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Fundamental factors in the housing markets of China

Zhi Wang [a,*], Qinghua Zhang [b]

[a] School of Economics, Fudan University, No. 600 Guoquan Road, Shanghai 200433, China
[b] Department of Applied Economics, Guanghua School of Management, Peking University, Beijing 100871, China

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ABSTRACT

This paper seeks to understand the importance of changes in the fundamental factors of demand and supply, such as the urban *hukou* population, wage income, urban land supply, and construction costs, in explaining the rising residential housing prices in major Chinese cities between 2002 and 2008. We propose an empirical approach that uses both city-level and residential development project-level data. Results suggest that, for most of the cities in our sample, changes in fundamental factors can account for a major proportion of the actual housing price appreciation. However, in several coastal cities, the actual increase in housing prices deviates largely from what can be predicted from fundamental changes.

1. Introduction

Since 2000, escalating residential housing prices have been a remarkable phenomenon in urban China, with the appreciation rate varying largely across major Chinese cities. As shown in Fig. 1, the average sale price across 35 major Chinese cities increased by 10 percent annually between 2002 and 2008.[1] Cities in the east coast, such as Beijing, Fuzhou, Ningbo, and Xiamen, experienced an annual appreciation rate of about 15–20 percent, whereas the average sale price in inland cities, such as Ha'erbin, Kunming, Shenyang, and Yinchuan, increased by around 2–5 percent annually. This paper seeks to understand the importance of changes in the fundamental factors of demand and supply, such as the urban *hukou* population, wage income, urban land supply, and construction costs, in explaining the changes in housing prices in major Chinese cities. The answer carries important policy implications because a large deviation of housing price growth from fundamentals can distort both housing construction and migration decisions, which may collectively harm the future growth and urban success of a city.

To answer our research question, we evaluate how much of the housing price appreciation between 2002 and 2008 can be explained by changes in fundamental factors. We first derive the equilibrium housing price appreciation as a function of the fundamental factors of supply and demand. We then infer the coefficients of these fundamental factors from the land-share parameter in the housing production function, as well as the income and price elasticities of housing demand. Finally, using the estimated coefficients, we calculate the housing price appreciation of each city from the

* Corresponding author.
E-mail addresses: wangzhi@fudan.edu.cn (Z. Wang), Zhangq@gsm.pku.edu.cn (Q. Zhang).

[1] The 35 cities are Beijing, Changchun, Changsha, Chengdu, Chongqing, Dalian, Fuzhou, Guangzhou, Guiyang, Ha'erbin, Haikou, Hangzhou, Hefei, Huhehaote, Jinan, Kunming, Lanzhou, Nanchang, Nanjing, Nanning, Ningbo, Qingdao, Shanghai, Shenyang, Shenzhen, Shijiazhuang, Taiyuan, Tianjin, Wuhan, Wulumuqi, Xi'an, Xiamen, Xining, Yinchuan, and Zhengzhou. About half of the completed national investment for residential housing in 2008 occurred in these 35 cities.

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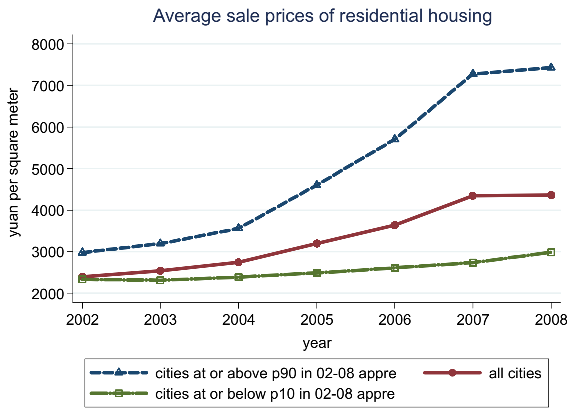

Fig. 1. Trends in average sale prices of residential housing. *Notes:* Housing prices are deflated to currency in 2005 by provincial CPI indices obtained from the National Statistical Yearbooks. The cities at or above the 90th percentile in the distribution of housing price appreciation between 2002 and 2008 are Beijing, Fuzhou, Ningbo, and Xiamen. The cities at or below the 10th percentile in the distribution of housing price appreciation between 2002 and 2008 are Ha'erbin, Kunming, Shenyang, and Yinchuan.

observed changes in fundamental factors and compare the actual price appreciation with the calculated equilibrium counterpart. The results suggest that, for most of the cities in our sample, changes in fundamental factors can account for a major proportion of the actual housing price appreciation. However, in several coastal cities, the actual increase in housing prices deviates largely from what can be predicted from fundamental changes.

To infer the coefficients of fundamental factors in the equation of equilibrium housing price appreciation, we first apply the method proposed by Epple et al. (2010a) to estimate the land-share parameter in the housing production function in urban China. Assuming a Cobb-Douglas production function with constant-returns-to-scale technology, we estimate the land-share parameter in the housing production function to be about 0.323 with a sample of matched land sale and residential development project data. In addition, we borrow the income and price elasticities of housing demand from the literature, which are around 1.0 and −0.5, respectively, in the case of China.

