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## *The Housing Market Effects of Local Home Purchase Restrictions: Evidence from Beijing*

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# Evidence from Beijing

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**Abstract**

Home prices have surged in major Chinese cities, leading to concerns of asset price bubbles and housing affordability. The policy of home purchase restrictions (HPR) has been one of China's harshest housing market interventions to squeeze out speculative demand and dampen the soaring home prices. Beijing was the first city to implement the HPR. Employing the regression discontinuity design technique, we find that Beijing's HPR policy triggered a 17-24% decrease in resale price, a drop in the price-to-rent ratio of about a quarter of its mean value, and a deep (1/2 to 3/4) reduction in the transaction volume of the for-sale market, with no significant change in the rent or the transaction volume of rental units. In submarkets where housing supply was less elastic, the effects of the HPR were larger in price and smaller in quantity, suggesting that wealthy buyers likely benefited more from the HPR. The scope of the analysis does not allow conclusions regarding the persistence or longevity of these effects.

# 1 INTRODUCTION

Growing at a nearly 10% average annual rate for three decades, China's economy overtook

Japan in 2010 to become the second largest in the world, and is now rapidly approaching the U.S.

Urbanization has accompanied the rapid economic development of China – the proportion of

population living in urban areas increased from less than 20% in 1980 to 52% in 2012,

representing the urbanization of over 400 million people in barely more than one generation, the

greatest such migration in history. Market-oriented reforms in the urban land and property

markets since the 1990s have replaced the socialist welfare housing regime and established

increasingly competitive housing markets in Chinese cities. Housing demand and supply have

been growing rapidly, becoming a major source for China's economic growth. The average

amount of floor space per capita among urban households has increased from 21.81 to 29.15

square meters or by 33.6% during the first decade of this century according to national census

data. By late 2009, real estate investment accounted for about 20% of total investment and

around 9% of GDP, with loans to property developers and mortgages together accounting for

about 20% of total loans (Ahuja et al., 2010).

Home prices have surged across Chinese cities, leading to concerns about an asset price

bubble and housing affordability. As of the writing of this paper, home prices are at all-time

highs, and have experienced real price appreciation on a par with or in excess of that realized in

other markets (e.g., the U.S.) that are widely considered to have had housing bubbles (Wu et al.,

2012). Nonetheless, given China's rapid income growth and large-scale rural-to-urban migration,

there are different opinions about the existence of a national housing price bubble. Higher home

prices may still be broadly in line with the fundamental factors and could be supported by a solid

demand for residential housing (World Bank, 2010). However, many agree that housing price

appreciation in the most expensive metropolitan areas, mainly the big coastal cities, has gone beyond changes in fundamentals (e.g., Peng et al., 2008; Ahuja et al., 2010; Yu, 2010; Dreger and Zhang, 2013; Wang and Zhang, 2012). In addition, given China's high income inequality, concerns about the possible overheating of the market and bubbles are aggravated by the concerns that lower and middle income households cannot afford to buy an apartment in or close to the center of large cities (World Bank, 2010).

The Chinese government owns urban land and plays the dominant role in controlling and managing housing supply, demand, and finance. The urban property markets' important roles in economic growth and local fiscal revenue (especially from the land leasehold sales) have led Chinese policymakers to closely monitor and frequently intervene in the housing market to maintain its stable growth, especially in light of the subprime mortgage crisis in the U.S. Authorities at the national and local levels have adjusted land supply, access to credit, and the permission to purchase properties alternately to cool and stimulate markets (Chen, 2012; Lu et al., 2012). However, there have been very few studies of the effects of government interventions in China's property markets, especially in local markets.

This research aims to evaluate the effects of home purchase restrictions (HPR), an unprecedented anti-speculation policy in Beijing. Instead of relying on aggregate housing price or rent indices, we apply the regression discontinuity design (RDD) technique to a large transaction dataset of resale and rental housing units in Beijing. We find that resale home prices dropped by 17-24% immediately after the implementation of the HPR, while rent remained largely unaffected. As a result, the price-to-rent ratio shrank by about 23-29% of its pre-HPR mean value. It suggests that the HPR did lower Beijing's housing price, at least during the initial

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years after the HPR. This paper also explores the intra-city spatial variations in the effects of the policy associated with submarket supply conditions.

The rest of the paper is organized as follows. We introduce the HPR policy in Beijing in Section 2, followed by descriptions of data and methods in Sections 3 and 4. Section 5 discusses results. Section 6 concludes the paper with policy implications.

## 2    HOME PURCHASE RESTRICTIONS IN BEIJING

Beijing, the capital city and a megacity of China, has one of the most heated housing markets in the world. According to the 2010 census, the urban population of Beijing reached 16.86 million, including about 64% locally registered residents (i.e., those with local household registration, or *Hukou*)[1] and 36% unregistered (or non-*Hukou*) residents. Between 2003-Q1 and 2010-Q1, Beijing's housing prices appreciated by nearly 20% per year in nominal terms (Wu et al., 2012). Recent housing price-to-income and price-to-rent ratios are at their highest levels in Beijing's history. By early 2010, estimated price-to-income ratios varied from just below 10 (Lu et al., 2012) to above 18 (Wu et al., 2012). Wu et al.'s (2012) estimates also indicate an increase in the price-to-(annual) rent ratio from 26.4 in 2007-Q1 to 45.9 in 2010-Q1, suggesting the possibility of a local housing bubble.

As China's housing markets recovered quickly from the influence of the subprime mortgage crisis and housing prices kept on rising, the government introduced two rounds of market regulations in 2010 mainly to deter speculation. On February 21st, the first round of

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[1] *Hukou* is a resident permit issued to households by the government of China. Every household has a *Hukou* that records information about the household members, including name, birth date, relationship with each other, marriage status (and with whom if married), address and employer. Rural Chinese who migrate to cities are often ineligible for basic urban welfare and social services due to the lack of a local urban *Hukou*.

regulation , hereinafter Policy I, required the down-payment ratio to be a minimum of 40% for the purchase of second homes (a reiteration of a 2007 policy[2]) and raised the profit tax rate on home resale within five years of last purchase. Due to the limited effect of Policy I, in April 2010 the State Council required local governments to impose direct restrictions on home purchases, a measure considered by many as "the harshest housing market regulation".[3] The larger cities were urged by the State Council to implement stricter HPR measures and to do so more promptly. Two weeks later, on April 30, 2010, Beijing became the first city to announce and enact immediately a bundle of policies, hereinafter Policy II.[4] The central feature of Policy II was the home purchase restrictions (HPR), the first command-and-control type regulation on housing demand. The HPR limits households with a Beijing local *Hukou* to a maximum of two homes (except that additional homes already owned were "grandfathered") while non-*hukou* households were simply prohibited from purchasing homes any more.

Accompanying the HPR in the bundle of Policy II there were two additional policies. One is the further strengthening of Policy I – requiring a minimum of 50% down payment with a mortgage rate at least 1.10 times the base interest rate for the purchase of second homes. The other policy is essentially a reiteration of a national policy enacted in 2007 (see footnote 2) requiring the minimum down payment ratio to be 30% for a first-home larger than 90 m$^2$ in size. Given that these two policies additional to the HPR in Policy II essentially only marginally

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[2] On September 27, 2007, People's Bank of China issued its No. 359 [2007] regulation: "notice of the People's Bank of China and China Banking Regulatory Commission on strengthening the management of commercial real estate credit loans".

[3] According to the State Council's guidelines, urban households with local *Hukou* can own up to two housing units, and non-*Hukou* households who have been working and paying tax in the city for more than one year can only own one housing unit. Other urban households were prohibited from purchasing a home. The Beijing restrictions discussed in this paper are stricter than these national guidelines.

[4] By the end of March 2011, 33 cities had imposed the HPR policy.

modified or reiterated previous policies and were less restrictive than the HPR's direct command and control, we will first focus our analysis on the HPR element of Policy II before returning to the two additional policies later in the paper.

To restrict the speculative housing demand in Beijing, the HPR does not deal with the factors motivating the speculative demand, and relies on a simple command-and-control of market entry based on *Hukou* status and the number of units owned. By restricting the eligibility to purchase homes to certain groups of people, the HPR significantly and suddenly alters the demand in Beijing's housing market, as detailed below.

The HPR brings two direct, first-order impacts on Beijing's housing market. The first impact is the dampening of demand for for-sale units as some households are denied access to the demand side of the market of for-sale housing, resulting in an exogenous negative demand shock in the for-sale market. This negative demand shock should lead to clear drops in both price and transaction volume in the for-sale market, although the impact may be somewhat mitigated after all sorts of secondary effects kick in. The other first-order impact is the forced shift of some households from buyers to renters. For households who have housing needs but no local *Hukou*, including many young graduates from colleges and universities, the HPR limits their options to either becoming renters or leaving Beijing, with the latter a more complicated and longer-term decision. However, whether and how such a shift of demand from the for-sale market (directly affected by the HPR) to the connected rental market will affect rents and rental volumes depend on a wide range of secondary market responses.

