cash flow normalized by lagged fixed asset, total sale (logged), total asset (logged), share of state ownership, as well as firm fixed effect interacted with bank branch fixed effect μ_{ib}, bank branch city fixed effects ι_{bt} and bank branch fixed effect interacted with year fixed effect τ_{bc}.

Table 7 reports the loan level results. The dependent variable in Column (1) is a dummy variable which equals to one if loan i has real estate collateral and zero otherwise. The result in Panel A indicates that a rise in commercial land prices in the bank branch city leads to an increase in the probability of lending with real estate collaterals. Similarly, Column (2) shows that the rising land price also increases the probability of lending with non-real-estate collateral. In contrast, Column (3) shows that the rising land price in a city decreases the probability for the bank branch located in the city to grant loans without any collateral. Column (4) adopts an alternative specification with a categorical dependent variable, which takes value of zero if the loan goes without collateral, one if the loan has non-real estate collateral, and two if it has real estate collateral. The regression result is consistent with the findings reported in Columns (1)-(3): an increase of land price in a bank branch city raises the likelihood of loans with real estate collateral and reduces that of loans without collateral. This table clearly shows that when a city experiences land price appreciation, bank lending will significantly favor firms with real estate collateral, crowding out financing available for non-land-holding firms.

Panels B and C of Table 7 replace the land price index in the bank branch city with residential and industrial land price indices, respectively. The crowding out effect of residential land price is similar to that of commercial land price while the effect is insignificant for industrial land price. Overall, the loan-level results provide evidence for real estate shocks (in particular commercial and residential land price shocks) crowding out bank lending to non-land-holding firms.

Taken together, Tables 5-7 present evidence supporting Hypotheses 2 and 3. There are two usual endogeneity arguments. One is that real estate shocks are potentially correlated with firms' investment opportunities, and the other is that land-holding firms tend to be better firms and thus have better investment opportunities than non-land-holding firms. Neither one of these arguments alone nor together can explain our findings. The first argument implies that in response to improved investment opportunities associated with a real estate boom, firms should all expand non-land investment in order to further develop their regular businesses. Our finding of both land-holding and non-land-holding firms reducing non-land investments in response to positive land price shocks contradicts this argument. The second argument may help explain the reduced investment of non-land-holding firms, but it makes the reduced non-land investment of land-holding firms even more puzzling. In the next subsection, we directly compare the productivities of land-holding and non-land-holding firms and show that land-holding firms tend to be less, rather than more, productive than non-land-holding firms, further invalidating this argument.

C. Comparing Land-Holding and Non-Land-Holding Firms

Figure 5 depicts a series of characteristics of land-holding and non-land-holding firms. The upper left panel shows the number of firms in these two groups for each year from 2000 to 2015. Before 2007, only few firms had acquired land. The situation quickly changed after 2007 when a large number started to acquire land in each year. After 2010, there are more land-holding firms than non-land-holding firms. Also note that the total number of firms expanded in our sample as more firms became listed on the stock market.

The upper right panel, the lower left panel, and the lower right panel show the average state share, the average Tobin's Q, and TFP, respectively, for the two groups of firms in each year. The grey bars represent non-land-holding firms, the black bars land-holding firms, and the white bar the difference between land-holding and non-land-holding firms. As few firms had land holdings before 2007, the variables related to land-holding firms in those years are subject to large noise. Thus, we pay more attention to years after 2007.

Figure 5 reveals several interesting observations. First, land-holding firms have greater state shares than non-land-holding firms for each year after 2007. Interestingly, the difference between the average state share of land-holding firms and non-land-holding firms was substantially expanded after 2008 with a peak in 2011, which was likely due to the massive economic stimulus program implemented by the Chinese government in 2008-2010. This stimulus program had injected a large amount of bank credit to the economy, most of which was given to SOEs. The widening gap between the state shares of land-holding and non-land-holding firms suggests that many of the SOEs might have used the credit from the stimulus program to buy land. Second, the two lower panels show that land-holding firms on average had consistently lower Tobin's Q and TFP than non-land-holding firms in each of the years after 2007.[18] Taken together, these patterns suggest that land-holding firms tend to be less productive, as opposed to being more productive as one might have expected, than non-land-holding firms.[19]

D. A Quasi-Policy Experiment

While the aforementioned endogeneity arguments are not relevant for explaining our findings, another more concerning argument is the massive economic stimulus implemented by the Chinese

[18] These patterns are consistent with the facts that SOEs tend to face less financial constraints and are less efficient than non-SOEs (e.g., Hsieh and Klenow, 2009; Liu and Siu, 2011; Dollar and Wei, 2014).

[19] We also use a regression analysis to further investigate how firms' land purchase decision is related to their Tobin's Q and TFP. We pool together the firm-year observations in our sample and regress the dummy variable of whether a firm made its initial land purchase or a continuing land purchase in a given year on a list of firm variables, including two lags of Tobin's Q and TFP, and one lag of firm sales, cash, asset, number of employees, and state share, as well as city-year fixed effects. The results reported in Appendix C show a consistent pattern that firms making either initial or continuing land purchases tend to have lower Tobin's Q and lower TFP than firms not making land purchases.

government in 2008-2010, which can lead to a reverse causality of our findings. Specifically, to implement the stimulus, the central government instructed banks to inject a large quantity of bank credit to firms, most of which was given to SOEs, e.g., Bai, Hsieh, and Song (2016). This is because banks have a preference for lending to SOEs due to their soft budget constraints and implicit government guarantees.[20] As some of the SOEs lacked good investment opportunities, they might have chosen to buy land, which in turn may have exacerbated the real estate boom. As our analysis so far is built on the responses of firm investment to lagged land price changes, this argument cannot exactly explain our findings. Nevertheless, to isolate this argument, we examine a specific real estate shock caused by a quasi-policy experiment unrelated to banks' credit policies.

The rapid and persistent increases in housing prices across China since 2000 prompted the city government of Beijing to first adopt on April 30, 2010 the "housing purchase restriction policy", which restricts each resident household to purchase only one additional property in the city. It was soon followed by more city governments across the country. Up to the end of 2011, 46 cities adopted this purchase restriction policy. These cities tend to be large cities that had experienced greater migrant inflow and greater housing price appreciations. In year 2014 and 2015, most of the 46 cities (with the exception of the four first-tier cities Beijing, Shanghai, Guangzhou, and Shenzhen) abolished the purchase restriction policy after the policy was proven to put too much pressure on real estate prices in some cities. Appendix D shows the list of these cities and their announcement date and abolishment date of the purchase restriction policy. The purchase restriction policy imposed constraints on housing demand in the affected cities. As the policy did not directly affect manufacturing and service firms in our sample, it provides an exogenous demand shock to land prices in the affected cities and thus allows us to employ a difference-in-difference (DID) approach to examine its effect on investments of firms in the cities affected by the policy relative to firms in other cities.

There are two potential concerns about this shock. First, as the purchase restriction was gradually adopted across the 46 cities, its adoption by an individual city might be anticipated by the public before the announcement. Second, the public might expect the policy to be eventually reversed when the housing boom slows down (as indeed happened). If either concern holds true,

[20] See Song and Xiong (2017) for a review of the extensive literature.

we would not observe a significant price drop after the announcement. This in turn would invalidate any subsequent effect on firm investment. We shall resolve these concerns by first examining the land price change around the announcement of the purchase restriction policy.

We estimate the impact of the purchase restriction policy on the land price of the affected cities by analyzing land price changes around the policy announcements of the 46 cities relative to other cities. We consider in total 12 quarters around the announcement quarter, from 6 before to 6 after. The regression using the whole land transaction sample is specified as below:

$$LandPrice_{i,j,t} = \alpha + \sum_{\epsilon t} \beta_{\epsilon t} * EventTime_{j,t,\epsilon t} + \sum \lambda_j * t + \mu_t + \gamma_j + \varepsilon_{i,t} \quad (5)$$

The subscript ϵt represents event quarter, which takes values from -6 to 6, with 0 representing the quarter when the policy was announced. $EventTime_{j,t,\epsilon t}$ takes value 1 if calendar quarter t in city j corresponds to an event quarter within 6 quarters around the announcement of its purchase restriction and 0 otherwise. This regression specification takes the land price in 6 quarters before the policy announcement as the benchmark. The regression controls for city fixed effects, time fixed effects, and, in particular, city specific time trend ($\sum \lambda_j * t$), which controls for heterogeneous trends across cities caused by fundamental factors such as immigration and economic growth. We also repeat the same regression around the abolishment date of the policy to analyze the impact on the land price after the policy is abolished.

