Habitat International 40 (2013) 9–17

Contents lists available at SciVerse ScienceDirect

Habitat International

journal homepage: www.elsevier.com/locate/habitatint

Relationship between urban land price and housing price: Evidence from 21 provincial capitals in China

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JEL classification:
R15
R21
R31

Keywords:
Housing price
Land price
Endogenous relationship
Simultaneous- equations model

A B S T R A C T

Economic fundamentals are recognized as determining factors for housing and land prices on the city level, but the relationship between housing price and land price has been disputed. In this paper, a simultaneous-equations model is developed to explore the interaction between housing price and land price. This model uses urban land price and housing price as endogenous variables and five factors for land price and seven factors for housing price as exogenous variables. By using sample data of 21 provincial cities in China from 2000 to 2005, the model is estimated by using the two-stage least-squares method. Housing price and land price have an endogenous interrelationship, and as a whole, housing price has greater influence on land price. Per capita disposable income is not only an important factor for land price but also has a direct impact on housing price. Lagged house price has the highest degree of influence on housing price, which implies that increased house price is the expected effect of housing price. The model is effective and reasonable, and it can provide a basis for relevant government departments to establish related policies.

Introduction

In 1998, China implemented major changes in its housing system. The housing system, with strong vestiges of the planned economy, was abolished by the State Council all over the country and changed from physical to monetary distribution. This institutional transformation rapidly advanced housing commercialization and accelerated the development of the real estate industry in China. Subsequently, along with the implementation of a new policy on housing mortgage loans and the deepening of reform in the land transfer system, the real estate market gradually prospered. Housing prices have continued to rise in many cities, unlike household income, and have gone beyond affordability in some large cities. In this context, the controversy about the Chinese real estate bubble has become an issue in domestic and international economic circles, thereby turning the argument on the relationship between housing price and land price into a major concern of all sectors in society.

Given this background, has high land price led to high housing price, or vice versa? Government departments, real estate developers, and academic scholars have different opinions regarding this matter. Overall, three main points are discussed:

(1) The cost-driven perspective. Housing price consists of land acquisition cost, development cost, marketing fee, and developer profit. As a component of housing cost, land price is bound to affect housing price. Yang (2003) and Bao (2004) claim that housing prices rise because of a shortage in land supply, and the rise of land price increases housing price. This opinion is supported in some studies on other regions. Evans (1987) observes that in the United Kingdom, government planning on land use limits land supply, thereby raising land price and boosting housing price. Peng and Wheaton (1994) and Hui (2004) reveal that land supply restrictions lead to higher prices in Hong Kong. Glaeser, Gyourko, and Saks (2005) found that land constraints are the main reason for high housing prices in U.S. cities.
(2) The derived demand perspective. From the perspective of urban space economics, Alonso (1964) and Muth (1960) set the bid price function, which implies that high housing prices cause high land prices. Muth (1971), Witte (1975), and Manning (1988) created the derived demand theoretical model of the land market, proposing that land is the derivative

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0197-3975/$ – see front matter
http://dx.doi.org/10.1016/j.habitatint.2013.01.004

demand for housing service and that land price is determined by housing price. Zhu and Dong (2005) and Liu and Jiang (2005) also hold this opinion. Through the market mechanism, housing demand, including real and speculative demand, determines housing price, but land demand is derived from housing. Strong demand in the Chinese real estate market causes housing demand to exceed the supply market and raises housing price, which, in turn, raises land price.

(3) The mutual causation perspective. Huang (2005) and Qu (2005) found that housing price and land price have a mutually causal relationship. From the demand perspective, rising housing price leads to an increase in land price, but from the supply perspective, land price is a factor in housing price increase. Housing price is not the sole determinant of land price and vice versa (Liu & Liu, 2003). We should analyze the causal relationship between housing price and land price based on different periods, different land supply policies, and different states of real estate development. Potepan (1996) found that in the U.S., housing rent and land price significantly impact housing price and vice versa, but the relationship between housing rent and land price is not significant.

Unfortunately, existing empirical studies on this issue in China have led to ambiguous conclusions. Quarterly data from January 1999 to December 2004 and the Granger causality test, Zou (2005) indicate that housing price significantly affects land price, but land price has an insignificant impact on housing price. Similarly, Li (2005) and Feng and Liu (2006), using monthly data from January 2002 to April 2005 and quarterly data from the first quarter of 1998 to the second quarter of 2005, respectively, prove that housing price is the Granger cause of land price, but land price is not the Granger cause of housing price, that is, changes in housing price affect land price, but changes in land price do not affect housing price. However, Gao and Mao (2003), using quarterly samples of the land price index and real estate price from 1999 to 2002, used the Granger causality test and regression analysis and found that Granger causes exist in the housing price of lagged two quarters on land price and land price of lagged two quarters on housing price. Based on lagged four quarters, housing price has a significant influence on land price, but land price has none on housing price. Using data from the first quarter of 1999 to the second quarter of 2005 from the same source, Kuang (2005) similarly concludes that housing price determines land price in the long term, but both affect each other in the short term. Chinese scholars generally use the Granger causal test and vector autoregression (VAR) models to analyze the relationship of urban land and housing prices with national time-series data. These studies do not consider the endogenous relationship between urban land price and housing price.