There are many possible secondary effects due to the behavioral changes of household groups indirectly affected by the HPR and the supply-side responses in both the for-sale and the rental markets. For example, the HPR still allows those households with local *Hukou* and fewer

than two homes to buy one home. They may be attracted by the housing price reduction (caused by the first-order demand drop) to buy, or alternatively, they may be discouraged from speculative purchase if the HPR reduces the expectation of price appreciation and thereby reduces expected investment returns.[5] On the supply side, while the HPR does nothing fundamentally to stimulate new physical supply of additional housing (the welfare-maximizing approach to putting downward pressure on home prices if there is not a bubble), such a policy could actually have a temporary positive effect on the supply of housing if speculative developers and investor/owners put their vacant properties into the market (including into the rental market) as a result of perceived effectiveness of the HPR at dampening price appreciation. As a result, although rental price and rental transaction volume would face upward pressure due to the shift in demand from for-sale to rental housing, an increased supply in rental housing could offset any upward pressure on rent.

Overall, the implications of the direct demand-side effects are unambiguous for for-sale home prices and sales volumes (downward). But the effects of the HPR are ambiguous for rents and volume in the rental market due to the above-noted range of potential secondary effects. The previous qualitative analysis has important implications for the interpretation of a price drop in the for-sale housing market in Beijing immediately following the HPR policies. Such a drop would point to speculation as having played a major role in the increase in for-sale housing prices in Beijing prior to May 2010, as the speculative demand from owning multiple homes is the target of the HPR policy. However, any such interpretation would not be air-tight, as directly-targeted groups were only partially responsible for speculative demand. To the extent any post-HPR price drop resulted from the removal of the owner-occupancy demand (non-speculative

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[5] Other possibilities are plausible given the different expectation effects. For example, if households view the HPR as a temporary policy, there could emerge a new expectation-based purchase demand.

demand) by some households (e.g., the non-*Hukou* households owning no home), such a resulting price drop does not imply a speculation-based cause of the previous for-sale home price increases or the price level just prior to May 2010.

Finally, there is an interesting question of whether and how effects of the HPR may be spatially heterogeneous within metropolitan Beijing. An exogenous demand shock's effects on a market always depend on the supply-price elasticity of a local housing market. Several recent studies have empirically tested the effects of housing supply constraints (caused by different geographic conditions or local regulatory regimes) on housing price in different countries (e.g., Glaeser et al., 2005; Glaeser et al., 2008; Hilber and Mayer, 2001; Paciorek, 2013; Saiz, 2010; Stadelmann and Billon, 2012). In Beijing, Zheng et al. (2014) find that the capitalization rate of public goods in home prices is larger in supply-constrained locations. We expect that the HPR affects Beijing's different housing submarkets differently. Specifically, submarkets with a smaller supply price-elasticity will show greater price drop and less volume drop following the HPR. This may have important policy implications about the distributional effects of the HPR. For example, if housing price is correlated with supply conditions (e.g., housing tends to be more expensive where there is little room for additional supply), then this suggests that the buyers of expensive homes probably benefit more from the HPR because affordability is improved more where supply is less elastic.

## 3    DATA

We obtain resale and rental transaction datasets from a major broker company "*WoAiWoJia*" (www.5i5j.com), the second largest broker in Beijing with a market share of more than 10

percent.[6] Judging from 5i5j.com's market share and the spatial distribution of sample transactions (see Figures 1 and 2), we believe their resale and rental transactions can be approximately considered as representative of the whole market.

Figure 1 shows the spatial distribution of all resale transactions conducted by 5i5j.com during 2005-2011. The effective sample contains 43,305 individual sales in about 3,300 residential complexes. For each transaction record we have the information of transaction date, exact location, and the housing unit's physical attributes such as unit size (*house_size*), age (*house_age*), floor number (*floor*), the number of bathrooms (*bathroom*) and decoration status in discrete levels (*decoration*). The average resale housing unit is 75.45 square meters in size, 14.9 years old, and the mean transaction price (*price*) is 16,841.2 yuan per square meter in 2005 price.

*** Figure 1 about here ***

Similarly, Figure 2 is a map of all rental transactions. After data cleaning, the rental transaction dataset has a total of 186,628 observations in about 3,000 residential complexes during 2005-2011. We have similar variables of rental transactions as for the resale observations. The average rental housing unit is 63.79 square meters in size (smaller than the average resale housing units) and the mean monthly rental price (*rent*) is 46.9 yuan per square meter in 2005 price.[7] Within this rental transaction dataset, 13,052 units have repeated transaction records. The average length of the lease term for those repeated transactions is 0.9 year.

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[6] "Study on the market share of Beijing real estate broker firms (June-October, 2012)" by China Index Academy (http://fdc.fang.com/report/6115.htm).

[7] The common practice in Beijing is that the landlord pays for the condo fee (property management fee) and winter heating fee, while the tenant pays utilities and other fees (there is no property tax). The sum of condo fee and winter

*** Figure 2 about here ***

We geocode all the resale and rental transactions and calculate the distances of each residential complex from the city center – Tian'anmen Square (*d_center*), the closest Key Primary School (*d_school*), subway stop (*d_subway*) and large park (*d_park*).[8]

Figures 3 through 6 plot the temporal distributions of the resale and rental transactions. The red vertical line in each figure is the announcement/implementation date of Beijing's HPR policy ("Policy II", April 30th/May 1st, 2010). The yellow data points are transactions that happened in the two weeks between the announcement of the national guidelines (April 17th, 2010) and the actual implementation of Beijing's HPR policy. A simple visual examination does not suggest any local market response to the national guidelines prior to the local HPR policy, understandable as Beijing rolled out its local policy promptly after the national guidelines.

Figure 3 shows the home prices documented in the resale transactions during 2005-2011, with a clear rising trend from 2005 to the first half of 2010. After the HPR policy (red line), the growth becomes somewhat stagnant and even negative in 2011. Rent has a relatively wider cross-sectional distribution than price (Figure 4). It also has a more persistent growth trend during our study period, with significant seasonal variations.

Our resale and rental datasets overlap in 2800 residential complexes, a large majority of the complexes in both datasets. The units in a complex share the same architectural design,

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heating fee is about 10% to 15% of the gross rent. Also, in Beijing the condo fee does not include hazard insurance, which can be purchased by property owners from insurance companies.

[8] There are altogether 40 Key Primary (high-quality) Schools, 10 subway lines and 64 large parks in Beijing during the study period.

location and neighborhood attributes, and they are of the same age, while only differing

somewhat in the physical attributes such as unit size, floor number, and level of decoration. We

take advantage of this high within-complex homogeneity to calculate the complex-level price-to-

rent ratio if a complex has both resale and rental transactions within the same week. We divide

the average housing price per square meter by the average monthly rent per square meter of the

transactions in that complex in each week to obtain this ratio.[9] Figure 5 shows the distribution of

complex-level price-to-rent ratio and its temporal changes.

Figure 6 plots the transaction volumes of resale units by week. 5i5j.com's transaction

volume steadily increased from 2005 to the end of 2007 before a significant drop in 2008, most

likely due to the global financial crisis. But starting from early 2009 it began to rise rapidly until

the implementation of the HPR policy, following which there seems to be a big shrinkage in

transaction volume, although later on it rose and fell again. As with the rental price trend in

Figure 4, the rental transaction volume (Figure 7) shows a clear annual cyclical pattern. Table 1

presents the definitions and summary statistics of the variables.


*** Figures 3-7 about here ***


*** Table 1 about here ***

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[9] Since the number of observations in a complex in a week is usually small, we are unable to run a hedonic regression to control for physical attributes. Therefore the ratio is calculated with simple averages at the complex-level.

## 4  METHOD

To identify a potential discontinuity in housing market indicators (price, rent, price-to-rent ratio, and transaction volumes) triggered by the HPR policy, we employ the regression discontinuity design (RDD) technique for resale and rental prices as specified below:

$$\log(Y_i) = \beta_0 + \beta_1 \cdot HPR_i + \sum_{k=1}^{K} \beta_{2k} \cdot Week_i^k + \sum_{l=1}^{11} \beta_{3l} \cdot Month_{li} + \sum_{m=1}^{M} \beta_{4m} \cdot X_{mi} + \varepsilon \,, \tag{1}$$

where $Y_i$ is unit home price or monthly rent of a transaction observation $i$,. $HPR_i$ equals one if transaction $i$ happens after April 30th, 2010, otherwise zero. $\beta_1$ is the primary coefficient of interest that captures the discontinuity in the dependent variable due to the HPR policy. Vector $\beta_2$ captures any pre-existing time trend using a $K^{th}$-order polynomial of sequential week numbers ($Week = 1, 2, 3, \ldots$). $Month_{li}$ represents 11 month dummies to capture seasonality. The physical and location controls $X_m$ capture the cross-sectional differences in housing unit/residential complex characteristics. $\beta_1$ represents a constant effect of HPR during the subsequent history in our data, which is relatively short as it goes only through 2011, less than two years after the HPR's implementation. After estimating Equation (1), we can calculate the direction and relative magnitude of the effect of the *HPR* on the housing price or rent as $\Delta Y(\%)|_{HPR=1} = e^{\beta_1} - 1$.[10]

Similar RDD regressions are implemented with the price-to-rent ratio (aggregated each week for complex $i$) and weekly resale and transaction volumes ($i$ is suppressed in this case) as dependent variables, although only location characteristics are controlled for in the complex-level price-to-rent ratio regressions and no physical or location control is used in the transaction volume regressions.[11]

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[10] This is because $\beta_1 = \log(Y_{HPR=1}) - \log(Y_{HPR=0}) = \log(Y_{HPR=1}/Y_{HPR=0}) = \log(\Delta Y(\%)|_{HPR=1} + 1)$.