Our study builds upon the existing literature that examines the roles of fundamental factors of supply and demand in driving housing price appreciation. Our results contribute new evidence from urban housing markets in China. First, several studies in this field examine how demand shifters, such as demographics, income, and credit market, affect the appreciation of real estate prices (e.g., Mankiw and Weil, 1989; Ortalo-Magne and Rady, 2006; Ferreira and Gyourko, 2011).[2] Since 2000, several major Chinese cities have experienced unprecedented growth in the urban *hukou* population. For the 35 cities, the urban *hukou* population increases by about 4 percent annually. In addition, the real wage income of these 35 cities grows at an annual rate of 11 percent on average. Rapid urbanization process and fast income growth are the strong driving forces behind the booming real estate markets.

Second, another set of papers addresses the causal impact of inelastic housing supply as a result of physical and regulatory constraints on the spatial dispersion of housing price appreciation since the 1970s (e.g., Glaeser et al., 2005; Saiz, 2010). Additionally, Glaeser et al. (2008) directly model the deviations between housing prices and fundamentals ("housing bubbles") with different supply conditions and characterize the extent to which supply mutes or exacerbates housing bubbles over a cycle. In China, urban land supply is under strict government regulations. During our study period, the average land price per square meter soared by 21 percent annually, from 467 yuan in 2002 to 1439 yuan (2005 yuan) in 2008. Whether local governments are too slow in adjusting the land supply to meet demand changes is a controversial policy issue. We estimate the land share in the housing production function in China to investigate how much land supply constraint contributes to housing price appreciation. Additionally, a relatively large land share amplifies the impacts of demand shifters on housing price appreciation. To our knowledge, we are the first to estimate the housing production function for urban China by using micro-level land and housing data.[3]

Third, no consensus exists among previous studies on the role of fundamentals in driving rising residential housing prices. For example, Wu et al. (2012) point out the limitation of the role of fundamentals in explaining the sharp changes in land price growth in Beijing or in price-to-rent ratios in eight major Chinese cities in the late 2000s. By applying a standard demand and supply framework on national-level data between 1988 and 2006, Chow and Niu (2010) conclude that the interaction of demand and supply can explain well the annual price of urban housing at the aggregate level. In our paper, we use both city-level and micro-level data to evaluate directly the housing price appreciation between 2002 and 2008 from the observed changes in the fundamental factors of demand and supply for the 35 major cities. Except for several coastal cities, our results generally support the importance of fundamentals in driving rising residential housing prices.

The rest of this paper is organized as follows. In Section 2, we develop a simple theoretical framework to derive the equilibrium housing price equation and discuss the empirical strategy. In Section 3, we estimate the land-share parameter in the housing production function. In Section 4, we calculate the equilibrium housing price appreciation of a city from changes in fundamentals and

[2] Mankiw and Weil (1989) find that the entry of the Baby Boom generation into its house-buying years is the main cause of the increase in real housing prices in the 1970s. Ortalo-Magne and Rady (2006) suggest that the ability of young households to afford the down payment on a starter home is a powerful driver of the housing market. Ferreira and Gyourko (2011) find that local income is the only potential demand shifter that significantly changed around the time that the local housing boom began. They also find that the key indicators in the lending market, such as the share of subprime lending, lag the beginning of the boom.

[3] Epple et al. (2010a) find the land share to be 0.144 by using separate assessed land and structure values for houses in Alleghany County, PA and assuming a Cobb-Douglas production function with the constant-returns-to-scale technology. Albouy and Ehrlich (2012) report that on average, 30 percent of housing costs due to land ranges from 0.13 to 0.51 across metropolitan areas in the US, accounting in sequence for the non Cobb-Douglas production function, geographic and regulatory constraints, non-land input costs, and disaggregated measures of regulatory constraints.

compare it with the actual housing price appreciation. Section 5 concludes.

2. Theoretical framework and empirical strategy

We use a standard supply–demand framework to understand how fundamentals determine the equilibrium residential housing price. The purpose is to specify the equilibrium housing price appreciation as a function of the fundamental factors of demand and supply.

We first model the supply side. Consider a city that is a geographic market for urban residential houses and land. The urban residential land market and urban residential housing market are two relevant markets in the model. In the urban residential housing market, real estate developers are suppliers. As observed from the land auction data provided by Cai et al. (2013b), the number of developers in any major city is large. We therefore assume perfect competition among developers in both markets. Note that the assumption of price-taking developers is not uncommon in the literature (e.g., Saiz, 2010; Epple et al., 2010a).

We assume that developers have the same production technology that exhibits constant returns to scale. $\bar{L}$ is the total land stock for residential housing supplied by the local government.[4] Developer i uses a land parcel of size L_i at rent p_L. This model assumes that housing is a homogeneous and perfectly divisible good denoted by H. Housing is produced from two factors, M and L, via a Cobb-Douglas production function,

$$H = H(M, L) = AM^{\alpha}L^{1-\alpha}, \quad A > 0, \quad 0 < \alpha < 1, \tag{1}$$

where L is the land, M is the composite of all mobile non-land factors, and A represents the housing production productivity.