Figure 6 reports the results. The dots in the figure shows the estimated value of the coefficients β over event time, while the range around each dot quantifies the 95th confidence interval. The left panel reports the price changes around the policy announcement, while the right panel reports the price changes around the policy abolishment. For residential land reported in Panel A, the β estimates display no significant difference between the treatment and control cities in several quarters before the announcements. The difference becomes significantly negative in the post-event quarters, indicating that the policy had negative impacts on residential land prices in the 46 treatment cities. The figure on the right panel shows that though residential land price starts to increase immediately after the abolishment of the policy, the difference is only statistically significant after 4 quarters.

Even though the purchase restriction policy only applied to residential homes, its effect could also spill over to commercial land given the strong correlation between residential and commercial land prices. Panel B indicates that there is indeed a negative effect of the policy on commercial land price, which emerged about 2 to 4 quarters after the announcement. But the abolishment of the policy has no significant effect in pulling up the commercial land price. As this policy shock did not apply to industrial land designated for industrial uses, Panel C shows that industrial land prices in the treatment cities did not drop after the policy announcement (and even slightly increased after 4 quarters of the announcement), nor did it change after the policy abolishment.

Before our DID analysis of firm investment, we further verify that the housing purchase restriction policy did not come with any change in banks' credit policy between treatment and control cities. As the purchase restriction policy was adopted roughly when the government's economic stimulus ended in 2010 and banks reduced total new bank credit across the country. However, the drop in bank credit is uniform across the cities that adopted and that did not adopt the purchase restriction policy. To verify this, we pool together a panel of annual bank credit to each city in our sample, from China Banking Regulatory Commission, and run regression (5). As the city-level bank loan data are annual, we examine the bank loan change from four years before to four years after the policy announcement, as well as abolishment. Panel D of Figure 6 confirms that there is not any notable difference between the treatment and control cities.

Since the purchase restriction policy indeed induced drops in residential and commercial land prices in the treatment cities and is not correlated with bank credit in these cities, we adopt a DID design to test whether the land price drops affected firm investment, as specified below:

$$Y_{i,t} = \alpha + \beta \cdot \frac{LandValue_{i,t-1}}{K_{i,t-1}} + \varphi \cdot Policy_{j,t} + \eta \cdot \frac{LandValue_{i,t-1}}{K_{i,t-1}} \cdot Policy_{j,t} + \kappa_0 \cdot I_{Non-owner} + \kappa_1 \cdot I_{Non-owner} \cdot Policy_{j,t} + \theta X_{it} + \sum_j \lambda_j * t + \mu_i + \zeta_t + \varphi_{i,t} \quad (6)$$

This regression uses panel data at firm-year level, where $Y_{i,t}$ is an investment variable of firm i in year t, $Policy_{j,t}$ is a dummy variable taking value of 1 if in year t the headquarter city j of firm i

adopted the purchase restriction policy and 0 otherwise.[21] The specification is thus similar to equation (3), except that we replace the variable $\Delta PriceIndex_{i,k,t-1}$ by the dummy $Policy_{j,t}$, which serves as the price shock. Similarly, the regression controls for firm fixed effects and year fixed effects, and includes Tobin's Q, cash flows, total sale revenues, total firm asset, and share of state ownership as additional control variables. One concern is that the selection of the treatment cities was not random. To ensure that the effects from the restriction policy are not driven by pre-existing differences between the treatment cities and the control cities, in additional to firm fixed effects, we further control for firm specific time trend in all specifications. Coefficient φ captures the DID effects for land holding firms, coefficient η the DID effects interacted with firms' land holding, and coefficient κ_1 the DID effects for non-land-holding firms. Note that these coefficients do not differentiate price drops induced by the policy on commercial and residential land.

Table 8 reports the regression results. As the adoption of the purchase restriction brought a negative shock to both residential and commercial land prices in the treatment cities relative to the control cities, we expect a reversal of the three aforementioned effects. As land prices across China were mostly rising throughout our sample period, this negative policy shock also serves to show that the aforementioned effects of the real estate boom on firm investment are symmetric on the negative side. The results reported in Table 8 indeed confirm this. For land-holding firms, if their headquarter cities adopted the purchase restriction policy, they had significantly lower gross investment, as shown by the estimate of coefficient φ in columns (1) and η in column (2), and specifically lower investment in commercial land columns, as shown by φ in column (5) and η in column (6). The coefficient η for non-land investment and residential land investment in columns (4) and (8) is also negative, albeit insignificant. For non-land-holding firms, if their headquarter cities adopted the housing purchase restriction, their investments in all categories are significantly higher, as shown by the estimate of coefficient κ_1 across columns (1) to (8).

Table 9 reports the results for firm innovation. For land holding firms, R&D expenditure and patent applications both increase with the policy shock. For example, there are an increase of 0.033 (multiples of lagged fixed asset) in R&D expenditure and 7.5% more new patent applications for those firms with headquarter in the 46 treatment cities, as shown by the estimates for coefficient

[21] We make the dummy 1 if the policy was in effect for more than half a year in a given city-year observation.

φ in columns (1) and (3). These estimates suggest that even though land-holding firms in the treatment cities cut their gross investment and commercial land investment after the policy shock, they increased their innovation activities, an exact reversal of the speculation effect revealed by our earlier analysis. The policy shock also led to significant increases in both R&D expenditure and patent applications by non-land holding firms in the treatment cities, with magnitudes almost doubling that for land-holding firms, as shown by columns (1) and (3).

Overall, by analyzing the DID effects of the housing purchase restriction policy on investments of firms in the treatment cities and the control cities, we find that the negative policy shock had led to reversal of the collateral effect, speculation effect, and crowding out effect, confirming that these effects are not simply driven by China's economic stimulus in 2008-2010.

IV. Resource Misallocation

In this section, we analyze the impact of the real estate boom on the efficiency of capital allocation. Hsieh and Klenow (2009) propose a measure of TFP (total factor productivity) loss due to resource misallocation. We simply adopt their measure by treating each city in our sample as a closed economy. We essentially assume that there is no capital or labor mobility across cities. While this is clearly an over-simplifying assumption, it nevertheless provides a useful baseline measure for evaluating efficiency of resource allocation inside each city.

To calculate the aggregate TFP loss at the prefectural-city level, we use firm-level sales (revenues), capital, and labor data for all firms in each city, including not only publicly listed firms but also private firms. We merge China's Industrial Census Data from 2000 to 2007 and the National Taxation Statistics Data 2008 to 2011 to construct a sample from 2000 to 2011.[22] The Industrial Census Data contain 1,896,731 firm-year observations for 684,848 unique manufacturing firms, covering all large and medium manufacturing firms with annual revenue larger than 5 million RMB in the pertinent period, while for the Taxation Statistics Data contain

[22] We do not use the Industrial Census Data from 2008 to 2011 because an important variable, industrial value added, is missing for these years.

1,374,939 firm year observations for 659,316 unique manufacturing firms, covering all large and medium firms. We closely follow Hsieh and Klenow (2009) to compute the TFP loss.

To systematically examine whether there is a correlation between the real estate boom and resource misallocation, we run the following city-level panel regression:

$$TFPLoss_{p,t} = \alpha + \beta * \Delta PriceIndex_{p,t} + \mu_p + \delta_t + \varphi_{p,t} \qquad (7)$$

The dependent variable is the TFP loss of city p in year t, and the key explanatory variable is the land price change in the city. All regressions control for city fixed effect and year fixed effect.

Table 10 reports the regression results in Panel A. Columns (1) to (3) use a simple average of aggregate TFP losses over 47 manufacturing sectors in each city-year, while columns (4) to (6) use the weighted average by industrial output. We also use the price change of commercial land, residential land, and industrial land, individually as the explanatory variable. Columns (1) and (4) point to a significantly positive effect of commercial land price appreciation on the TFP loss. The OLS estimates show that a 100% increase in the commercial land price index leads to losses of 9.0% and 28.6% to the simple average and weighted average of aggregate TFP, respectively. Columns (2) and (6) show significant resource misallocation associated with residential price appreciations: a 100% increase in the residential land price index leads to losses of 3.5% and 9.1% to the simple average and weighted average of aggregate TFP, respectively. While these estimates are slightly smaller than that for commercial land price appreciations, they are nevertheless substantial. The greater losses shown by the weighted average of TFP losses suggest that the resource misallocation is stronger for large cities. Column (3) and (6) show that industrial land price appreciations are not related to any significant resource misallocation.

To verify robustness, we employ the DID analysis of the housing purchase restriction policy on the TFP losses across the treatment and control cities. In doing so, we simply replace the variable $\Delta PriceIndex_{p,t}$ in the regression specification (7) by the policy dummy defined in regression specification (6). Its coefficient captures the DID effect of the policy shock on the city-level TFP loss. The regression results are reported in Panel B of Table 10. The policy shock led to a reduction of 21.2% in TFP loss by simple average across the treatment cities, and 23.3% by weighted average (columns (1) and (3)). These two magnitudes are similar because the treatment cities are all large cities. To further control for other confounding trends in different cities, we also include city-specific time trend in columns (2) and (4). The coefficient for simple average remains significant with similar magnitude of -22.4%, but for weighted average becomes insignificant, albeit still negative. Overall, we find that the policy shock substantially reduced TFP losses in the treatment cities.