[11] Although the transactions in our datasets are only part of the whole market, we can still use the RDD technique to identify the effect of the HPR on transaction volumes, employing the reasonable assumption that other factors

It is difficult to estimate the dynamic effects of the HPR (or any similar housing market intervention) – whether and how the effects change over time (including how persistent they may be – due to both data and modeling reasons. To reliably estimate the HPR's effect on the housing market over time after the policy implementation requires additional information on the evolution of market fundamentals as well as on other relevant local and national policy interventions during the period of study, and it also requires a housing market model sensitive to all policy interventions involved (including perhaps inter-city market interactions). Such an analysis would be very complex and methodologically challenging, and is beyond the scope of the current paper.[12] For example, in the long term, deprived of the option to buy a home, some non-*Hukou* households at the margin may decide to move away from Beijing, which may restrict labor supply and hurt the long-term economic growth and housing demand in Beijing. There could be other side-effects or unanticipated consequences, such as the behavior of household formation, including possibly an increase in divorces (allowing the same two people to form two households, hence, buy two housing units), a reduction in marriage rate (for the same reason), and/or increased tendency for separate living between the generations.

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affecting the broker's market share remained unchanged during the short period immediately before and after the implementation date of HPR policy.

[12] Polynomial regressions, as adopted in this study, have the ability to approximate a difficult-to-evaluate nonlinear function, but very limited interpretability.

# 5   RESULTS

## 5.1   City-wide price, rent, and volume effects

We obtain strong and robust city-wide effects of the HPR on the price and volume in the resale but not the rental market. Table 2 reports a representative set of RDD results.[13] Column (1) provides the regression result for resale housing price. The coefficient of *HPR* is statistically significant (0.1% level) and shows a 22.7% (exp(-0.258)-1) drop in housing price after the implementation of HPR. For the control variables, unit size and house age both have a "U-shape" relationship with price. The peak value happens around 160 square meters in unit size and 24 years in age. On the other hand, there is an "inverse-U" relationship between price and floor number. Housing units on the 6th -7th floor are the most expensive, while units on the top floor have their price discounted. The number of bathrooms and better decoration contribute to a higher price. For the location attributes, proximities to the city center, Key Primary Schools and subway stops all show significant price premiums. Column (2) reports the result for rents. The coefficient of HPR is also negative (at 0.1% level) and shows a 6.33% (exp(-0.0654)-1) decrease in rent, much smaller compared to the decrease of housing price. Results for control variables are similar to those of housing price in column (1). Column (3) shows that after the implementation of the *HPR*, the average price-to-(monthly) rent ratio decreased by 110.1, more than one quarter of the sample mean ratio of 379.82.

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[13] We choose to highlight the results of a tenth-order polynomial time trend because (1) it has a higher adjusted $R^2$ compared to the regressions with other orders of polynomial time trend; and (2) perhaps more importantly, we are trying to be conservative on identifying the HPR effects, and the higher the polynomial order the easier for the regression to model changes in the historical market prices in the polynomial, and the more difficult it will be for the regression to "find" a significant treatment effect of the HPR. Nevertheless, in this paper we also present extensive robustness checks for alternative specifications including different polynomial orders and time windows.

*** Table 2 about here ***

Table 3 reports the RDD estimates with different polynomial time trends. The effects of HPR on resale housing prices are significantly negative and consistent in magnitude (about a 20-23% drop). But for the rental market effects, with fifth- and sixth-order polynomial time trends, HPR has a small positive effect around 3%. However, this effect flips its sign (-5% to -7%) with higher orders of polynomial time trends. The effect of the HPR on price-to-(monthly) rent ratio is negative and statistically significant in all specifications with the coefficient ranging from -85.85 to -110.1, indicating that the HPR policy suppressed the price-to-rent ratio by about 23-29% of its mean.

*** Table 3 about here ***

The inconsistent estimates of the effects of the HPR on the rental market might result from the fact that the RDD analysis of the full sample mostly compares the before-and-after-HPR rents of different housing units, because the terms of rental contracts usually last for the whole period of lease. To address this problem, we focus on the 13,052 repeated rental transactions in our sample to compare the longitudinal changes in rent around the implementation of the HPR. In Table 4, we estimate rent change in time windows of one week, two weeks and one month on both sides of the HPR. However, we cannot identify a price

discontinuity due to the HPR in the price trend of the rental market as the t-tests cannot reject the null that there was no difference in the way rents changed around the HPR.[14]

*** Table 4 about here ***

Table 5 presents the RDD regression results on transaction volumes with different orders of polynomial time trends. The transaction volume of resale units experienced a huge negative impact from the implementation of the HPR, with the sizes of magnitude ranging from about 50.9% (exp(-0.712)-1) to 76.7% (exp(-1.458)-1). On the contrary, the rental transaction volume did not show significant change around the HPR.

*** Table 5 about here ***

Table 6 shows the results of the robustness tests using alternative symmetric time windows: 1.67 years before and after the HPR – the longest symmetric time window allowed by our data, and one year before and after the HPR, the minimum time window to control for seasonality. Overall, we get very consistent results about the direction and magnitude of the

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[14] At the aggregate level, we also obtain similar price and rent effects of the HPR based on the monthly indices of new and resale price and rent. These aggregate-level analyses use the quality-controlled hedonic monthly price indices for newly-built houses constructed by the Institute of Real Estate Studies of Tsinghua University for 90 Chinese cities (Zheng et al., 2010) and similar quality-controlled hedonic monthly price and rent indices calculated using our micro resale and rental transaction data. We find that the effect of the HPR on the price index of newly-built housing is a significant drop of about 12.3-17.3% with multiple orders of time polynomials, while the effects of the HPR on resale housing price and rent indices are basically the same as the results obtained from the micro data reported above. Results are available upon request.

resale price effect no matter which time window or polynomial order we use (once that order is reasonably high).

*** Table 6 about here ***

To remove the potential disturbance of Policy I (the earlier down-payment and tax policies implemented in February 2010) on our analysis of the effect of the HPR implemented at the end of April 2010, we consider an additional very narrow time window: from February 21, 2010 to June 30, 2010, about 2 months before and after the HPR. This time window excludes the period prior to Policy I and thereby isolates the intervention analysis to only the effect of Policy II. The results for resale housing price and rent are consistent with what we have found above. But the sample sizes of the transaction volume regressions are now too small to produce reliable results as the narrow time window cannot control for seasonality.

Finally, to explore possible dynamic effects of the HPR, we augment Equation (1) with a time effect of the HPR as a quadratic term or discrete time dummies. Under each specification, we also alternate the time units (week, month, and quarter) used.[15] However, no clear or definitive dynamic pattern is identifiable across various polynomial orders and/or time windows. For example, we cannot say definitively whether the HPR effect was growing or diminishing (or first growing and then diminishing) during the 20 months in our data after the HPR was

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[15] We used alternative time units to model HPR's dynamic effect, not the overall market trend, which has always been fitted by polynomials of weeks. The use of time units other than the week and specifications other than the polynomial alleviates the potential problem of multicollinearity between the market trend and HPR's dynamic effect.

implemented.[16] But the main HPR effects remain robust and consistent in magnitude once the polynomial order is reasonably high.

## 5.2 Potential effects of simultaneous policies

In Section 5.1 we assume that the HPR dominates the effect of Policy II. But, as noted earlier, that policy also includes some additional elements: a further increase in the required down payment ratio from 40% to 50% for second homes, and a reiteration of a 2007 policy requiring differentiated down payments for homes smaller and bigger than $90m^2$.[17] While it is difficult to quantify the precise independent effects of these two additional policy elements, we believe their effects were limited compared to that of the HPR, in view of the evidence presented below.

To estimate the effect of the increase in the second-home down payment ratio requirement (from 40% to 50%), we refer back to the earlier Policy I, implemented in February 2010. Recall that Policy I's main component is also an increase in the required down payment ratio (from 30% to 40%). With this in mind, we can examine some indirect evidence. Table 7 presents the RDD regression results for Policy I using an asymmetric time window of January 1st 2009 to April 29th 2010. This time window avoids other policies' effects on housing markets, while simultaneously controlling for seasonality. In contrast to the significant results of the HPR (or Policy II), all of the estimated effects of Policy I are statistically insignificant and much smaller in magnitude. These results indicate that the effect of an increase in the required down-payment for a second house may be quite limited. Indeed, this finding is consistent with prior

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[16] Housing price indices of Beijing do indicate substantial subsequent appreciation in housing prices after the end of our study period, at least through 2013, after a pause in appreciation during latter 2010 and 2011. (See for example the CQCHPI, published by Tsinghua and Peking Universities: http://www.cre.tsinghua.edu.cn/.)