The price of housing unit is denoted by p_h, and the price of M is denoted by p_M. The aggregate housing supply equation is given by

$$\ln H^S = \rho_S + \ln \bar{L} + \frac{\alpha}{1-\alpha}\ln p_h - \frac{\alpha}{1-\alpha}\ln p_M, \tag{2}$$

where $\rho_S = (1/(1-\alpha))\ln A + (\alpha/(1-\alpha))\ln \alpha$.[5]

[4] In China, urban land supply is under strict government regulations. All urban land is owned by the state. What is transacted in the market through public auctions is the leasehold of land. Three auction types exist in urban land auction: English auction (called *paimai* in Chinese), two-stage auction (*guapai*), and sealed-bid auction (*zhaobiao*). For detailed descriptions of these auction types, see Cai et al. (2013b). The city government is the monopolistic supplier of land to real estate developers. Each year, the city government converts a certain amount of rural land owned by the farmer collectives to urban land, which becomes one part of the urban land supply. The other part of the supply comes from urban re-development planned by the city government.

[5] Developer i maximizes its profit

$$\Pi_i = p_h AM_i^{\alpha}(L_i)^{1-\alpha} - p_M M_i - p_L L_i.$$

The first-order condition gives

$$M_i^{ast} = (\alpha A p_h/p_M)^{1/(1-\alpha)} L_i.$$

Therefore, the aggregate supply equation is

$$H^S = \sum_i A(M_i^*)^{\alpha}(L_i)^{1-\alpha} = A^{1/(1-\alpha)}(\alpha p_h/p_M)^{\alpha/(1-\alpha)}\bar{L}.$$

Taking the logarithms on both sides of this equation gives Eq. (2).

To specify the aggregate housing demand, consider separating the total quantity of housing consumption as follows:

$$H^D = h^D \times N, \tag{3a}$$

where h^D is the consumption of space per person, and N represents the population size of the city.

The demand function for h^D is given by:

$$\ln h^D = \delta_0 + \delta_1 \ln w + \delta_2 \ln p_h, \tag{3b}$$

where w represents the average income of the city. Eq. (3b) characterizes the "intensive margin" of demand in the city. δ_1 represents the income elasticity of housing demand, and δ_2 represents the price elasticity of housing demand. $\delta_1 > 0$, and $\delta_2 < 0$.

From (3a) and (3b), we specify the aggregate housing demand as follows:

$$\ln H^D = \delta_0 + \delta_1 \ln w + \delta_2 \ln p_h + \ln N, \tag{3}$$

From (2) and (3), we have the equilibrium housing price:

$$\ln p_h = \phi_0 + \phi_1 \ln w + \phi_2 \ln N - \phi_3 \ln \bar{L} + \phi_4 \ln p_M, \tag{4}$$

where

$$\phi_0 = ((1-\alpha)(\delta_0 - \rho_S))/(1-(1+\delta_2)(1-\alpha)),$$
$$\phi_1 = (\delta_1(1-\alpha))/(1-(1+\delta_2)(1-\alpha)),$$
$$\phi_2 = (1-\alpha)/(1-(1+\delta_2)(1-\alpha)),$$
$$\phi_3 = (1-\alpha)/(1-(1+\delta_2)(1-\alpha)),$$
$$\text{and } \phi_4 = \alpha/(1-(1+\delta_2)(1-\alpha)).$$

Notice that ϕ_k, $k = 1, 2, 3, 4$, are determined by the land-share parameter in (1), $(1-\alpha)$, and the income and price elasticities of housing demand in (3b), δ_1 and δ_2.

Differencing (4) on both sides derives the following relationship between equilibrium housing price appreciation and fundamental factors:

$$\Delta \ln p_h = \phi_1 \Delta \ln w + \phi_2 \Delta \ln N - \phi_3 \Delta \ln \bar{L} + \phi_4 \Delta \ln p_M. \tag{5}$$

In (5), the growth in average income ($\Delta \ln w$) and population size ($\Delta \ln N$) of the city work as demand shifters, which positively affect the growth in the equilibrium housing price. The growth in urban residential land stock ($\Delta \ln \bar{L}$) and construction cost ($\Delta \ln p_M$) are supply shifters, which have negative and positive impacts, respectively, on the housing price appreciation in the city in equilibrium.

To answer our research question, we adopt the following basic strategy. If we know all the coefficients in (5), we can directly compare the actual housing price appreciation with the equilibrium counterpart calculated from the changes in fundamental factors for each city and evaluate the degree to which housing price appreciation can be explained by changes in the fundamental variables. The conventional method to estimate these coefficients is to obtain the OLS estimates by directly regressing housing price changes on changes in fundamental factors. However, the estimates are usually inconsistent because of endogene-

Table 1
Summary statistics.

Variable	Label	Mean	Std. dev.	Obs
Residential development level characteristics				
$\tilde{v}$	Housing value per unit of land, yuan per sqm	20191.997	21510.844	505
$\tilde{p}_l$	Price per unit of land, yuan per sqm	4464.492	5254.265	505
dist	Distance to CBD, km	11.376	11.606	505
railway	Whether there exists a railway (subway/light rail) within 2.5-km radius	0.455	0.499	505
highway	Whether there exists a highway within 2.5-km radius	0.576	0.495	505
auctiontype	Whether the land sale is done through two-stage auction	0.774	0.418	505
City level characteristics				
$\Delta \ln p_{h0208}$	The percent change in price of residential housing sales, 2002–2008	0.553	0.207	35
$\Delta \ln w_{0208}$	The percent change in city average wage, 2002–2008	0.615	0.146	35
$\Delta \ln N_{0208}$	The percent change in local urban hukou holders, 2002–2008	0.254	0.152	35
$\Delta \ln \bar{L}_{0208}$	The percent change in urban land stock, 2002–2008	0.422	0.232	35
$\Delta \ln p_{M0208}$	The percent change in construction cost between 2002 and 2008	0.226	0.076	35

ity issues.[6] In this paper, instead of directly estimating the coefficients in (5) with a single regression, we infer each coefficient separately from the land-share parameter, $(1-\alpha)$, and the income and price elasticities of housing demand, δ_1 and δ_2.