V. Conclusion

In this study, we investigate the consequences of real estate shocks on firm investment, using China's real estate boom as a laboratory. In addition to confirming the well-known collateral effect of positive real estate shocks allowing firms with land holdings to invest more, we also uncover two other effects. Specifically, by studying different components of firm investment, we show that the real estate boom in China caused land-holding firms to buy more land, especially commercial land and residential land, and to reduce other investments, revealing a speculation effect; and crowded out bank financing to non-land-holding firms, leading to a crowding out effect.

Due to resource misallocation caused by the speculation and crowding out effects, we further find that across different cities, real estate shocks are positively correlated with inefficient resource allocation. Specifically, a 100% increase in the commercial land price index in a city is associated with an estimated loss of 9.0% in simple average of aggregate TFP. Taken together, our findings caution the common view that real estate booms help to mitigate firms' financing constraints and thus boost the economy by stimulating firm investment.

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Table 1. The Summary Statistics and Correlation Matrix of Land Price Index Change

Panel A	Commercial Land Price Growth Rate	Residential Land Price Growth Rate	Industrial Land Price Growth Rate	Wu's Land Price Index Growth Rate
Commercial Land Price Change	1			
Residential Land Price Change	0.4066	1		
Industrial Land Price Change	-0.2043	0.0133	1	
Wu's Land Price Index Change	0.3373	0.4065	-0.1788	1

Panel B	N	Mean	Std. Dev.	P10	Median	P90
Commercial Land Price Change	2,228	13.63%	44.22%	-28.70%	12.64%	56.94%
Residential Land Price Change	2,102	10.46%	49.03%	-36.83%	11.34%	58.61%
Industrial Land Price Change	1,818	1.74%	26.49%	-16.43%	2.10%	21.31%

Table 2. Summary Statistics

	Mean	Std. Dev	p10	Median	p90
			All Firm-Years (24,685)		
Gross Investment	448,000,000	2,200,000,000	7,880,429	94,400,000	775,000,000
Net Fixed Asset (Lagged)	2,070,000,000	10,000,000,000	78,200,000	426,000,000	3,190,000,000
Non-land Investment	363,200,000	2,150,000,000	3,701,758	83,400,000	695,000,000
Residential land Investment	19,800,000	156,000,000	0	0	22,500,000
Commercial Investment	48,600,000	714,000,000	0	0	0
Industrial Investment	16,300,000	277,000,000	0	0	0
Total Land Value	496,000,000	4,180,000,000	0	0	534,000,000
Residential Land Value	143,000,000	1,640,000,000	0	0	16,500,000
Commercial Land Value	225,000,000	3,020,000,000	0	0	22,400,000
Industrial Land Value	129,000,000	815,000,000	0	0	199,000,000
Tobin's Q	2.009	1.501	0.525	1.549	4.402
Cash Flow	872,000,000	3,630,000,000	-185,000,000	163,000,000	1,870,000,000
Sale	4,570,000,000	15,400,000,000	227,000,000	1,190,000,000	8,550,000,000
Total Asset	6,660,000,000	21,000,000,000	637,000,000	2,150,000,000	11,900,000,000
R&D Expenditure	33,900,000	390,000,000	0	0	34,700,000
Number of New Patent (Invention+Utility Model+1)	2.997	30.844	0	0	4
Commercial Land Price Growth	13.35%	44.16%	-35.31%	13.70%	59.80%
Residential Land Price Growth	12.75%	50.42%	-27.20%	15.00%	57.60%
Industrial Land Price Growth	0.92%	34.21%	-19.30%	3.48%	24.10%

Table 3. Land Value and Gross Investment

	Gross Investment			
	(1)	(2)	(3)	(4)
Land Value$_{t-1}$	0.037***			
	(0.010)			
Land Value$_{t-1}^{Commercial}$		0.140***		
		(0.034)		
Land Value$_{t-1}^{Residential}$			0.072***	
			(0.016)	
Land Value$_{t-1}^{Industrial}$				-0.046
				(0.036)
Tobin's Q	-0.002	-0.003	-0.001	-0.001
	(0.011)	(0.011)	(0.011)	(0.011)
Sale	0.023***	0.023***	0.023***	0.024***
	(0.004)	(0.004)	(0.004)	(0.004)
Cash Flow	0.011***	0.011***	0.011***	0.012***
	(0.003)	(0.003)	(0.003)	(0.003)
Total Asset	0.076*	0.078**	0.075*	0.070*
	(0.030)	(0.030)	(0.030)	(0.030)
State Share	0.013	0.001	0.013	0.022
	(0.042)	(0.042)	(0.042)	(0.043)
Number of Observations	10850	10804	10809	10771
Adj. R-squared	0.413	0.416	0.417	0.412

Table 4. Land Price Change and Loan to Value Ratio for Land Collateralized Loans

	Loan to Value Ratio					
	(1)	(2)	(3)	(4)	(5)	(6)
Commercial Land	0.091***	0.090***	0.054*	0.091***	0.089***	0.090***
	(0.027)	(0.027)	(0.029)	(0.027)	(0.027)	(0.027)
Residential Land	0.020***	0.019***	0.019***	0.017***	0.008	0.020***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.009)	(0.004)
Price Change $_{t-1}^{Commercial}$ (Bank Branch City)		0.189***	0.006			
		(0.054)	(0.008)			
Price Change $_{t-1}^{Commercial}$ (Bank Branch City)*Commercial Land			0.225***			
			(0.072)			
Price Change$_{t-1}^{Residential}$ (Bank Branch City)				0.114**	0.005	
				(0.055)	(0.016)	
Price Change$_{t-1}^{Residential}$ (Bank Branch City)*Residential Land					0.114**	
					(0.055)	
Price Change $_{t-1}^{Industrial}$ (Bank Branch City)						0.044
						(0.028)
$\beta_{Commercial} - \beta_{Residential}$	0.071***	0.071***	0.035**	0.074***	0.081***	0.070***
	(0.016)	(0.018)	(0.016)	(0.018)	(0.021)	(0.019)
Number of Observations	354912	354912	354912	354912	354912	354912
Adj. R-squared	0.712	0.708	0694]	0.711	0.698	0.702

Table 5. Land Price Change and Firm Investment

Panel A	Gross Investment		Non-land Investment		Commercial Land Investment		Residential Land Investment		Industrial Land Investment	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Land Value$_{t-1}^{Commercial}$ (LVC)	0.133***	0.121***	0.129***	0.139***	0.008	-0.011	0.039***	0.034***	0.009***	0.009***
	(0.035)	(0.035)	(0.033)	(0.033)	(0.011)	(0.011)	(0.012)	(0.011)	(0.003)	(0.003)
Price Change$_{t-1}^{Commercial}$ (PCC)	0.016	0.005	-0.039***	-0.028**	0.045***	0.026**	0.009***	0.004	-0.001	-0.001
	(0.019)	(0.016)	(0.012)	(0.013)	(0.015)	(0.010)	(0.003)	(0.003)	(0.001)	(0.001)
LVC*PCC		0.106		-0.098***		0.171**		0.046**		-0.002
		(0.094)		(0.034)		(0.084)		(0.022)		(0.005)
Non-owner	-0.036	-0.038	0.029	0.030	-0.008**	-0.010***	-0.052***	-0.052***	-0.006***	-0.006***
	(0.024)	(0.025)	(0.024)	(0.024)	(0.003)	(0.003)	(0.003)	(0.003)	(0.001)	(0.001)
Non-owner*PCC	-0.100***	-0.088***	-0.039	-0.049	-0.044***	-0.026***	-0.015***	-0.010***	0.000	-0.000
	(0.034)	(0.033)	(0.031)	(0.032)	(0.015)	(0.010)	(0.004)	(0.004)	(0.001)	(0.001)
Number of Observations	10804	10804	10804	10804	10804	10804	10804	10804	10804	10804
Adj. R-squared	0.397	0.398	0.401	0.401	0.148	0.195	0.150	0.156	0.103	0.103