[17] We thank an anonymous reviewer for detailed comments on this issue with helpful suggestions on empirical strategies.

literature, including Chen (2012, pp. 295-296) and in particular Lu et al.'s (2012, pp. 286-287) observation based on multiple waves of down payment ratio regulations from January 2005 to May 2010 in Beijing.

*** Table 7 about here ***

Furthermore, we can directly detect the influence of a differentiated down-payment ratio by home size, given that this element of Policy II effectively shifted demand from larger to smaller homes, since the down-payment ratio requirement only applied to homes greater than $90m^2$. We estimate the HPR's effects in markets of different home sizes with specific attention paid to any difference around the demarcation point ($90m^2$). We spilt the overall sample into eight groups ($<60m^2$, $60-70m^2$, $70-80m^2$, $80-90m^2$, $90-100m^2$, $100-110m^2$, $110-120m^2$, and $>120m^2$) and run subsample regressions. Table 8 shows the subsample RDD estimates of the effect of the HPR on resale prices with different polynomial time trends. Estimated HPR coefficients are all negative and statistically significant, suggesting a market-wide effect of the HPR on resale home price, including in particular on the smaller home sizes below the threshold of the down-payment policy impact. The estimated HPR effects in different home size categories ranges from a more dispersed -0.19 (a 17% reduction) to -0.38 (a 32% reduction) with $6^{th}$ order polynomial time trend, to a narrower -0.23 (a 20% reduction) to -0.35 (a 30% reduction) with $5^{th}$ order polynomial time trend, compared to the more focused range of 20-23% reduction estimated using the full sample in Table 3. Interestingly, there is a clear trend that the HPR effects become more significant (negatively) as we move from the 80-90 $m^2$ category (estimated HPR effects of -0.22 to -0.27 or 20-24% reduction) to the 100-110 $m^2$ category (estimated HPR effects of -0.35

to -0.38 or 30-32% reduction), but beyond this size group the trend in the impact is reversed. This is shown graphically in Figure 8. The significant jump in price discontinuity around the 90 m$^2$ threshold could well be due to the differentiated down payment policy.[18]

While there is no reason to believe that independently the HPR would necessarily have an equal effect in the different home size categories, the effect of the differentiated down payment ratios does seem to be consistent with an independent effect of the HPR, given the results below the down-payment impact threshold at 90m$^2$. The market-wide significant effect of Policy II, and in particular the impact on the smaller housing units below the 90m$^2$ down-payment policy threshold, suggests that it is reasonable to claim that the independent effect of the HPR by itself lies in the range of about -0.19 (a 17% reduction) to -0.27 (a 24% reduction), the corresponding lower and higher bounds of the estimates from subsamples below 90m$^2$.

*** Table 8 about here ***

*** Figure 8 about here ***

### 5.3    Spatial heterogeneous effects across submarkets

As a final focus of our study, our analysis confirms that Policy II's effects (presumably largely the HPR's effects, based on the above results) are heterogeneous across submarkets in Beijing with different supply elasticity. We follow Zheng et al. (2014) to combine three to six adjacent

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[18] Comparing these results to those in Table 7, it seems that the increase in down-payment ratio for the first home has a more significant effect on the market than for a second home, probably reflecting the difference in demand from occupancy residence buyers versus buyers for speculation.

*Jiedao*s (Street Offices) with continuous concentrated economic activities into 25 zones as the

basic geographic unit of submarket analysis. Instead of using a direct measure of housing supply

elasticity, we use an exogenous variation in land availability across different locations in Beijing.

During the pre-reform socialist era, state-owned manufacturing enterprises were located across

the central and periphery locations in cities (Zheng et al., 2006). After the reinstatement of the

urban land markets in the late 1980s and especially since the SOE reform started in the late

1990s, the state-owned manufacturers, as large land users, have been gradually moved away

from their original locations. The relocation or disassembly of old state-owned manufacturing

firms and plants thus became an important source of land for new development.[19] Zheng et al.

(2014) show that the density of state-owned manufacturing employment during the early years of

state-owned enterprise (SOE) reform is statistically correlated with the amount of land leased

thereafter and a valid instrument for land availability.[20]

We divide the 25 zones into two subgroups – those with lower land availability (lower

SOE employment density in 2000) and those with higher land availability (i.e., higher SOE

employment density in 2000). We estimate Equation (1) using the two subsamples and compare

the subsample effects of the HPR. Table 9 presents the sub-sample RDD regression results. The

HPR policy decreases the resale price by about 23.5% in the zones with relatively inelastic land

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[19] At the end of 1999, the Beijing municipal government announced its plan for manufacturing SOEs' relocation: in three to five years from 2000, 738 manufacturing firms within the fourth ring road would be relocated away (see http://house.focus.cn/news/1999-11-03/654.html). According to the plan, the share of industrial land would decrease from 8.74 percent to 7 percent within the fourth ring road.

[20] The correlation coefficient between ln(SOE) (SOE is measured as employment density based on SOE manufacturing employment numbers by zone from the Year 2000 China Manufacturing Census) and the logarithm of the amount of land leased during 2006 to 2008 is 0.36 (*p*-value=0.001). In the meantime, ln(SOE)'s correlation with ln(home price) is very weak (correlation coefficient is -0.02 for resale housing and 0.06 for new housing) and statistically insignificant. We have also examined the suitability of historical population density as an exogenous source of land supply variation but found its validity to be questionable.

supply, larger than its effect in the zones with relatively elastic land supply (21%). A similar

contrast is found in the resale volume effects, with the reduction in resale volume reaching 59%

in submarkets of more elastic supply, compared to the 46% reduction where supply is less elastic.

Two-sample t-test results suggest that the intra-city differences in both price and volume effects

are statistically significant at the 0.1% level.


*** Table 9 about here ***


## 6 CONCLUSION

Home prices have surged in major Chinese cities, leading to concerns about asset price bubbles

and home affordability. China has enacted numerous policies to intervene in its urban housing

market, but there have been few studies evaluating their intended and unintended consequences.

The HPR has been one of China's harshest housing market interventions, aimed at squeezing out

speculative demand and thereby dampening the rise in home prices. Our findings provide

evidence of the HPR's early or initial effects. Using large datasets of resale and rental market

transactions in Beijing and employing the regression discontinuity design technique, we find that

Beijing's HPR policy triggered a 17% to 24% decrease in resale price, a decrease in the price-to-

rent ratio of 23-29% of its pre-HPR mean, and a very deep reduction in the transaction volume in

the for-sale market, with no significant change in the rent or the rental transaction volume of

rental units. In submarkets where housing supply was less elastic, the effects of the HPR were

larger in price and smaller in quantity.

A few policy implications arise from our results. A direct interpretation of our results is

that the HPR policy achieved the goal of lowering housing prices without hurting renters (usually

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the less wealthy), at least during the 1.67 years of post-HPR time period we have examined. Of course, to improve housing affordability, simply reducing home prices in the short run may not help in the long run if it does not reduce the vacancy rate and if it suppresses new construction. The ultimate evaluation of the HPR's welfare effect thus depends on whether it helps to get units occupied (the lack of significant effects in the rental market observed in this study does suggest the possibility of increased rental supply from previously unoccupied units) and whether it avoids suppressing new construction. On the other hand, our results that submarkets with smaller supply price-elasticity show greater price drop and less volume drop point to the spatially heterogeneous effect that may be of concern to policy makers. As in many cities, home price is likely correlated with supply conditions in Beijing (e.g., housing tends to be more expensive where supply is less elastic, such as in the densely developed areas). This means that the buyers of more expensive homes probably benefit more from the HPR because it triggered a bigger relative decline (and an even larger absolute decline) in market price in those submarkets.

It should be noted that the HPR's negative effects on the resale market and price-to-rent ratio identified in this study are only suggestive about the possibility of the existence and magnitude of speculative demand in Beijing's housing market. These results do not represent a "clean" piece of evidence of the existence of speculative demand, because the owner-occupancy demand of some non-*Hukou* households is also curtailed by the HPR policy. In addition, the HPR cannot prevent speculative purchases by some, especially the *Hukou* households with one home. The HPR effects quantified in this paper may be an underestimate of the magnitude of speculative demand in this regard.[21] Similarly, the lack of significant rental price and volume

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[21] Likewise, the lack of significant effect in the rental market also cannot suggest a definitive existence of unusually large number of vacant units (a sign of significant speculation) before the HPR, because some previous renters who are eligible to buy may move from the rental to the purchase market as a result of the HPR effect on housing prices.

impacts cannot be exclusively attributed to an increase in occupancy, a sign of the existence of a pre-HPR bubble. Overall, one could be more definitive about the existence of a housing bubble if crucial information such as the change in vacancy and new construction were available. In the long run, the best policy choice to avoid or curtail excessive speculative purchase of housing perhaps should be the provision of more alternatives for people to save and invest their money that offer the prospect of good returns and inflation protection (i.e., development of a more modern and complete capital market). The scope of the analysis does not allow conclusions regarding the persistence or longevity of these effects.

**REFERENCE**

Ahuja, A., Cheung, L., Han, G., Porter, N., & Zhang, W. (2010). Are house prices rising too fast in China?. *IMF Working Papers*, 1-31.