3. Estimation of housing production function

We follow the method proposed by Epple et al. (2010a) to estimate the housing production function. Similar to Epple et al. (2010a), we use a micro-level data set, including information on land parcel sales and their matched residential development (*loupan*), to estimate the housing production function. Information on land parcel sales and their ex-post residential developments are retrieved from the matched land auction and *loupan* data sets provided by Cai et al. (2013b). The land auction data set is used for completed sales from the Land Bureau of China (or its branches at the city level). The data set consists of information on the area, auction type (two-stage auction, or English auction), sale price, and sale date. In addition, the data set includes the geo-economic characteristics of each piece of land for sale, namely, the line distance between the land parcel and the central business district (CBD) of the city, and whether a railway (including a light rail or a subway) or highway exists within a 2.5 km radius of the center of the property for sale. In the *loupan* data set, the average price per square meter of floor space as of April 2009 and the actual floor-area-ratios are listed for each development. Each residential development is matched to a land parcel by its address and the identity of its developer. The match requires that the *loupan* should have new property for sale as of April 2009. We have 505 matched pairs from 23 cities for the regression analysis.[7]

To implement the method of Epple et al. (2010a), we measure its price per unit of land for each match by using the sale price of the land parcel divided by the total land area, and we calculate the corresponding housing value per unit of land by using the *loupan*'s average price per square meter multiplied by the floor-to-area-ratio. Appendix A and Table 1 present the details on the data construction and the summary statistics for the main variables, respectively.

From Eq. (1), we have the production function per unit of land

$$h(m) = Am^{\alpha},$$

where $h = H/L$ and $m = M/L$.

Profit maximization and zero-profit conditions give

$$p_l = (1-\alpha)v, \tag{6}$$

where p_l is the price per unit of land, and v is the housing value per unit of land.

[6] For example, a local government may accommodate a positive demand shift with an increase in land supply, a situation that leads to an upward bias for the estimate of ϕ_3. High housing prices might discourage potential permanent migrants from settling down in this city, which leads to a downward bias for the estimate of ϕ_2. Furthermore, the changes in wage and construction cost may be correlated with other unobserved local economic shocks in the error term.

[7] These cities are Beijing, Changchun, Chengdu, Chongqing, Dalian, Fuzhou, Guangzhou, Hangzhou, Nanchang, Nanjing, Nanning, Ningbo, Shanghai, Shenyang, Shenzhen, Suzhou, Taiyuan, Tianjin, Wuhan, Wuxi, Xi'an, Xiamen, and Zhengzhou.

$$\pi = p_h h(m) - p_M m - p_l.$$

From profit maximization, we have

$$m(p_h) = (A\alpha p_h/p_M)^{1/(1-\alpha)}.$$

Therefore, the supply function per unit of land is

$$S(p_h) = q(m(p_h)) = A(A\alpha p_h/p_M)^{\alpha/(1-\alpha)}.$$

The housing value per unit of land is

$$v = p_h S(p_h) = A(A\alpha/p_M)^{\alpha/(1-\alpha)} p_h^{1/(1-\alpha)}.$$

The function forms of $m(p_h)$ and v, together with $p_l = v - p_M m(p_h)$ implied by the zero-profit condition, give Eq. (6).[8] $(1-\alpha)$ is the land-share parameter. Eq. (6) is used to estimate the housing production function. We assume that all the cities share a single housing production function with a Cobb-Douglas function form. Although the Cobb-Douglas function form is a somewhat strong assumption, it provides a simple analytical function form describing the relationship between the price per land unit and the housing value per land unit. In addition, this assumption is not uncommon in the literature (e.g., Thorsnes, 1997; Epple et al., 2010a; Albouy and Ehrlich, 2012).

[8] The profit of the firm per unit of land is given by

Let the observed price per unit of land for each land parcel-*loupan* match be

$$\tilde{p}_l = p_l(1 - \tau \times auctiontype) + \varepsilon_p, \quad (7)$$

where p_l is the actual unit land cost paid by the land developer, ε_p is the measurement error, *auctiontype* indicates that the land sale was done through a two-stage auction (otherwise, it was done through English auction), and $\tau > 0$.[9] Cai et al. (2013b) find that land sales through two-stage auctions are more corruptible than English auctions. Their empirical results suggest that overall, sales prices are significantly lower for two-stage auctions than for English auctions. Corrupt land sales cost land developers extra money to bribe local land officers. This extra cost causes a gap between the actual unit land cost (p_l) and the observed price per unit of land ($\tilde{p}_l$). We assume that this gap is proportional to the actual price per unit of land ($\tau \times p_l$).