Panel B	Gross Investment		Non-land Investment		Commercial Land Investment		Residential Land Investment		Industrial Land Investment	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Land Value$_{t-1}^{Commercial}$ (LVC)	0.134***	0.132***	0.129***	0.137***	0.008	0.001	0.039***	0.032***	0.009***	0.010***
	(0.035)	(0.035)	(0.032)	(0.033)	(0.011)	(0.009)	(0.012)	(0.010)	(0.003)	(0.003)
Price Change$_{t-1}^{Residential}$ (PCR)	-0.022	-0.023	-0.038**	-0.029	0.008	0.001	0.009**	0.002	0.000	0.001*
	(0.017)	(0.017)	(0.017)	(0.018)	(0.009)	(0.006)	(0.004)	(0.003)	(0.000)	(0.000)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
LVC*PCR		0.010		-0.074**		0.062		0.058***		-0.003
		(0.062)		(0.038)		(0.057)		(0.019)		(0.003)
Non-owner	-0.044*	-0.044*	0.030	0.031	-0.015***	-0.016***	-0.053***	-0.054***	-0.006***	-0.006***
	(0.025)	(0.025)	(0.025)	(0.025)	(0.003)	(0.004)	(0.003)	(0.003)	(0.001)	(0.001)
Non-owner*PCR	-0.063*	-0.062*	-0.047	-0.056*	-0.008	-0.000	-0.010**	-0.003	0.000	-0.000
	(0.033)	(0.033)	(0.033)	(0.033)	(0.009)	(0.006)	(0.004)	(0.004)	(0.001)	(0.001)
Number of Observations	10804	10804	10804	10804	10804	10804	10804	10804	10804	10804
Adj. R-squared	0.397	0.397	0.401	0.402	0.129	0.137	0.150	0.163	0.103	0.103

Panel C	Gross Investment		Non-land Investment		Commercial Land Investment		Residential Land Investment		Industrial Land Investment	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Land Value$_{t-1}^{Commercial}$ (LVC)	0.132***	0.136***	0.128***	0.135***	0.008	0.008	0.038***	0.027**	0.009***	0.011***
	(0.035)	(0.036)	(0.033)	(0.034)	(0.011)	(0.011)	(0.012)	(0.011)	(0.003)	(0.003)
Price Change$_{t-1}^{Industrial}$ (PCI)	0.025	0.029	0.006	0.013	0.012*	0.013*	0.010*	-0.001	-0.002	-0.000
	(0.022)	(0.023)	(0.022)	(0.023)	(0.007)	(0.006)	(0.006)	(0.006)	(0.003)	(0.002)
LVC*PCI		-0.042		-0.070		-0.002		0.116**		-0.020
		(0.059)		(0.056)		(0.023)		(0.052)		(0.012)
Non-owner	-0.054**	-0.054**	0.022	0.022	-0.016***	-0.016***	-0.054***	-0.055***	-0.006***	-0.006***
	(0.025)	(0.025)	(0.024)	(0.024)	(0.004)	(0.004)	(0.003)	(0.003)	(0.001)	(0.001)
Non-owner*PCI	-0.035	-0.038	-0.028	-0.033	-0.013**	-0.013**	0.002	0.011*	0.003	0.001
	(0.033)	(0.033)	(0.032)	(0.032)	(0.006)	(0.006)	(0.006)	(0.006)	(0.003)	(0.002)
Number of Observations	10804	10804	10804	10804	10804	10804	10804	10804	10804	10804
Adj. R-squared	0.396	0.396	0.399	0.399	0.128	0.128	0.149	0.162	0.103	0.108

Table 6. Land Price Change and Firm Innovation

Panel A	R&D Expenditure		Patent (Logged)	
	(1)	(2)	(3)	(4)
Land Value$_{t-1}^{Commercial}$ (LVC)	0.064	0.123**	0.076	0.122**
	(0.065)	(0.054)	(0.053)	(0.057)
Price Change $_{t-1}^{Commercial}$ (PCC)	-0.054***	-0.026**	-0.166***	-0.120***
	(0.017)	(0.013)	(0.033)	(0.032)
LVC*PCC		-0.366**		-0.424**
		(0.151)		(0.165)
Non-owner	0.049	0.061*	0.047	0.053
	(0.036)	(0.034)	(0.041)	(0.041)
Non-owner*PCC	-0.089**	-0.119***	-0.172***	-0.218***
	(0.043)	(0.041)	(0.063)	(0.063)
Number of Observations	2535	2535	10804	10804
Adj. R-squared	0.644	0.662	0.737	0.738

Panel B	(1)	(2)	(3)	(4)
Land Value$_{t-1}^{Commercial}$ (LVC)	0.060	0.072	0.075	0.095*
	(0.066)	(0.061)	(0.054)	(0.054)
Price Change $_{t-1}^{Residential}$ (PCR)	-0.025*	-0.006	-0.059**	-0.036
	(0.014)	(0.012)	(0.028)	(0.029)
LVC*PCR		-0.152*		-0.182*
		(0.088)		(0.104)
Non-owner	0.029	0.034	0.021	0.025
	(0.034)	(0.033)	(0.040)	(0.040)
Non-owner*PCR	-0.001	-0.019	-0.014	-0.037
	(0.026)	(0.025)	(0.052)	(0.052)
Number of Observations	2535	2535	10804	10804
Adj. R-squared	0.633	0.641	0.734	0.734

Panel C	(1)	(2)	(3)	(4)
Land Value$_{t-1}^{Commercial}$ (LVC)	0.061	0.075	0.075	0.084
	(0.067)	(0.061)	(0.054)	(0.053)
Price Change $_{t-1}^{Industrial}$ (PCI)	-0.033	-0.005	-0.028	-0.019
	(0.023)	(0.022)	(0.042)	(0.043)
LVC*PCI		-0.313		-0.093
		(0.197)		(0.141)
Non-owner	0.027	0.029	0.020	0.021
	(0.033)	(0.033)	(0.040)	(0.040)
Non-owner*PCI	0.001	-0.025	0.062	0.055
	(0.050)	(0.050)	(0.064)	(0.064)
Number of Observations	2535	2535	10804	10804
Adj. R-squared	0.633	0.635	0.734	0.733

Table 7. Land Prices and Accessibility of Bank Loans, Loan-Level Analysis from 2000 to 2015

	Loans with Real Estate Collateral	Loans with Non-Real Estate Collateral	Loans without Collateral	Real Estate Collateral =2; Non-Real Estate Collateral=1; No Collateral=0
Panel A	(1)	(2)	(3)	(4)
Price Change $_{t-1}^{Commercial}$ (Bank Branch City)	0.059***	0.076***	-0.060***	0.044***
	(0.004)	(0.004)	(0.005)	(0.006)
Number of Observations	41930	41930	41930	41930
Adj. R-squared	0.314	0.283	0.302	0.296
Panel B	(5)	(6)	(7)	(8)
Price Change$_{t-1}^{Residential}$ (Bank Branch City)	0.049***	0.050***	-0.054***	0.059***
	(0.003)	(0.002)	(0.003)	(0.005)
Number of Observations	41930	41930	41930	41930
Adj. R-squared	0.314	0.283	0.302	0.296
Panel C	(9)	(10)	(11)	(12)
Price Change $_{t-1}^{Industrial}$ (Bank Branch City)	-0.005	0.000	-0.001	0.001
	(0.006)	(0.006)	(0.007)	(0.009)
Number of Observations	41930	41930	41930	41930
Adj. R-squared	0.308	0.275	0.297	0.293

Table 8. House Purchase Restriction Policy and Firm Investment

	Gross Investment		Non-land Investment		Commercial Land Investment		Residential Land Investment		Industrial Land Investment	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Land $Value_{t-1}^{Commercial}$ (LVC)	0.137***	0.220***	0.131***	0.175***	0.009	0.039*	0.039***	0.046	0.009***	0.009**
	(0.035)	(0.058)	(0.033)	(0.050)	(0.011)	(0.023)	(0.012)	(0.030)	(0.003)	(0.004)
Policy Shock	-0.032*	-0.018	0.014	0.021	-0.041***	-0.036***	-0.004	-0.003	-0.001	-0.001
	(0.018)	(0.018)	(0.017)	(0.017)	(0.006)	(0.005)	(0.003)	(0.004)	(0.001)	(0.001)
LVC*Policy Shock		-0.141***		-0.074		-0.052**		-0.011		0.000
		(0.053)		(0.048)		(0.022)		(0.038)		(0.004)
Non-owner	-0.103***	-0.099***	-0.011	-0.009	-0.027***	-0.025***	-0.059***	-0.058***	-0.006***	-0.006***
	(0.026)	(0.026)	(0.026)	(0.026)	(0.005)	(0.005)	(0.004)	(0.004)	(0.001)	(0.001)
Non-owner*Policy Shock	0.129***	0.117***	0.085***	0.079***	0.031***	0.027***	0.011***	0.011***	0.001	0.001
	(0.028)	(0.029)	(0.028)	(0.029)	(0.005)	(0.004)	(0.003)	(0.004)	(0.001)	(0.001)
Number of Observations	10804	10804	10804	10804	10804	10804	10804	10804	10804	10804
Adj. R-squared	0.398	0.399	0.401	0.401	0.141	0.145	0.149	0.149	0.103	0.103