Chen, Jie. (2012). Home Mortgage and Real Estate Market in Shanghai. *Global Housing Markets: Crises, Policies, and Institutions.* Ashok Bardhan, Robert H. Edelstein, and Cynthia A. Kroll. Hoboken: John Wiley & Sons.

Dreger, C., & Zhang, Y. (2013). Is there a bubble in the Chinese housing market? *Urban Policy and Research*, 31(1): 27-39.

Glaeser, E. L., Gyourko, J., & Saks, R. (2005). *Why have housing prices gone up?* National Bureau of Economic Research, No. w11129.

Glaeser, E. L., Gyourkob, J., & Saiz, A. (2008). Housing supply and housing bubbles. *Journal of Urban Economics*, 64: 198–217.

Hilber, C. A., & Mayer, C. J. (2001). Land supply, house price capitalization, and local spending on schools. The Wharton School, University of Pennsylvania, http://realestate.wharton.upenn.edu/newsletter/392.pdf, accessed 17/12/2010.

Lu, P., H. Zhen, &Y. Xu. (2012). Irrational Prosperity, Housing Market and Financial Crisis. *Global Housing Markets: Crises, Policies, and Institutions.* Editors Ashok Bardhan, Robert H. Edelstein, and Cynthia A. Kroll. Hoboken: John Wiley & Sons.

Paciorek, A. (2013). Supply constraints and housing market dynamics. *Journal of Urban Economics*, 77: 11–26.

Peng, W., Tam, D. C., & Yiu, M. S. (2008). Property market and the macroeconomy of mainland China: a cross region study. *Pacific Economic Review*, *13*(2), 240-258.

Saiz, Albert. (2010). The geographic determinants of housing supply. The Quarterly Journal of

Economics, *125*(3), 1253-1296.

Stadelmann, D., & Billon, S. (2012). Capitalisation of Fiscal Variables and Land Scarcity. *Urban Studies*, *49*(7), 1571-1594.

Wang, Z., & Zhang, Q. (2012). *Fundamentals in China's Housing Markets*. Brown University Working Paper.

World Bank (2010). China Quarterly Update, March.

Wu, J., Gyourko, J., & Deng, Y. (2012). Evaluating conditions in major Chinese housing markets. *Regional Science and Urban Economics*, *42*(3), 531-543.

Yu, H. (2010). China's house price: Affected by economic fundamentals or real estate policy? *Frontiers of Economics in China*, *5*(1), 25-51.

Zheng, S., Fu, Y., & Liu, H. (2006). Housing-choice hindrances and urban spatial structure: Evidence from matched location and location-preference data in Chinese cities. *Journal of Urban Economics*, *60*(3), 535-557.

Zheng, S., Kahn, M. E., & Liu, H. (2010). Towards a system of open cities in China: Home prices, FDI flows and air quality in 35 major cities. *Regional Science and Urban Economics*, *40*(1), 1-10.

Zheng, S., Sun, W., & Wang, R. (2014). Land supply and capitalization of public goods in housing prices: evidence from Beijing. *Journal of Regional Science*, *54*(4): 550-568.

**FIGURES**

**Figure 1  Spatial Distribution of Sampled Resale Transactions in Beijing (2005-2011)**
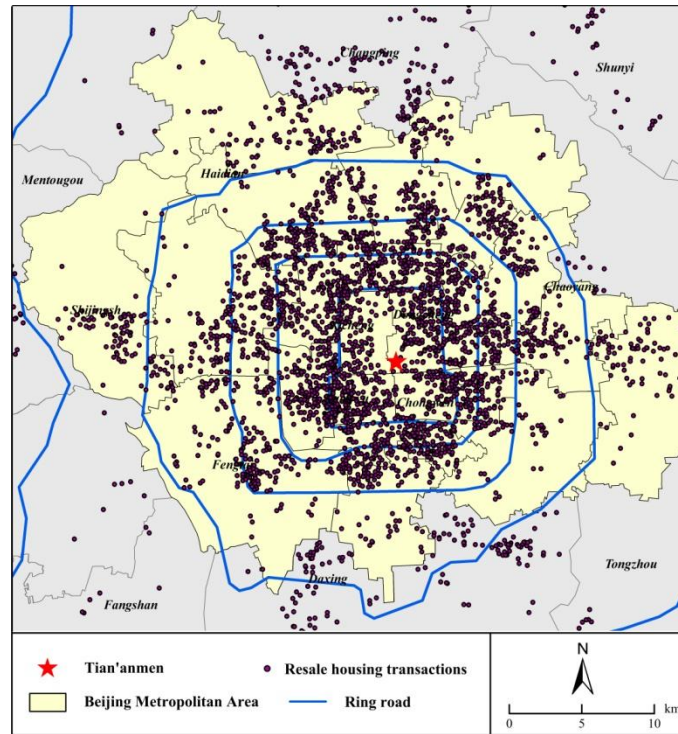


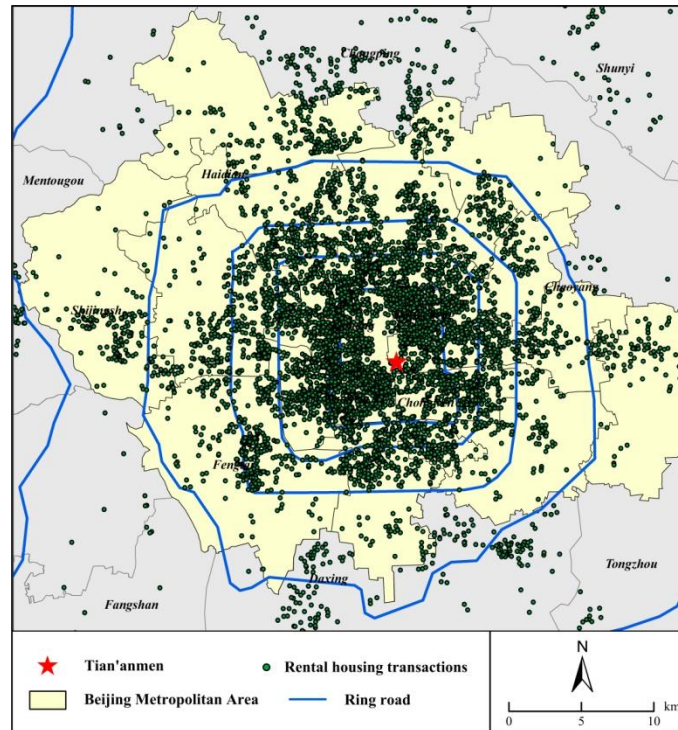**Figure 2  Spatial Distribution of Sampled Rental Transactions in Beijing (2005-2011)**
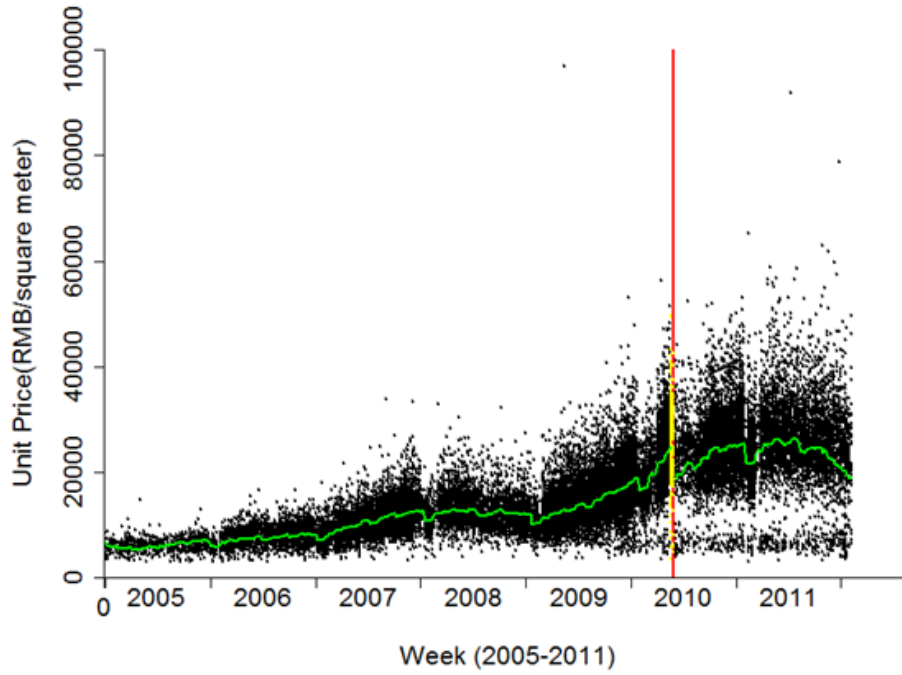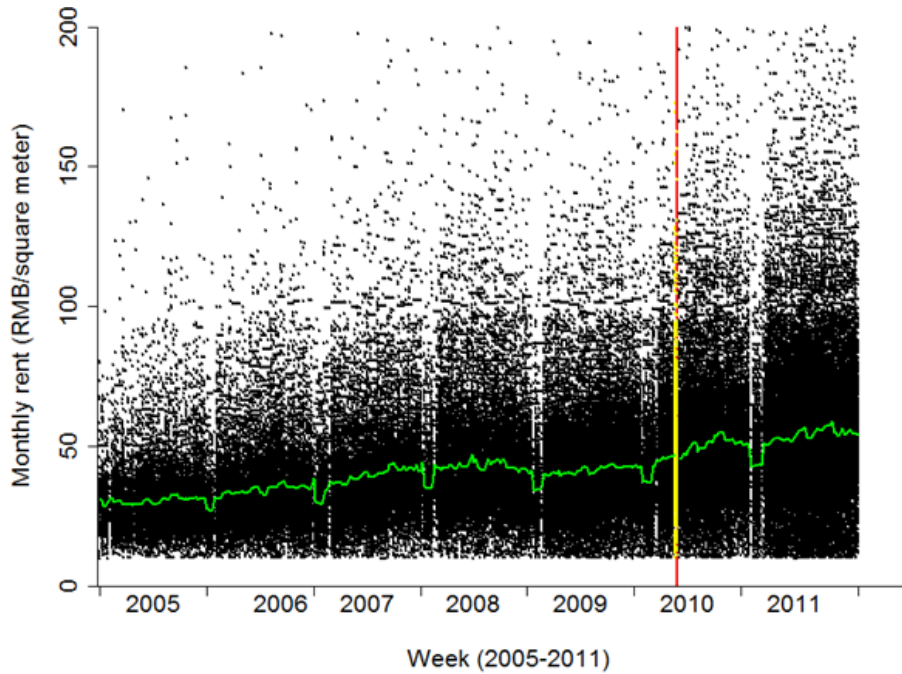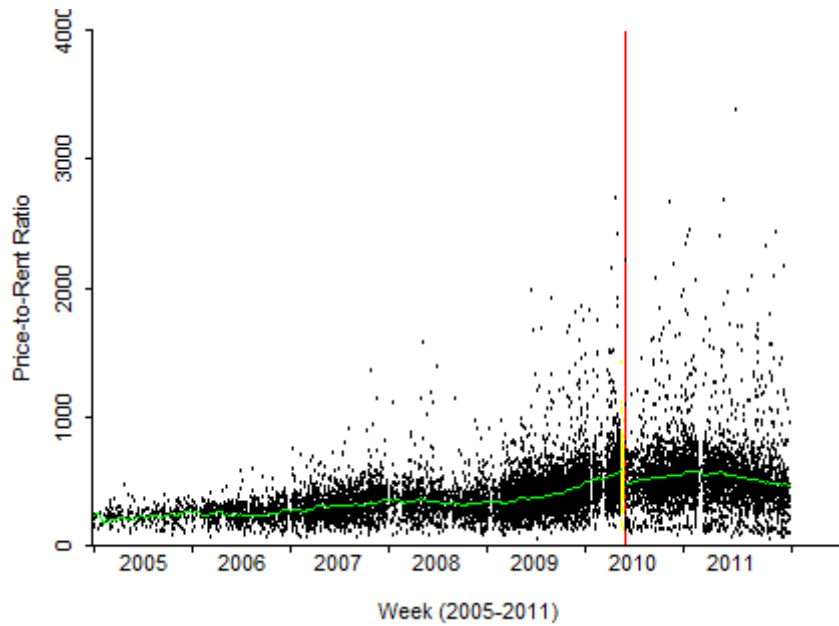
**Figure 3  Resale Prices**