The value of housing per unit of land for each land parcel-*loupan* match may also be measured with error ε_v:

$$\tilde{v} = v + \varepsilon_v, \quad (8)$$

where v is the value of housing per unit of land perceived by the land developer. As Epple et al. (2010a) suggest, ε_v may reflect either measurement error or productivity shocks (for example, the uncertainty about the appeal of the completed structure).

Substituting (7) and (8) into (6), we have

$$\tilde{p}_l = (1-\alpha)\tilde{v} - (1-\alpha)\tau \times \tilde{v} \times auctiontype + \varepsilon_p - (1 - \alpha)\varepsilon_v + (1-\alpha)\tau \times \varepsilon_v \times auctiontype.$$

For estimation purpose, we rewrite it as

$$\tilde{p}_{li} = \beta_1 \tilde{v}_i + \beta_2 \tilde{v}_i \times auctiontype_i + u_i, \quad (9)$$

where i indexes the land parcel-*loupan* match, $u_i = \varepsilon_{pi} - \beta_1\varepsilon_{vi} - \beta_2\varepsilon_{vi} \times auctiontype_i$, $\beta_1 = (1-\alpha)$, and $\beta_2 = -(1-\alpha)\tau$.

An endogeneity problem exists in the estimation of (9) because $\mathrm{cov}(\tilde{v}_i, u_i) = -\beta_1 \mathrm{var}(\varepsilon_v)$. This problem indicates that the OLS estimate will be attenuated. We use the following variables as instruments for the observed housing value per unit of land: $dist_i$, which is the distance between the land parcel and the CBD; $railway_i$, which represents whether a railway exists within a 2.5 km radius (including a light rail or a subway); and $highway_i$, which represents whether a highway exists within a 2.5 km radius. The auction type of land sale, represented by $auctiontype_i$, is also controlled in the first stage because properties with better unobserved characteristics are likely to be selected in corrupt land sales (Cai et al., 2013b).

The following assumptions for valid instrumental variables (IVs) are required. First, the IVs should strongly affect the observed housing value per unit of land. This assumption is likely to hold because property values tend to decrease as the commuting time increases (Zheng and Kahn, 2008) and to increase for corrupt land sales (Cai et al., 2013b). Second, the geographic characteristics should be uncorrelated with the measurement errors, an assumption that is likely to be valid. Third, it is unlikely that the uncertainty about the appeal of the completed structure correlates with the proximity to the CBD or to the public transit. Finally, the auction type of land sale is unlikely to correlate with either ε_p or ε_v .

Table 2 shows the results, and Column 1 presents the first-stage findings. Our instruments are strong (*F*-static is 34.812). Similar to Zheng and Kahn (2008), we find evidence that proximity to the CBD or public transit infrastructure is capitalized into real estate prices. The OLS estimate (Column 2) is smaller than the 2SLS (Column 3), which implies the existence of attenuation bias because of measurement errors. No constant terms in the OLS and the 2SLS specifications exist because p_l must go to zero as v goes to zero. The estimated land-share parameter $(1-\alpha)$ in the case of China is 0.323 (Column 3). As a comparison, the estimate for this parameter ranges from 0.13 to 0.51 across metropolitan areas in the US (Epple et al., 2010a; Albouy and Ehrlich, 2012).

Ideally, we would like to use the current market values of land parcels, instead of their historical land sale prices. Given the institutional changes in urban land markets during the 2000s, the deviation of historical land sale price and current market value may vary over the years. These year-specific effects would be captured in the measurement error of the observed price per land unit. If these year-specific effects also correlate with the housing value per land unit predicted from the first stage (e.g., the city government may sell land parcels far away from the city center in later years), the 2SLS estimate would be biased. We implement two strategies to test the robustness of our results. First, we add year dummies as controls in the 2SLS regression. As shown in column (4) of Table 2, the estimate for land-share parameter remains stable. Second, we regress the housing value per land unit predicted from the first stage on year dummies. Only the year dummy indicating 2009 has a significant positive coefficient. We then run the 2SLS regression while dropping the land parcel sold in 2009. Column 5 shows that the estimate for land-share parameter remains stable.

4. Calculated housing price appreciation and discussions

In this section, we calculate the equilibrium housing price appreciation rates from the changes in the fundamental factors of demand and supply between 2002 and 2008 according to the equilibrium relationship between housing price appreciation and the fundamentals presented in Eq. (5). By comparing the actual housing price appreciation with the calculated equilibrium counterpart, we then evaluate how much of the increase in housing prices during the study period can be explained by the observed changes in the fundamental variables.

The data sources for the fundamental variables used in our calculations are as follows. We consider the population size of a city as the total population of local urban *hukou* holders, which is reported in the National Urban Yearbooks. We opt not to use the actual population of a city reported in the census because it also includes a large number of the "floating population," who are residents without local urban *hukou*. In general, these people are not likely to settle down in the city and own local houses.

[9] Among 505 land parcels in our sample, 391 land parcels were sold through two-stage auctions, and 114 were sold through English auctions.

Table 2
Estimation of housing production function..