Table 9. House Purchase Restriction Policy and Firm Innovation

	R&D Expenditure		Patent (Logged)	
	(1)	(2)	(3)	(4)
Land Value$_{t-1}^{Commercial}$ (LVC)	0.064	0.035	0.079	0.036
	(0.066)	(0.053)	(0.054)	(0.058)
Policy Shock	0.033**	0.027*	0.075**	0.068**
	(0.015)	(0.015)	(0.032)	(0.032)
LVC*Policy Shock		0.054		0.073
		(0.065)		(0.103)
Non-owner	0.000	-0.003	-0.028	-0.030
	(0.032)	(0.033)	(0.045)	(0.045)
Non-owner*Policy Shock	0.058*	0.063*	0.115**	0.121**
	(0.033)	(0.034)	(0.053)	(0.053)
Number of Observations	2535	2535	10804	10804
Adj. R-squared	0.635	0.635	0.734	0.734

Table 10. Land Prices and TFP Loss from Misallocation, 2000-2012

Panel A	Simple Average			Weighted Average by Industrial Output		
	(1)	(2)	(3)	(4)	(5)	(6)
Price Change^{Commercial}	0.090**			0.286***		
	(0.029)			(0.081)		
Price Change^{Residential}		0.035***			0.091***	
		(0.010)			(0.010)	
Price Change^{Industrial}			-0.046			0.017
			(0.032)			(0.055)
Number of Observations	654	963	696	654	963	696
Adj. R-squared	0.511	0.522	0.491	0.477	0.478	0.423

Panel B	Simple Average		Weighted Average by Industrial Output	
	(7)	(8)	(9)	(10)
Policy Shock	-0.212**	-0.224**	-0.233**	-0.081
	(0.100)	(0.107)	(0.108)	(0.274)
City Specific Time Trend	No	Yes	No	Yes
Number of Observations	985	985	985	985
Adj. R-squared	0.517	0.547	0.485	0.481

Figure 1. Size of Primary Land Market in China, 2000-2015

This figure depicts the total size of China's primary land market in terms of both total land payment (upper panel) and total area (lower panel) by type. The blue, red and green bar in both panels refer to the size of commercial land, residential, and industrial land respectively.

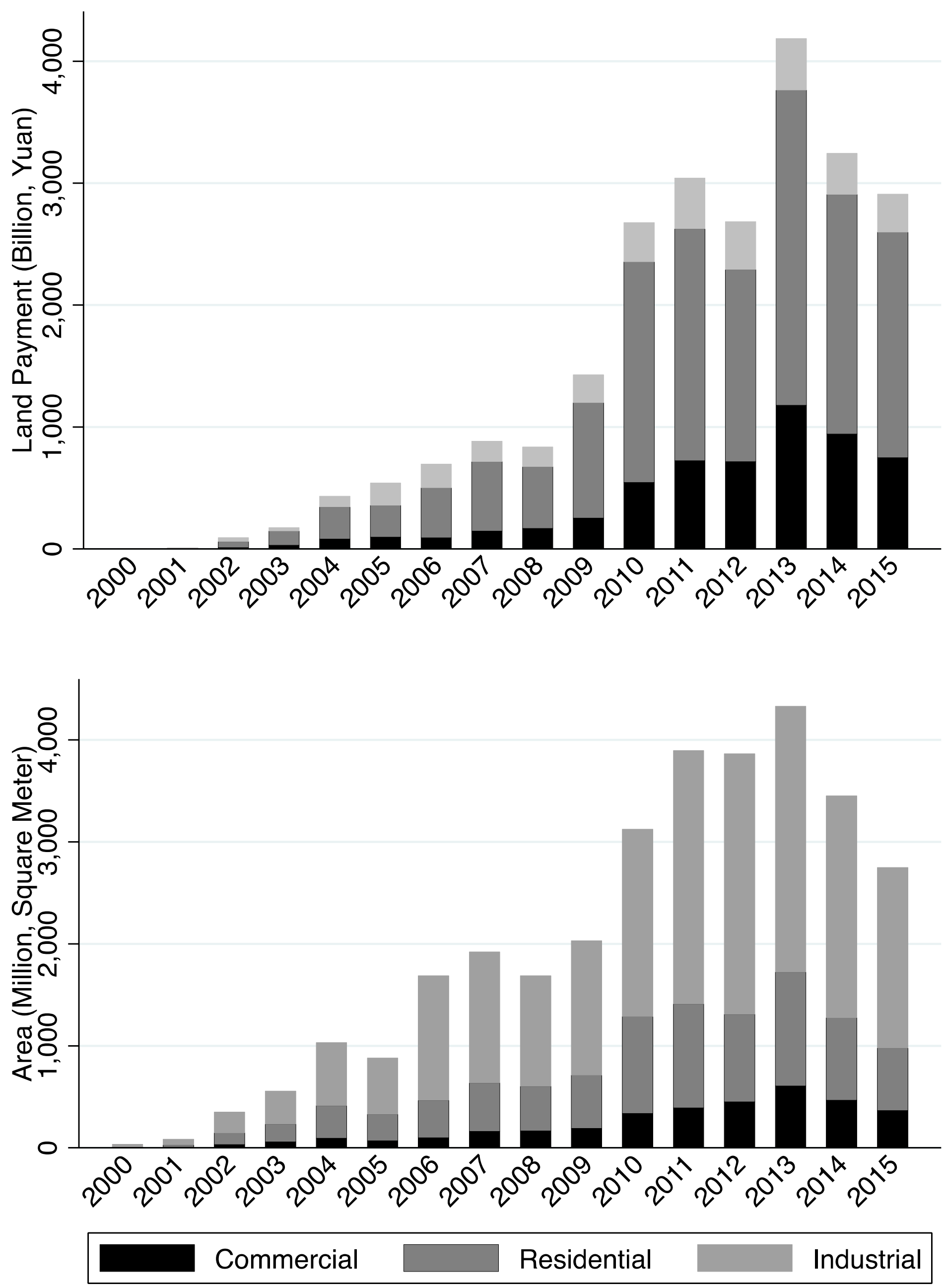
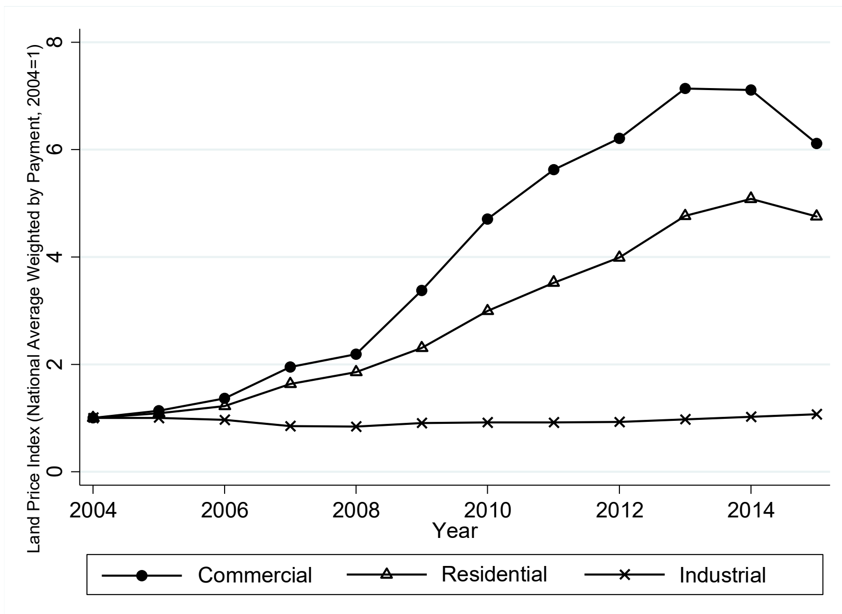


Figure 2. Land Prices, 2000-2015

Panel A depicts the national land price indices for residential, commercial, and industrial land between 2004 and 2015. We take average of the annual price growth calculated from the price indices of individual cities, weighted by payment for each of the 284 cities and normalize year 2004 to 1. Panel B depicts the one standard deviation land price change calculated from the city-year level land price indices. In both panels, the line with crosses is for the residential land price index, the line with circles for the commercial land price index, and the dot dash line for the industrial land price index.