Note: the green line is the fitted resale price in the RDD regression with a tenth-order polynomial time trend.

**Figure 4  Monthly Rents of New Rental Contracts**



Note: the green line is the fitted rent in the RDD regression with a tenth-order polynomial time trend.

**Figure 5  Complex-Level Price-to-Rent Ratios**



Note: the green line is the fitted price-to-rent ratio in the RDD regression with a tenth-order polynomial time trend.
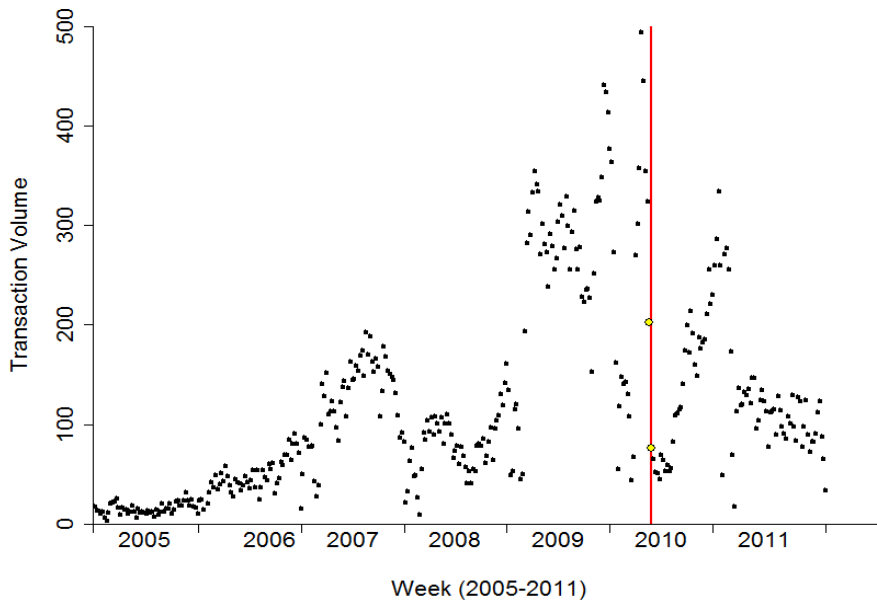
**Figure 6  Weekly Resale Volumes**



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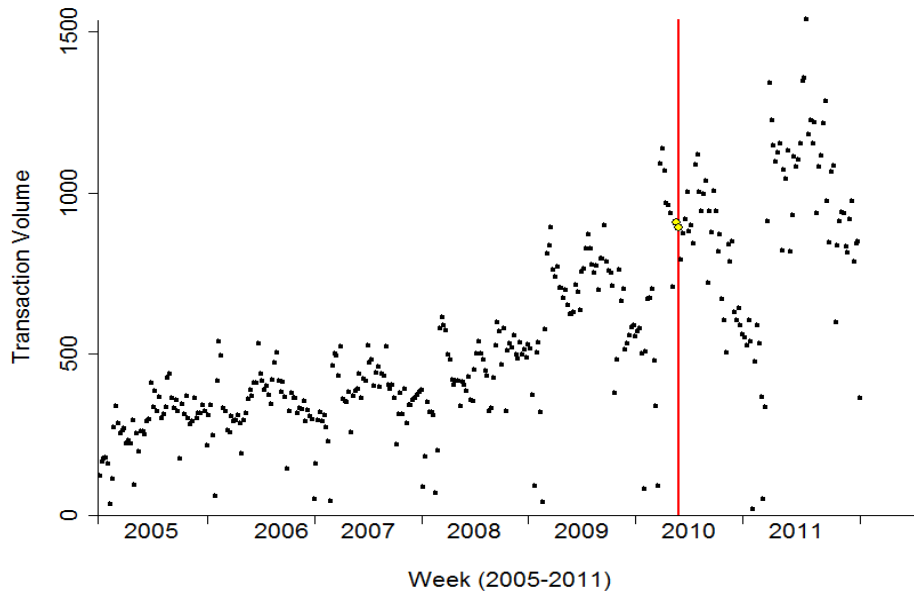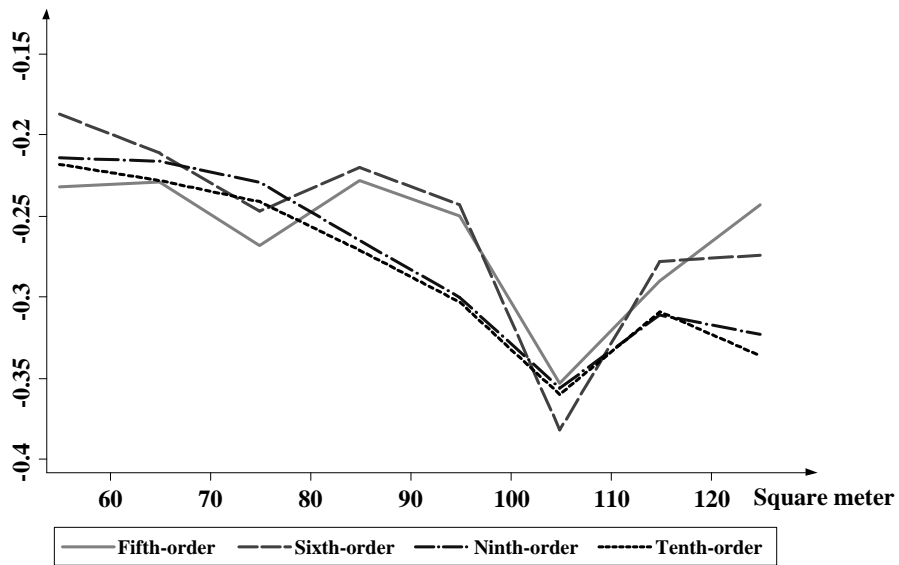
**Figure 7  Weekly Rental Transaction Volumes**