Independent variable	Dependent variable				
	$\tilde{v}$	$\tilde{p}_l$	$\tilde{p}_l$	$\tilde{p}_l$	$\tilde{p}_l$
	1	2	3	4	5
	FS	OLS	2SLS	2SLS	2SLS
$\tilde{v}$		0.287***	0.323***	0.327***	0.323***
		(0.025)	(0.034)	(0.039)	(0.034)
$\tilde{v}$ * *auctiontype*		−0.119***	−0.118***	−0.086***	−0.118***
		(0.031)	(0.034)	(0.020)	(0.034)
dist	−348.562***				
	(77.047)				
railway	4388.828**				
	(1899.987)				
highway	1647.277				
	(1912.329)				
auctiontype	3740.127**				
	(1539.120)				
Year fixed effects	N	N	N	Y	N
Constant	Y	N	N	N	N
F-Stat for weak IV	34.812		34.812	6.023	34.784
Hansen *J*-stat	3.630		3.630	1.476	3.685
p-Value of Hansen *J*	0.163		0.163	0.478	0.158
Obs	505	505	505	505	503

Notes: Heteroskedasticity-robust standard errors are in parentheses. We drop the land parcels sold in 2009 in column 5.
** Significance at 5%.
*** Significance at 1%.

The majority of the floating population lives either in the outskirts of the city proper where low-quality and cheap rental housing is available or in dorms or temporary housing offered by their employees. For example, Logan et al. (2009) show that less than 5 percent of non-*hukou* migrants are homeowners in former urban housing markets (i.e., market purchase, economic purchase, and public purchase).[10] Meanwhile, the local urban *hukou* status is highly correlated with homeownership status. Home buyers usually have already got local urban *hukou*, or they are very likely to obtain a local urban *hukou* right after housing purchases because of their individual characteristics that are correlated with both homeownership status and local urban *hukou* status (e.g., education, skills, income, and family characteristics).

Wage income data are from the National Urban Yearbooks. The city's average wage variable measures salaries and subsidies paid to the formal employees in the state or collective sectors as well as some newly emerging ones such as joint ventures with international companies in the high technology industry. Majority of the workers have local urban *hukou*.

The total area of land whose leaseholds were sold to developers by the city government between 2003 and 2007 measures the new increase in the urban land stock of a city. The total built-up land area within the city proper (i.e., land area with completed construction) in 2002 and 2003 measures the initial urban land stocks. The figures are obtained from the National Land Resource Yearbooks and the National Urban Yearbooks.

The growth rate of construction cost is determined by the provincial price indices of investment in fixed assets for newly completed buildings and the provincial average labor cost in the construction sector. We weight these two factors by capital and labor shares, which are 0.8 and 0.2, respectively, in China (Jin et al., 2005).

Housing price data are taken from the National Statistical Yearbooks, which report the average sale prices of newly-built residential housing for the 35 major Chinese cities. One drawback of this data set is that housing quality is not controlled.[11] However, to the best of our knowledge, this housing price measure is the only one that covers most of the major Chinese cities with a decent time span.

We also deflate the growth rates of all price variables by the provincial CPI. The data are taken from the National Statistical Yearbooks (2003–2009). Table 1 presents the summary statistics.

According to Eq. (4), the four coefficients of fundamental changes in Eq. (5) can be inferred using the land-share parameter, $(1-\alpha)$, as well as the income and price elasticities of housing demand, δ_1 and δ_2. Specifically,

$$\phi_1 = (\delta_1(1-\alpha))/(1-(1+\delta_2)(1-\alpha)),$$
$$\phi_2 = (1-\alpha)/(1-(1+\delta_2)(1-\alpha)),$$
$$\phi_3 = (1-\alpha)/(1-(1+\delta_2)(1-\alpha)),$$
$$\text{and } \phi_4 = \alpha/(1-(1+\delta_2)(1-\alpha)).$$

[10] In addition, consistent with our assumption that non-*hukou* residents are unlikely to be potential home buyers, we find that the purchase restriction introduced in 2010 and 2011 to prohibit non-*hukou* residents from local housing markets in several major cities did not cause any substantial drop in housing prices.

[11] Wu et al. (2014) show evidence on housing suburbanization in the newly-built sector between 2004 and 2007. This trend of quality change for newly-built houses leads to an underestimation of the housing price growth rate when the non-constant-quality housing prices are used.

Polinsky and Ellwood (1979) find that the permanent income elasticity of housing demand is around 0.8. Harmon (1988) sets it at 1 for the long-run housing consumption, Epple and Sieg (1999) estimate it at 0.938, and Epple et al. (2010b) suggest that it is 0.787. The price elasticity ranges from −0.5 to −0.9 (e.g., Polinsky and Ellwood, 1979; Epple and Sieg, 1999; Epple et al., 2010b). In the case of China, Chow and Niu (2010) apply a standard supply–demand framework with a partial adjustment mechanism on aggregate time series data to estimate long-run income and price elasticities in the demand equation for the average urban consumer across cities. Their study finds that the long-run income elasticity of demand for urban housing is about 1.0, and the price elasticity of demand is between −0.5 and −0.6. We follow Chow and Niu (2010) and place the income elasticity of demand δ_1 at 1.0 and the price elasticity of demand δ_2 at −0.5. We also experiment with different values for these two parameters as a robustness check. Specifically, we let $\delta_1 \in \{0.8, 0.9, 1, 1.1\}$ and $\delta_2 \in \{-0.4, -0.5, -0.6, -0.7\}$. The calculated results are all similar across different sets of values.