Panel A



Panel B

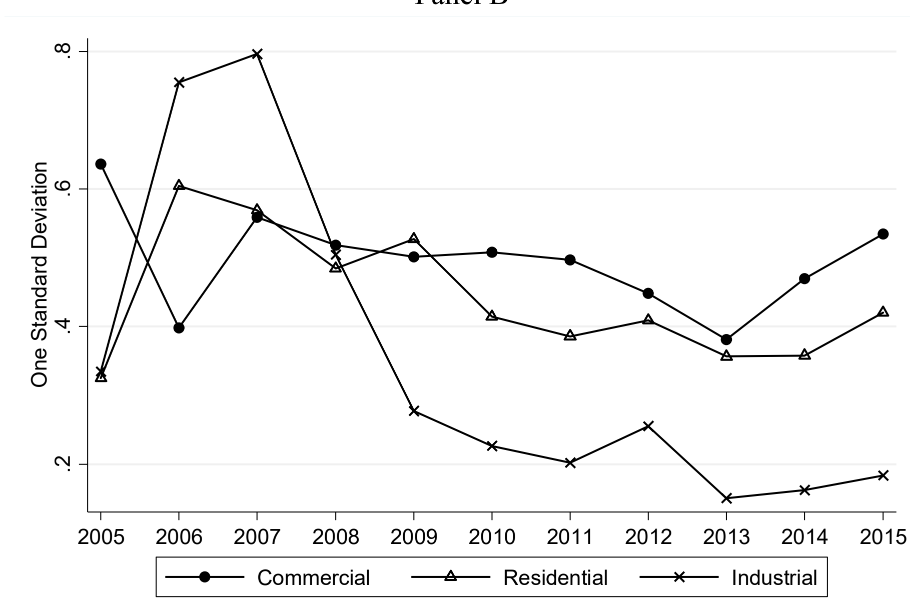


Figure 3. Land Price Indices in Three Tiers of Cities, 2004-2015

This figure compares land price indices over 2004-2015 in three tiers of cities in China. The line with triangles is the residential land price index, the line with dots the commercial land price index, the line with crosses the industrial land price index.

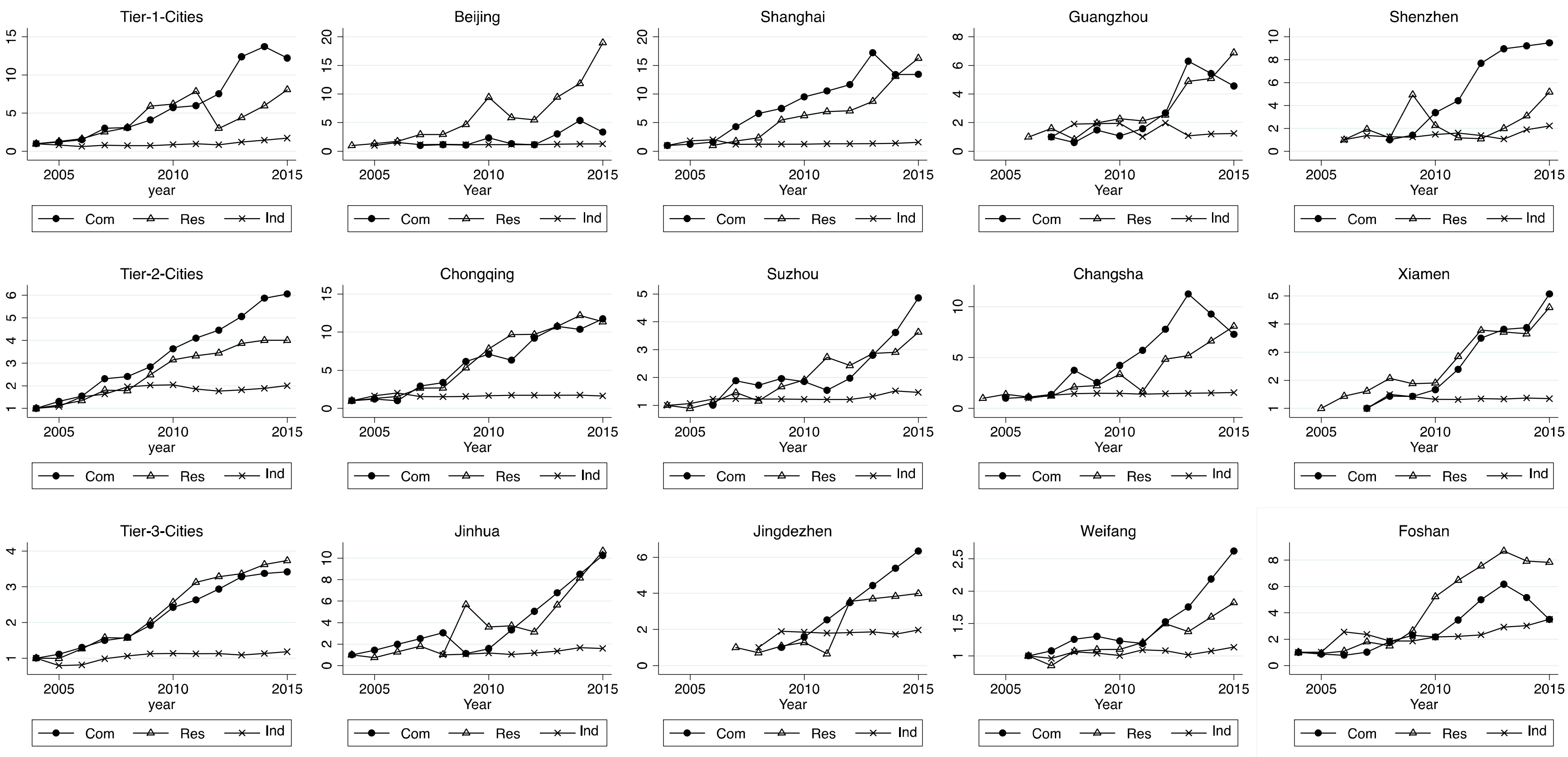


Figure 4. Firm Investment, 2000-2015

This figure depicts the total quantity of firm investment, divided into four components: non-land, residential land, commercial land, and industrial land, for all publicly listed firms in our sample from 2000 to 2015.