**Figure 8  Effects of the HPR by Home Size**

# TABLES

**Table 1  Variable Definitions and Summary Statistics**

| Variable | Definition | Obs. | Mean | Std.Dev. | Min | Max |
|---|---|---|---|---|---|---|
| *Resale Home* | | | | | | |
| *price* | Transaction price (RMB yuan/square meter) | 43305 | 16841.20 | 7741.39 | 3069.28 | 96781.22 |
| *house_size* | Housing unit size (square meter) | 43305 | 75.45 | 31.33 | 20.06 | 199.90 |
| *house_age* | Housing age (years) | 43305 | 14.90 | 7.64 | 1 | 40 |
| *floor* | Floor number | 43305 | 7.94 | 6.17 | 1 | 39 |
| *top* | Whether unit is on the top floor: 1=yes, 0=no | 43305 | 0.12 | 0.32 | 0 | 1 |
| *bathroom* | Number of bathrooms | 43305 | 1.11 | 0.32 | 1 | 3 |
| *decoration* | Decoration level: 1=no decoration, 2=simple decoration, 3=medium decoration, 4=full decoration | 43305 | 2.81 | 0.99 | 1 | 4 |
| *Rental Home* | | | | | | |
| *rent* | Monthly rent (RMB yuan/square meter) | 186628 | 46.90 | 21.56 | 10 | 199.88 |
| *house_size* | Housing unit size (square meter) | 186628 | 63.79 | 31.95 | 10 | 200 |
| *floor* | Floor number | 186628 | 7.23 | 5.86 | 1 | 39 |
| *top* | Whether unit is on the top floor: 1=yes, 0=no | 186628 | 0.12 | 0.33 | 0 | 1 |
| *living_room* | Whether unit has at least one living room: 1=yes, 0=no | 186628 | 0.96 | 0.20 | 0 | 1 |
| ***Price-to-Rent Ratio*** | Quality-controlled price to (monthly) rent ratio, by residential complex by week | 13507 | 425.19 | 212.57 | 44.12 | 1248.486 |
| *Location Attributes* | | | | | | |
| *d_cbd* | Distance to Tian'anmen Square (km) | 3316 | 8.95 | 4.69 | 0.09 | 25.33 |
| *d_school* | Distance to the nearest key primary school (km) | 3316 | 2.40 | 1.88 | 0.01 | 11.13 |
| *d_subway* | Distance to the nearest subway station (km) | 3316 | 1.69 | 1.45 | 0.01 | 10.58 |
| *d_park* | Distance to the nearest park (km) | 3316 | 1.83 | 1.23 | 0.02 | 8.76 |

**Table 2 Effects of the HPR on ln(*Resale Price*) and ln(*Rent*) with a Tenth-Order Polynomial Time Trend**

| | (1)<br>ln(*Price*) | (2)<br>ln(*Rent*) | (3)<br>Price-to-Rent Ratio |
|---|---|---|---|
| *HPR* | -0.258*** | -0.0654*** | -110.1*** |
| | (0.0193) | (0.00695) | (14.59) |
| *house_size* | -0.00314*** | -0.0168*** | |
| | (0.000661) | (0.000224) | |
| *house_size* $^2$(/100) | 0.000987** | 0.00764*** | |
| | (0.000302) | (0.000141) | |
| *house_age* | -0.0116*** | 0.0154*** | |
| | (0.00214) | (0.00123) | |
| *house_age* $^2$(/100) | 0.0239*** | -0.0395*** | |
| | (0.00527) | (0.00478) | |
| *floor* | 0.00419*** | -0.0966*** | |
| | (0.00122) | (0.00486) | |
| *floor* $^2$(/100) | -0.0173*** | | |
| | (0.00467) | | |
| *top* | -0.0491*** | | |
| | (0.00566) | | |
| *bathroom* | 0.0702*** | | |
| | (0.00942) | | |
| *decoration* | 0.0142*** | | |
| | (0.00171) | | |
| *living_room* | | 0.0105 | |
| | | (0.00765) | |
| *d_cbd* | -0.00879*** | -0.00835*** | 1.737*** |
| | (0.00141) | (0.00145) | (0.413) |
| log(*d_school*) | -0.0786*** | -0.0807*** | -4.070 |
| | (0.00891) | (0.00742) | (2.451) |
| log(*d_subway*) | -0.0614*** | -0.0621*** | 8.910*** |
| | (0.00772) | (0.00775) | (1.929) |
| log(*d_park*) | -0.0120 | 0.0187* | 0.767 |
| | (0.00784) | (0.00831) | (2.752) |
| Constant | 9.135*** | 4.115*** | 179.5** |
| | (0.0595) | (0.0405) | (54.78) |
| Month-of-year dummies | Yes | Yes | Yes |
| Observations | 43305 | 186628 | 13507 |
| Adjusted $R^2$ | 0.714 | 0.436 | 0.243 |

Notes: (1) Standard errors are reported in parentheses. (2) ***: significant at the 0.1% level; **: significant at the 1% level;*: significant at the 5% level. (3) Standard errors are clustered by residential complex.

**Table 3  Effects of the HPR on ln(*Resale Price*) and ln(*Rent*) with Alternative Polynomial Orders**

| | (1) Fifth-order polynomial time trend | (2) Sixth-order polynomial time trend | (3) Ninth-order polynomial time trend | (4) Tenth-order polynomial time trend |
|---|---|---|---|---|
| ln(*Price*) | -0.243*** | -0.221*** | -0.257*** | -0.258*** |
| | (0.0109) | (0.0136) | (0.0193) | (0.0193) |
| | [0.699] | [0.699] | [0.714] | [0.714] |
| ln(*Rent*) | 0.0279*** | 0.0271*** | -0.0476*** | -0.0682*** |
| | (0.00544) | (0.00535) | (0.00625) | (0.00713) |
| | [0.433] | [0.433] | [0.436] | [0.436] |
| *Price-to-Rent Ratio* | -96.57*** | -85.85*** | -105.3*** | -110.1*** |
| | (10.15) | (10.47) | (14.47) | (14.59) |
| | [0.235] | [0.236] | [0.243] | [0.243] |

Notes: (1) Standard errors are clustered by residential complex and reported in parentheses; adjusted R-squares are reported in square brackets. (2) ***: significant at the 0.1% level; **: significant at the 1% level;*: significant at the 5% level. (3) Control variables are the same as in Table 2.

**Table 4  Longitudinal Comparisons of ln(*Rent*) Changes before and after the HPR**

| Time window | Leasing period adjustment | Pre-HPR mean ($X_a$) (Std. dev.) | Post-HPR mean ($X_b$) (Std. dev.) | t-statistic $H_0: X_a = X_b$ (p-value) |
|---|---|---|---|---|
| Two weeks | No | 11.56 (10.94) | 12.28 (12.04) | 0.39 (0.69) |
| | Yes | 16.40 (10.66) | 17.11 (11.74) | 0.39 (0.69) |
| Four weeks | No | 12.46 (11.13) | 11.82 (10.40) | 0.56 (0.57) |
| | Yes | 17.26 (10.89) | 16.58 (10.21) | 0.61 (0.54) |
| Two months | No | 12.18 (10.56) | 12.33 (10.14) | 0.21 (0.83) |
| | Yes | 16.83 (10.36) | 16.99 (10.03) | 0.23 (0.82) |

**Table 5  Effects of the HPR on ln(*Volumes*) with Alternative Polynomial Orders**

| | | (1) Fifth-order polynomial time trend | (2) Sixth-order polynomial time trend | (3) Ninth-order polynomial time trend | (4) Tenth-order polynomial time trend |
|---|---|---|---|---|---|
| ln(*Volume*) | Resale | -1.458*** | -1.282*** | -0.966*** | -0.712*** |
| | | (0.183) | (0.182) | (0.230) | (0.219) |
| | | [0.765] | [0.778] | [0.784] | [0.810] |
| | Rental | -0.0858 | -0.0837 | 0.258 | 0.303 |
| | | (0.159) | (0.163) | (0.207) | (0.209) |
| | | [0.570] | [0.568] | [0.577] | [0.578] |

Notes: (1) Standard errors are reported in parentheses; adjusted R-squares are reported in square brackets. (2) ***: significant at the 1% level; **: significant at the 5% level;*: significant at the 10% level. (3) Month-of-year dummies are controlled.