Column 1 of Table 3 presents the actual housing price appreciation rate for each city. Columns 2 and 3 of Table 3 report the housing price appreciation rates calculated from fundamental changes and their 95 percent confidence intervals. Variations in the observed changes in the fundamental factors of supply and demand during the study period generate a large variation in the calculated housing price appreciation rate across the 35 cities.

The cities are ranked by the share of the calculated housing price appreciation rate in the actual one. For the first 25 cities listed in Table 3, the fundamental changes explain more than half of the increase in housing prices. In Yinchuan, Shenyang, Wulumuqi, Ha'erbin, Nanning, Nanjing, Shijiazhuang, and Taiyuan, changes in fundamental variables predict even greater housing price appreciation rates than what have been actually observed. Note that, all of the eight cities except Nanjing are inland cities. Besides the first 25 cities, changes in fundamental variables can also account for about 45–49 percent of the actual appreciation rates in Guangzhou, Chengdu, and Tianjin.

However, in Haikou, Wuhan, Hangzhou, Kunming, Xiamen, Fuzhou, and Ningbo, the fundamental changes explain much less than half of the increase in housing prices. Especially in Xiamen, Fuzhou, and Ningbo, even the upper bounds of the 95 percent confidence intervals are far below half of the actual appreciation rates.

We also calculate the appreciation rates with changes in fundamental variables between 2002 and 2009. Table 4 presents the results. Although a rapid housing price surge occurred in 2009 following the stimulus plan from the central government, fundamental changes can still account for a major proportion of the actual housing appreciation for most of the cities in our sample. Similar to the results presented in Table 3, in Xiamen, Hangzhou, Fuzhou, and Ningbo, the observed changes in fundamental variables between 2002 and 2009 explain significantly less than half of the actual appreciation during this period.

For the cities in which fundamental changes account for only a small proportion of the increase in housing prices, what has caused the housing price appreciation rates to deviate largely from what can be predicted from the changes in the fundamental variables? First, Cai et al. (2013a) shows that high expected capital gains encourage investment demand in housing markets, especially for rich urban households by using household survey data. In the coastal cities (Haikou, Hangzhou, Xiamen, Fuzhou, and Ningbo are all coastal cities), the housing price growth rates are higher than those in other major cities during the earlier half of this paper's study period and thus help to form a higher expectation of capital gains from owning housing as an asset later on. Moreover, the households in these cities might be relatively rich and are therefore likely to have higher investment demand for housing. Therefore, we may expect investment demand to be another important driving factor for the housing price appreciation in these coastal cities.

Second, this paper assumes a constant housing supply elasticity across cities. However, geographic limitations and local restrictions on increase in density may lead to a smaller housing supply elasticity in these cities and hence

Table 3
Actual and calculated housing price appreciation, 2002–2008.

City Name	Actual	Calculated		
	1	2	3	
Yinchuan	0.11	0.33	(0.28	0.37)
Shenyang	0.25	0.43	(0.40	0.45)
Wulumuqi	0.35	0.44	(0.39	0.49)
Ha'erbin	0.32	0.39	(0.35	0.44)
Nanning	0.33	0.40	(0.34	0.46)
Nanjing	0.38	0.46	(0.40	0.51)
Shijiazhuang	0.34	0.41	(0.37	0.45)
Taiyuan	0.48	0.56	(0.49	0.62)
Jinan	0.56	0.52	(0.47	0.57)
Zhengzhou	0.41	0.37	(0.34	0.39)
Shanghai	0.57	0.48	(0.46	0.51)
Hefei	0.56	0.47	(0.43	0.50)
Huhehaote	0.57	0.47	(0.42	0.51)
Nanchang	0.56	0.46	(0.41	0.50)
Changchun	0.32	0.26	(0.24	0.28)
Guiyang	0.48	0.37	(0.32	0.42)
Chongqing	0.55	0.41	(0.38	0.45)
Dalian	0.60	0.43	(0.41	0.46)
Xi'an	0.49	0.35	(0.31	0.40)
Xining	0.57	0.40	(0.34	0.46)
Lanzhou	0.55	0.37	(0.31	0.44)
Beijing	0.85	0.55	(0.50	0.60)
Changsha	0.46	0.29	(0.28	0.30)
Shenzhen	0.73	0.43	(0.36	0.51)
Tianjin	0.68	0.39	(0.37	0.42)
Chengdu	0.78	0.38	(0.35	0.42)
Guangzhou	0.63	0.30	(0.26	0.35)
Qingdao	0.70	0.32	(0.31	0.32)
Haikou	0.62	0.25	(0.24	0.25)
Wuhan	0.68	0.27	(0.25	0.29)
Hangzhou	0.80	0.22	(0.21	0.24)
Kunming	0.28	0.07	(0.05	0.08)
Xiamen	1.07	0.15	(0.15	0.15)
Fuzhou	0.82	0.03	(0.00	0.06)
Ningbo	0.92	−0.02	(−0.07	0.02)

Notes: Column 1 reports the actual housing price appreciation between 2002 and 2008. Columns 2 and 3 report the housing price appreciation rates calculated from fundamental changes and their 95 percent confidence intervals.

Table 4
Actual and calculated housing price appreciation, 2002–2009.