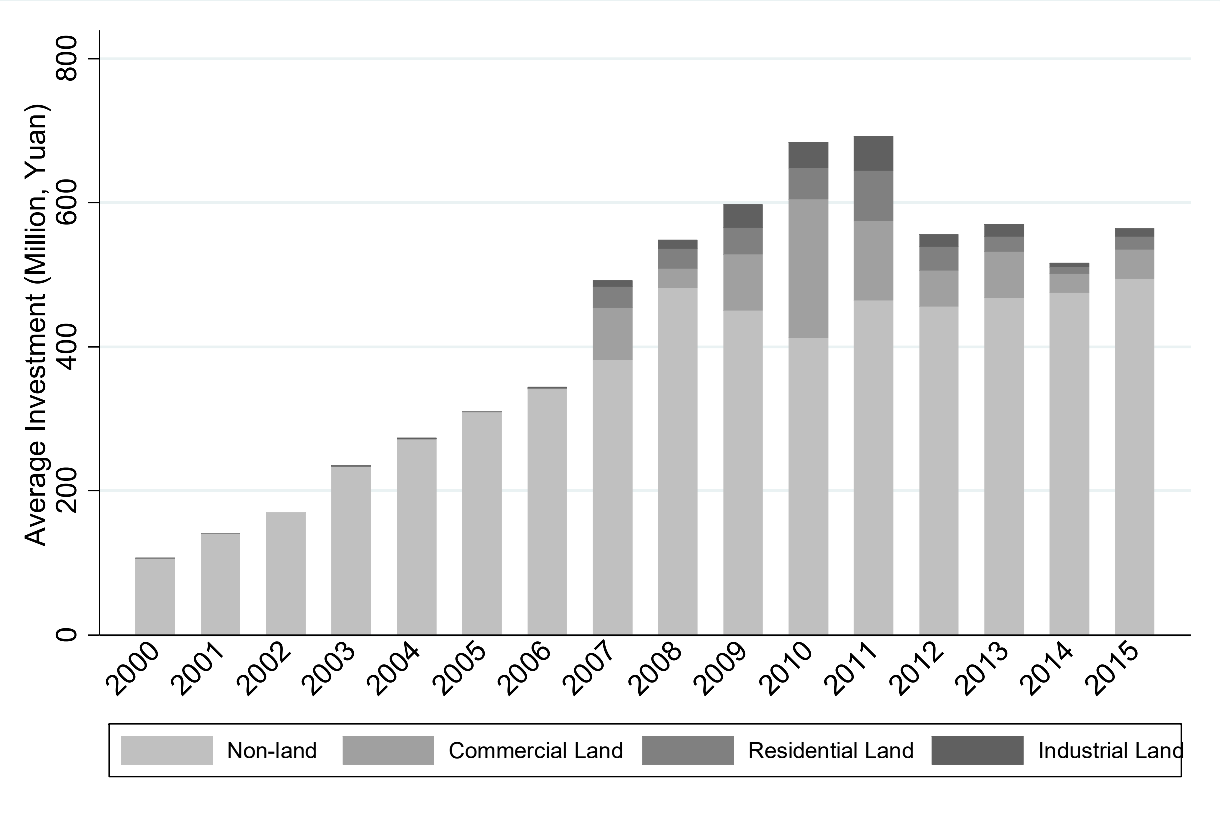


Figure 5. Comparing Land-Holding and Non-Land-Holding Firms

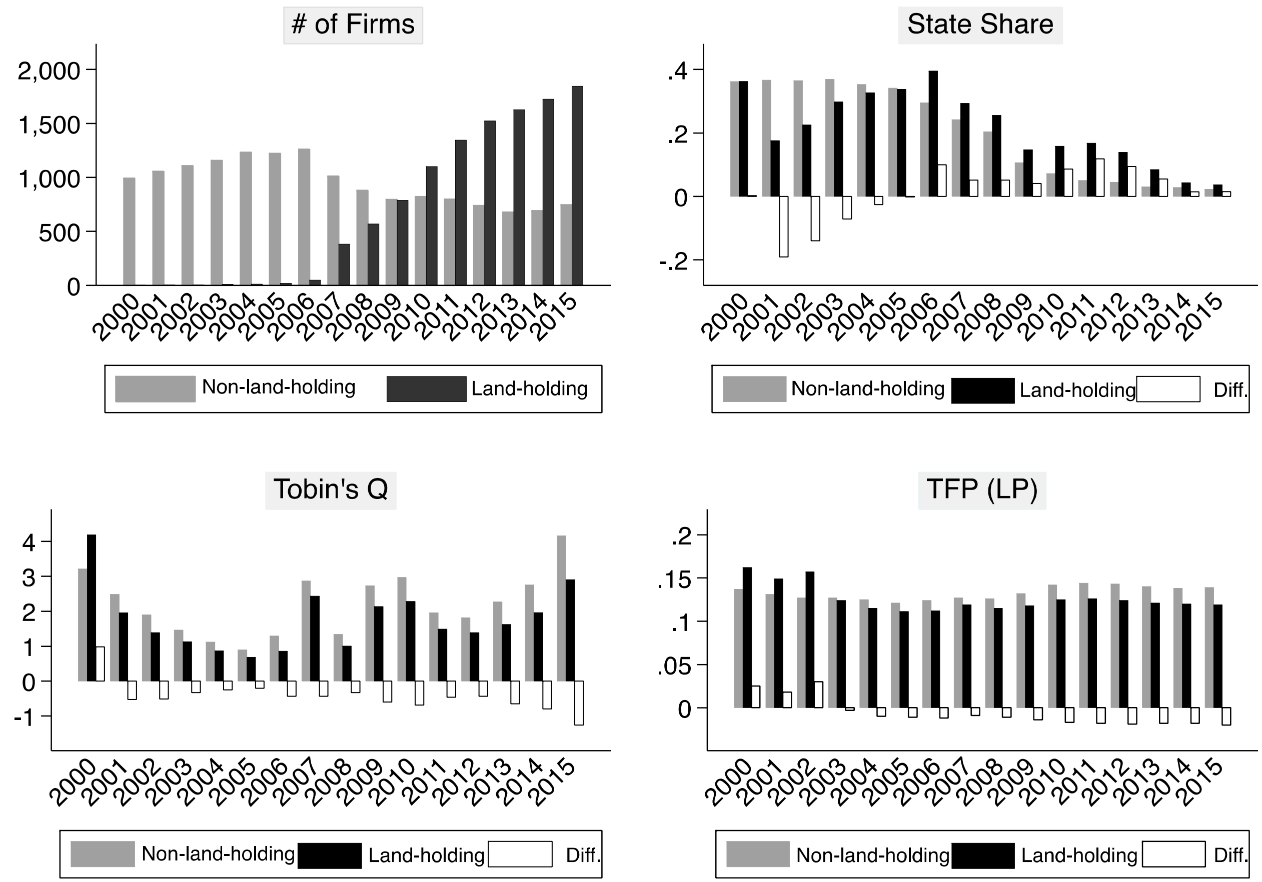
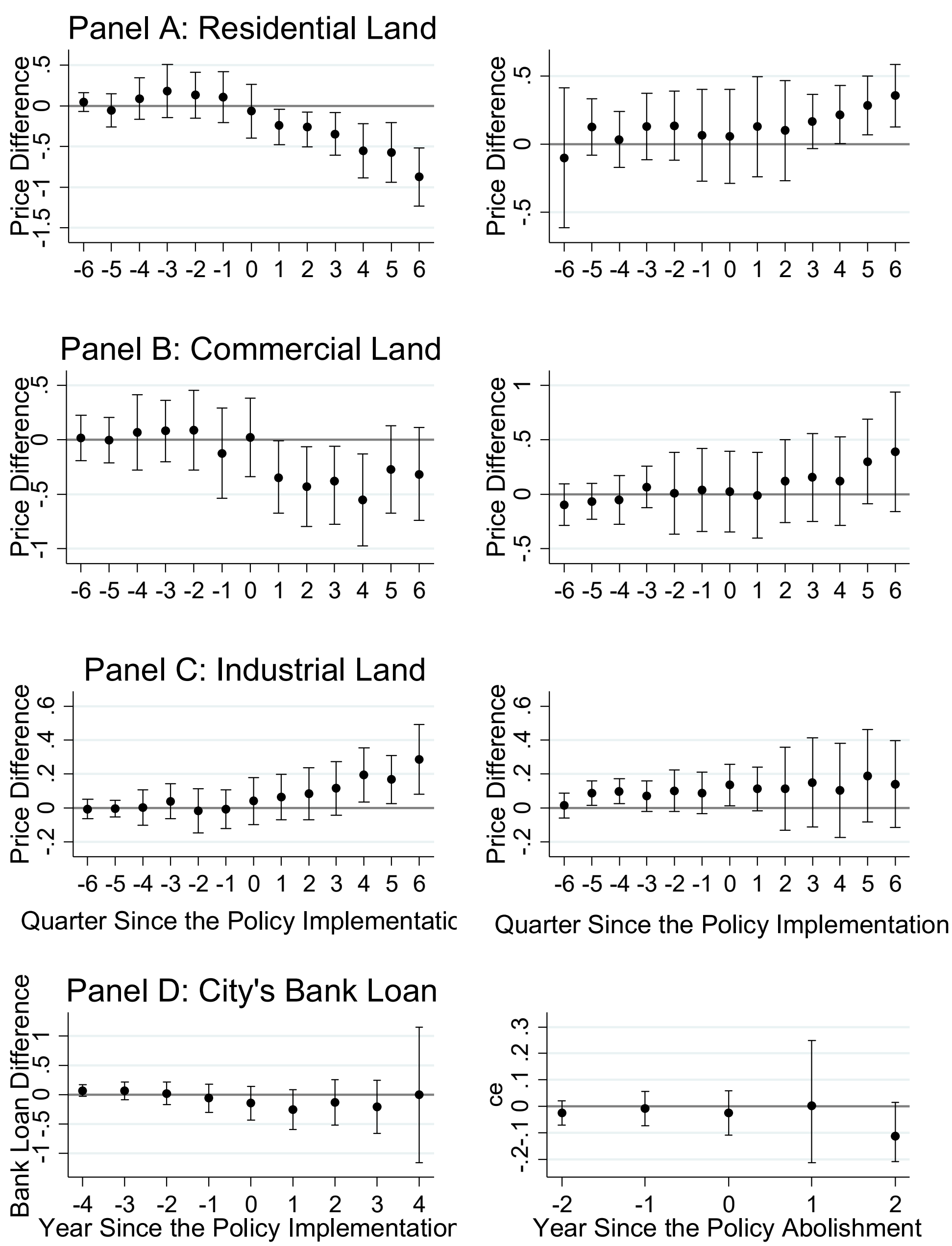


Figure 6. The Effect of Purchase Restriction Policy on Land Prices, DID Estimation

This figure plots the difference-in-differences estimators by the pre- and post-policy treatment period. The left panels use the implementation of restriction policy as benchmark treatment, while the right panels use the abolishment of the pertinent policy as benchmark treatment. Panel A uses the average price difference for residential land between the cities with restriction policy and those without as the dependent variable (y-axis), Panel B for commercial land Panel C for industrial land. The x-axis is the number of quarters since the announcement of the housing purchase restriction policy. The difference-in-differences coefficients in these three panels are estimated using the land transaction sample. Panel D uses the average difference in total size of bank loan as dependent variable, which are estimated using a city-level panel data on total size of bank loan.