**Table 6 Robustness Tests of the HPR Effects with Alternative Polynomial Orders and Time Windows**

| | Time window [obs.] | Polynomial orders of time trend | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th | 9th | 10th |
| ln(Price) | 3.33 yrs [30,826] | -0.0142 | 0.0630*** | -0.226*** | -0.203*** | -0.256*** | -0.242*** | -0.253*** | -0.257*** | -0.263*** | -0.265*** |
| | | (0.00927) | (0.00938) | (0.0130) | (0.0162) | (0.0279) | (0.0284) | (0.0282) | (0.0284) | (0.0289) | (0.0289) |
| | | [0.496] | [0.553] | [0.574] | [0.575] | [0.575] | [0.575] | [0.575] | [0.575] | [0.575] | [0.575] |
| | 2 yrs [21,613] | -0.0203 | -0.0403 | -0.245*** | -0.235*** | -0.233*** | -0.231*** | -0.240*** | -0.239*** | -0.240*** | -0.237*** |
| | | (0.0410) | (0.0429) | (0.0517) | (0.0520) | (0.0522) | (0.0524) | (0.0592) | (0.0590) | (0.0596) | (0.0611) |
| | | [0.475] | [0.493] | [0.497] | [0.497] | [0.497] | [0.497] | [0.497] | [0.497] | [0.497] | [0.497] |
| ln(Resale Volume) | 3.33 yrs [174] | -0.777*** | -0.795*** | -0.669*** | -0.601*** | -1.422*** | -1.505*** | -1.383*** | -1.438*** | -1.530*** | -1.655*** |
| | | (0.176) | (0.159) | (0.228) | (0.193) | (0.310) | (0.298) | (0.306) | (0.309) | (0.309) | (0.298) |
| | | [0.255] | [0.391] | [0.390] | [0.562] | [0.588] | [0.600] | [0.604] | [0.602] | [0.606] | [0.641] |
| | 2 yrs [106] | -0.937* | -0.584 | -1.770*** | -1.857*** | -1.859*** | -1.861*** | -1.905*** | -1.860*** | -1.911*** | -1.734*** |
| | | (0.509) | (0.475) | (0.483) | (0.510) | (0.514) | (0.517) | (0.566) | (0.569) | (0.572) | (0.620) |
| | | [0.475] | [0.493] | [0.497] | [0.497] | [0.497] | [0.497] | [0.497] | [0.497] | [0.497] | [0.497] |
| ln(Rent) | 3.33 yrs [124,111] | 0.0615*** | 0.0594*** | -0.0170** | -0.0228*** | 0.00428 | -0.000513 | 0.00565 | 0.00845 | 0.0155 | 0.00799 |
| | | (0.00448) | (0.00441) | (0.00590) | (0.00586) | (0.00870) | (0.00856) | (0.00870) | (0.00879) | (0.00946) | (0.00859) |
| | | [0.399] | [0.399] | [0.401] | [0.401] | [0.401] | [0.401] | [0.401] | [0.401] | [0.401] | [0.401] |
| | 2 yrs [75,010] | 0.0384** | 0.0258* | 0.0266 | 0.0157 | 0.0147 | 0.0138 | 0.0117 | 0.0112 | 0.0118 | 0.0126 |
| | | (0.0127) | (0.0128) | (0.0141) | (0.0145) | (0.0146) | (0.0146) | (0.0160) | (0.0159) | (0.0160) | (0.0162) |
| | | [0.401] | [0.401] | [0.401] | [0.401] | [0.401] | [0.401] | [0.401] | [0.401] | [0.401] | [0.401] |
| ln(Rental Volume) | 3.33 yrs [174] | -0.117 | -0.116 | -0.104 | -0.103 | 0.0779 | 0.155 | 0.0439 | 0.0430 | 0.0655 | 0.0975 |
| | | (0.141) | (0.141) | (0.203) | (0.204) | (0.337) | (0.328) | (0.337) | (0.340) | (0.342) | (0.344) |
| | | [0.439] | [0.437] | [0.433] | [0.430] | [0.428] | [0.430] | [0.432] | [0.432] | [0.431] | [0.431] |
| | 2 yrs [106] | -0.121 | -0.196 | 0.0725 | 0.225 | 0.232 | 0.238 | 0.0779 | 0.0440 | -0.00517 | -0.248 |
| | | (0.550) | (0.561) | (0.636) | (0.669) | (0.673) | (0.678) | (0.742) | (0.747) | (0.749) | (0.804) |
| | | [0.317] | [0.313] | [0.312] | [0.308] | [0.308] | [0.308] | [0.303] | [0.303] | [0.305] | [0.303] |

Notes: (1) Standard errors are clustered by residential complex and reported in parentheses; adjusted R-squares are reported in square brackets. (2) ***: significant at the 0.1% level; **: significant at the 1% level;*: significant at the 5% level. (3) Control variables are the same as in Table 2.

**Table 7  Policy I's Effects on ln(*Price*), ln(*Rent*) and ln(*Volumes*) (Period: January 1, 2009 to April 29, 2010)**

| | obs. | (1) Fifth-order polynomial time trend | (2) Sixth-order polynomial time trend | (3) Ninth-order polynomial time trend | (4) Tenth-order polynomial time trend |
|---|---|---|---|---|---|
| ln(*Resale Price*) | 17,946 | -0.00674 (0.0229) [0.585] | -0.00671 (0.0229) [0.585] | -0.0204 (0.0233) [0.585] | -0.0192 (0.0252) [0.585] |
| ln(*Rent*) | 45,478 | 0.00682 (0.0136) [0.412] | 0.00677 (0.0136) [0.412] | 0.00137 (0.0138) [0.412] | 0.00323 (0.0138) [0.412] |
| *Price-to-Rent Ratio* | 5,650 | 26.02 (18.56) [0.184] | 25.61 (18.58) [0.184] | 27.84 (19.83) [0.184] | 27.16 (20.16) [0.184] |
| ln(*Resale Volume*) | 70 | 0.256 (0.404) [0.531] | 0.242 (0.405) [0.531] | 0.152 (0.436) [0.525] | 0.160 (0.440) [0.524] |
| ln(*Rental Volume*) | 70 | 0.713 (0.672) [0.122] | 0.714 (0.672) [0.122] | 0.687 (0.684) [0.107] | 0.728 (0.689) [0.105] |

Notes: (1) Standard errors are clustered by residential complex and reported in parentheses; adjusted R-squares are reported in square brackets. (2) ***: significant at the 0.1% level; **: significant at the 1% level;*: significant at the 5% level. (3) Control variables are the same as in Tables 2 (for price/rent/ratio regressions) and 5 (for volume regressions).

**Table 8 Effects of the HPR on ln(*Resale Price*) by Housing Unit Size**

| Subsamples [obs.] | (1) Fifth-order polynomial time trend | (2) Sixth-order polynomial time trend | (3) Ninth-order polynomial time trend | (4) Tenth-order polynomial time trend |
|---|---|---|---|---|
| *house_size<60m²* [16,937] | -0.232*** (0.0136) [0.753] | -0.187*** (0.0155) [0.755] | -0.214*** (0.0211) [0.772] | -0.218*** (0.0493) [0.772] |
| *60m²≤house_size<70m²* [7,634] | -0.229*** (0.0205) [0.755] | -0.211*** (0.0251) [0.755] | -0.216*** (0.0351) [0.768] | -0.228*** (0.0348) [0.768] |
| *70m²≤house_size<80m²* [4,242] | -0.268*** (0.0357) [0.688] | -0.247*** (0.0437) [0.688] | -0.229*** (0.0639) [0.702] | -0.241*** (0.0632) [0.703] |
| *80m²≤house_size<90m²* [3,292] | -0.228*** (0.0437) [0.671] | -0.220*** (0.0514) [0.671] | -0.265*** (0.0791) [0.690] | -0.271*** (0.0780) [0.690] |
| *90m²≤house_size<100m²* [2,772] | -0.250*** (0.0494) [0.640] | -0.243*** (0.0594) [0.640] | -0.300*** (0.0840) [0.652] | -0.303*** (0.0834) [0.651] |
| *100m²≤house_size<110m²* [2,329] | -0.353*** (0.0420) [0.666] | -0.382*** (0.0525) [0.666] | -0.356*** (0.0734) [0.680] | -0.360*** (0.0714) [0.680] |
| *110m²≤house_size<120m²* [1,498] | -0.290*** (0.0651) [0.597] | -0.278*** (0.0834) [0.597] | -0.311** (0.0989) [0.614] | -0.309** (0.0983) [0.614] |
| *house_size≥120m²* [4,601] | -0.243*** (0.0439) [0.557] | -0.274*** (0.0542) [0.558] | -0.323*** (0.0815) [0.569] | -0.336*** (0.0805) [0.570] |

Notes: (1) Standard errors are clustered by residential complex and reported in parentheses; adjusted R-squares are reported in square brackets. (2) ***: significant at the 0.1% level; **: significant at the 1% level;*: significant at the 5% level. (3) Control variables are the same as in Table 2.

**Table 9 Subsample Regressions of ln(*Resale Price*) and ln(*Volume*) under Different Land Supply Conditions (Tenth-Order Polynomial Time Trend)**

| | Resale price | | Resale volume | |
|---|---|---|---|---|
| | (1) *Inelastic land supply* | (2) *Elastic land supply* | (1) *Inelastic land supply* | (2) *Elastic land supply* |
| *HPR* | -0.268*** (0.0239) | -0.234*** (0.0298) | -0.619*** (0.231) | -0.901*** (0.236) |
| Constant | 9.199*** (0.0761) | 9.104*** (0.0629) | 2.936*** (0.289) | 1.781*** (0.296) |
| Control variables | Yes | Yes | - | - |
| Month-of-year dummies | Yes | Yes | Yes | Yes |
| Observations | 29,492 | 13,813 | 369 | 368 |
| Adjusted $R^2$ | 0.718 | 0.738 | 0.807 | 0.761 |

Notes: (1) Standard errors are reported in parentheses. (2) ***: significant at the 0.1% level; **: significant at the 1% level;*: significant at the 5% level. (3) Control variables are the same as in Tables 2 (for price regressions) and 5 (for volume regressions).