City Name	Actual	Calculated		
	1	2	3	
Shenyang	0.33	0.50	(0.47	0.53)
Wulumuqi	0.43	0.51	(0.45	0.56)
Yinchuan	0.32	0.38	(0.34	0.43)
Xi'an	0.49	0.49	(0.44	0.54)
Taiyuan	0.68	0.63	(0.55	0.70)
Ha'erbin	0.49	0.43	(0.37	0.48)
Nanning	0.53	0.46	(0.39	0.53)
Jinan	0.70	0.57	(0.51	0.63)
Zhengzhou	0.55	0.41	(0.37	0.45)
Huhehaote	0.83	0.63	(0.58	0.68)
Hefei	0.75	0.56	(0.52	0.60)
Guiyang	0.69	0.50	(0.46	0.55)
Dalian	0.69	0.50	(0.47	0.54)
Shijiazhuang	0.69	0.48	(0.42	0.53)
Nanjing	0.74	0.51	(0.45	0.57)
Changchun	0.50	0.34	(0.32	0.36)
Chongqing	0.78	0.52	(0.48	0.57)
Xining	0.54	0.36	(0.32	0.40)
Lanzhou	0.68	0.45	(0.38	0.52)
Wuhan	0.80	0.50	(0.44	0.56)
Shenzhen	0.87	0.52	(0.44	0.61)
Beijing	0.99	0.59	(0.54	0.64)
Changsha	0.57	0.34	(0.33	0.35)
Guangzhou	0.67	0.37	(0.32	0.43)
Chengdu	0.79	0.44	(0.40	0.48)
Nanchang	0.64	0.34	(0.34	0.35)
Kunming	0.30	0.16	(0.15	0.17)
Shanghai	1.00	0.50	(0.47	0.54)
Haikou	0.80	0.39	(0.39	0.40)
Tianjin	0.86	0.41	(0.38	0.44)
Qingdao	0.82	0.35	(0.35	0.36)
Xiamen	1.09	0.29	(0.26	0.32)
Hangzhou	1.07	0.26	(0.24	0.29)
Fuzhou	1.04	0.09	(0.07	0.11)
Ningbo	1.22	0.00	(−0.04	0.04)

Notes: Column 1 reports the actual housing price appreciation between 2002 and 2009. Columns 2 and 3 report the housing price appreciation rates calculated from fundamental changes and their 95 percent confidence intervals.

a greater impact of population growth (Glaeser et al., 2005; Saiz, 2010). For example, in Kunming, Hangzhou, Ningbo, Xiamen, and Fuzhou, the city proper is surrounded by mountains, water, or prefecture boundaries, which hinder further expansion of the urban area and curtail residential development. In addition, Wang and Zhang (2014) show that density restrictions are stricter in coastal cities than in inland cities. As a result, the housing supply elasticity is lower there which in turn may amplify the impact of population and income growth on housing price appreciation.

Third, some of these cities may be "superstar cities" which high income households disproportionately sort in (Gyourko et al., 2006). As the absolute number of rich households in the country increases and as their income rises, more families become willing to pay a higher price to live in these cities and thereby support greater growth in local housing prices. A thorough examination of the reasons for the "overly high" housing price appreciation in these cities is beyond the scope of this paper, and we leave it to future studies.

5. Conclusion

In this paper, we investigate the role of fundamental factors in the urban housing markets of China. We use both city-level and residential development project-level data to evaluate the importance of fundamental factors from both the demand and supply sides. Our results suggest that, for most of the cities in our sample, changes in fundamental factors, such as the urban *hukou* population, wage income, land supply, and construction costs, can account for a major proportion of the actual housing price appreciation. However, in several coastal cities, the actual increase in housing prices deviates largely from what can be predicted from fundamental changes.

Interest rates and taxes may also be important factors that affect housing prices because of their influences on the user cost of housing (Himmelberg et al., 2005). Unlike homeowners in the US, homeowners in China cannot deduct mortgage interest expenses from their income taxes. In addition, China has generally no local property taxes over our study period. Mortgage rates are also roughly constant across cities, and changes in interest rates over time are relatively small.[12] Considering China's specific institutional context, we do not introduce interest rates and taxes into our specification.

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Appendix A. Data for the estimation of housing production function

The land auction data set consists of 13,030 land parcel sales from 2001 to 2009 across 60 cities, among which 6,294 are for residential use. Observations are properties put up for auction with completed transactions later. The *loupan* data set covers 13,083 development projects in April 2009 across 55 cities.

In the raw data of matched land parcel sales and *loupan*, we have 797 matched pairs between land parcel sales and *loupan* developments. We drop projects with different house types (villa versus apartment) but the same floor-

[12] According to the National Statistical Yearbooks, the real loan rate for 5 years and above increased from 5.81 to 6.74 percent between 2002 and 2008. Chow and Niu (2010) show that between 1999 and 2006, four adjustments in the rates of the Individual House Accumulation Fund were made, among which the rate for five years and above varied between 4.05 and 4.59 percent. Three changes in commercial bank mortgage rates were also made, with the rate for 5 years and above varying between 5.04 and 6.12 percent.

area-ratio. We treat multiple observations as one project if they are using identical land parcel information and keep the observation with the lowest price per square meter of floor space. We treat multiple observations with same project name and different land parcel information as separate projects. We also drop observations with missing or unreasonable floor-area-ratios. We drop observations that are transacted through sealed-bid auctions. Finally, we drop observations with missing information on prices and the size of land parcels. We end up with 505 observations for the final regression.

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