Appendix A. Variable Definition

Variable Name	Definition
Land-holding Firm	A dummy variable indicates a firm has holding land in our sample period from 2000 to 2015.
Corporate Investment	Corporate investment is measured as capital expenditures divided by the lagged book value of PPE and capital expenditures are calculated as the sum of cash paid for the acquisition of fixed assets, intangible assets and other long-term assets in the annual statement of cash flows.
Land Value	Land value is the market value of land assets holding by company normalized by lagged PPE.
Tobin's Q	Tobin’s Q is measured as the market value plus total debt normalized by the book value of the firm.
Cash Flow	Cash flow is computed as the net operating cash flow divided by lagged PPE. Sales revenue is measured as cash received from sales of goods and services divided by lagged PPE.
Sale	Sale is defined as the natural logarithm of annual sale revenue.
Total Asset	Size is expressed as the natural logarithm of current total assets.
New Bank Loan	New bank loan is defined as the new loans a firm got within a given year from different banks, which is normalized by lagged book value of PPE.
Change in Total Debt	Change in total debt measure the change of book value of (long term debt + short term debt) at year t, which is normalized also by lagged PPE.
Firm-specific Policy Shock	Firm-specific policy shock is the diffs-in-diff dummy estimator indicates a firm holds lands in the cities with "housing purchase restriction" policies at year after the policy is in Effect.
Treatment Group Firm	Treatment group firm is a dummy variable indicates that a firm holds lands in the cities with "housing purchase restriction” policies.

Appendix B. Three Channels using Non-listed Firms Sample between 2008 to 2011

	Gross Investment		Non-land Investment		Commercial Land Investment		Residential Land Investment		Industrial Land Investment	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Land Value$_{t-1}^{Commercial}$ (LVC)	0098***	0.077***	0.123*	0.118*	0.022***	0.006*	0.017***	0.015***	0.037**	0.036**
	(0.033)	(0.020)	(0.074)	(0.075)	(0.004)	(0.004)	(0.004)	(0.006)	(0.017)	(0.017)
Price Change $_{t-1}^{Commercial}$ (PCC)	0.033	0.011	-0.014***	-0.017***	0.048***	0.054***	0.082	0.054	-0.025*	-0.026*
	(0.060)	(0.063)	(0.003)	(0.003)	(0.005)	(0.005)	(0.064)	(0.072)	(0.015)	(0.015)
LVC*PCC		0.016*		-0.121***		0.074***		0.034***		-0.044
		(0.009)		(0.027)		(0.026)		(0.011)		(0.073)
Non-owner	-0.083	-0.088	-0.062	-0.016	-0.008***	-0.009***	-0.003**	-0.003**	-0.007***	-0.009***
	(0.065)	(0.078)	(0.069)	(0.095)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
Non-owner*PCC	-0.306***	-0.346***	-0.525***	-0.390*	-0.006*	-0.006	-0.002	-0.005	-0.001	-0.002
	(0.083)	(0.091)	(0.160)	(0.205)	(0.004)	(0.004)	(0.002)	(0.004)	(0.002)	(0.002)
Number of Observations	2434196	2434196	2434196	2434196	2434196	2434196	2434196	2434196	2434196	2434196
Adj. R-squared	0.124	0.120	0.125	0.171	0.170	0.174	0.148	0.154	0.155	0.169

Appendix C. Firm Characteristics and Land Purchase Behavior

	Initial Purchase				Continuing Purchase			
	Panel A: Commercial Land							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
L.Tobin's Q	-0.006***				-0.007***			
	(0.001)				(0.003)			
L2.Tobin's Q		-0.001				-0.004*		
		(0.001)				(0.003)		
L.TFP (LP)			-0.287***				-0.531***	
			(0.048)				(0.087)	
L2.TFP (LP)				-0.264***				-0.545***
				(0.050)				(0.090)
L.Sale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L.Cash	0.000	0.000	0.001*	0.001*	0.001	0.001	0.001**	0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)
L.Asset	0.008***	0.010***	0.009***	0.010***	0.021***	0.023***	0.021***	0.021***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.005)	(0.005)	(0.004)	(0.005)
L.# of Employee	0.001	0.001	-0.001	-0.001	0.001	0.001	-0.002	-0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
L.State Share	0.026***	0.028***	0.028***	0.030***	0.029*	0.031**	0.031**	0.034**
	(0.010)	(0.010)	(0.010)	(0.010)	(0.015)	(0.016)	(0.015)	(0.016)
Number of Obs.	17540	16732	17909	17100	20012	19213	20444	19622
Adj. R-squared	0.060	0.071	0.066	0.067	0.047	0.049	0.050	0.051

	Initial Purchase				Continuing Purchase			

	Panel B: Residential Land							
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
L.Tobin's Q	-0.004				-0.002			
	(0.003)				(0.004)			
L2.Tobin's Q		0.007**				0.009**		
		(0.003)				(0.004)		
L. TFP (LP)			-0.098				-0.480***	
			(0.075)				(0.113)	
L2. TFP (LP)				-0.040				-0.421***
				(0.081)				(0.118)
L.Sale	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L.Cash	-0.001***	-0.001***	-0.001***	-0.001***	-0.003***	-0.003***	-0.002***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
L.Asset	0.019***	0.025***	0.021***	0.022***	0.082***	0.089***	0.078***	0.080***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.007)	(0.007)	(0.006)	(0.006)
L. # of Employee	0.005***	0.005***	0.005**	0.006***	0.010***	0.010***	0.009***	0.009***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
L. State Share	0.020	0.023	0.021	0.023	0.017	0.022	0.021	0.024
	(0.013)	(0.014)	(0.013)	(0.014)	(0.020)	(0.021)	(0.020)	(0.021)
Number of Obs.	13766	12948	14038	13237	20038	19243	20472	19647
Adj. R-squared	0.119	0.119	0.116	0.113	0.178	0.177	0.177	0.175

Appendix D. The List of 46 Cities That Adopted the Housing Purchase Restriction Policy with Dates of Announcing and Abolishing the Policy

City		City ID	Restriction Begin			Restriction End		
			Year	Month	Day	Year	Month	Day
北京市	Beijing	110000	2010	4	30			
天津市	Tianjin	120000	2010	10	13	2014	10	19
石家庄市	Shijiazhuang	130100	2011	2	20	2014	9	24
太原市	Taiyuan	140100	2011	1	14	2014	8	4
呼和浩特市	Huhehaote	150100	2011	4	14	2014	6	26
沈阳市	Shenyang	210100	2011	3	1	2014	9	12
大连市	Dalian	210200	2011	3	2	2014	9	3
长春市	Changchun	220100	2011	5	20	2015	6	4
哈尔滨市	Haerbin	230100	2011	2	28	2014	8	16
上海市	Shanghai	310000	2010	10	7			
南京市	Nanjing	320100	2010	10	13	2014	9	21
无锡市	Wuxi	320200	2011	2	24	2014	8	29
徐州市	Xuzhou	320300	2011	5	1	2014	8	1
苏州市	Suzhou	320500	2011	3	3	2014	9	26
杭州市	Hangzhou	330100	2010	10	11	2014	8	28
宁波市	Ningbo	330200	2010	10	9	2014	7	31
温州市	Wenzhou	330300	2011	3	11	2013	8	1
绍兴市	Shaoxing	330600	2011	8	25	2014	8	1
金华市	Jinhua	330700	2011	3	23	2014	8	1
衢州市	Quzhou	330800	2011	9	9	2014	7	23
舟山市	Zhoushan	330900	2011	8	2	2013	1	1
台州市	Taizhou	331000	2011	8	25	2014	8	19
合肥市	HeOLSi	340100	2011	1	25	2014	8	2
福州市	Fuzhou	350100	2010	10	11	2014	8	1
厦门市	Xiamen	350200	2010	10	1	2014	8	15
南昌市	Nanchang	360100	2011	2	20	2014	7	14
济南市	Jinan	370100	2011	1	21	2014	7	10
青岛市	Qinghai	370200	2011	1	30	2014	9	1
郑州市	Zhengzhou	410100	2011	1	6	2014	8	9
武汉市	Wuhan	420100	2011	1	15	2014	7	18
长沙市	Changsha	430100	2011	3	4	2014	8	6
广州市	Guangzhou	440100	2010	10	15			
深圳市	Shenzhen	440300	2010	9	30			
珠海市	Zhuhai	440400	2011	11	1	2016	3	16
佛山市	Foshan	440600	2011	3	18	2014	8	7
南宁市	Nanning	450100	2011	3	1	2014	10	1
海口市	Haikou	460100	2010	10	15	2014	7	23
三亚市	Sanya	460200	2010	10	12			
成都市	Chengdu	510100	2011	2	16	2015	1	21
贵阳市	Guiyang	520100	2011	2	18	2014	9	1
昆明市	Kunming	530100	2011	1	19	2014	8	11
西安市	Xi'an	610100	2011	3	1	2014	9	1
兰州市	Lanzhou	620100	2011	3	7	2014	7	28
西宁市	Xining	630100	2011	8	1	2014	9	9
银川市	Yinchuan	640100	2011	2	24	2014	8	26
乌鲁木齐市	Wulumuqi	650100	2011	3	9	2014	8	1