Understanding the relationship between land price and housing price is very important for scientific policy making and promoting the healthy development of the real estate market. This paper develops a simultaneous-equations model that uses urban land and housing prices as endogenous variables and five factors for land price and seven factors for housing price as exogenous variables. In addition, this paper conducts an empirical analysis to explore the interaction between housing price and land price using panel data of 21 cities in China from 2000 to 2005. Compared with existing empirical studies in China, this paper has three features: (1) The variables are not just housing and land prices, but also numerous factors that reflect economic fundamentals. (2) Research data are extended from the time series to the panel, and spatial scope is more specific, from the national to the city level. (3) A simultaneous-equations model identifies the quantitative mutual influence between housing price and land price.

The rest of this paper is organized as follows. Section 2 reviews literature related to the determinants of urban housing and land prices from economic fundamentals. Section 3 presents the identification and estimation method of simultaneous equations and defines model variables. Section 4 estimates the model by using two-stage least squares (2SLS) and discusses the empirical results. Section 5 provides conclusions and policy implications.

Literature review

Determinants of urban housing price

At the city level, housing price is determined by economic fundamentals. Empirical studies start with supply and demand, and they use exogenous macroeconomic variables, such as income, population, and construction cost, to explain housing price. Such factors are related to the supply and demand of the local housing market; thus, their impact on housing price is often estimated. Urban economic fundamental variables are significant and could interpret intercity differences in housing price.

Mankiw and Weil (1989) examine the impact of major demographic changes on housing price in the United States. Fortura and Kushner (1986) found a strong positive correlation between average income and housing price. Manning (1986) developed an equilibrium model with a single equation to explain intercity variation in housing price appreciation. The empirical model considers 16 independent variables of both housing demand and supply, and accounts for 68.8% of housing price appreciation. Shen and Liu (2004) conducted empirical research on the relationship between housing prices and economic fundamentals with panel data on 14 cities in China from 1995 to 2002. The logarithmic model shows that four variables of urban households (i.e., per capita disposable income, population, unemployment rate, and vacancy rate) significantly influence and can explain about 60% of the housing price.

Case and Shiller (1989, 1990) and Hort (1998) reveal that housing prices are serially correlated. Englund and Ioannides (1997) modeled housing price changes in 15 member-countries of the Organisation for Economic Co-operation and Development from 1970 to 1992. With a rich autocorrelation structure, the first-order autocorrelation coefficient is estimated significantly as high as 0.45. Quigley (1999) used per capita income, employment, number of households, vacancy rate, and construction permits as model variables. The simple models show that these factors can explain 10–40% of the housing price variation. Coupled with lagged housing price, the predictive power of the combined models improved greatly, and the fitness coefficients of regression equations were all more than 0.95. Thus, in addition to local economic conditions, lagged housing prices are important predictors of housing price.

Determinants of urban land price

Compared with housing price studies, fewer studies focus on the determinants of urban land price across cities, but their analytical frameworks are similar. Using land price data of 94 US metropolitan areas in 1980 as samples, Manning (1988) set up an equilibrium model to analyze the factors for inter-urban land price. Construction cost, population growth, population density, urban climate conditions, and household income of high-income groups are statistically significant to urban land price.

Based on two traditional land rent models, Hardie, Parks, Gottleib, and Wear (2000) present a county-level land use analysis of 1459 counties in the U.S. South. Their model shows that agricultural land price is related to land proportion, population, household income, real estate price, cost, and urbanization. Davis and Heathcote (2007) conceptualized a house as a bundle which comprises a reproducible tangible structure and a non-reproducible plot of land and found that economic fundamentals affect housing price by association with land price. Davis and Palumbo (2008) reveal that residential land values have appreciated in more cities since the mid-1980s. By the end of 2004, the value of residential land accounted for about 50% of the total market value of housing, up from 32% in 1984. With land value, population density changes, and percentage of work at home as dependent variables, Clapp, Rodriguez, and Pace (2001) constructed three simultaneous equations and used three-stage least-squares on model estimation. Lagged dependent variables have a strong autoregressive pattern in each equation, which illustrates the need to pay attention to dynamic changes even though the main focus of the research is cross-sectional relationships.

Relationship between housing price and land price

The literature features two major research threads regarding the relationship between housing price and land price. The first method uses co-integration and the Granger causality test. Ooi and Lee (2006) examined the housing and land markets by using quarterly data (price index) of Singapore from 1990 to 2005. Augmented Dickey–Fuller and Johansen tests reveal that land and housing prices are integrated in the long term. The error correction model shows that housing price is the Granger cause of land price, but no reverse causality is found from land price to housing price. As described in the introduction, Chinese scholars mainly apply this method to conduct empirical studies on the national level (Feng & Liu, 2006; Gao & Mao, 2003; Kuang, 2005; Li, 2005; Zou, 2005) but have not made consistent conclusions.

The second method constructs simultaneous-equations models to test the existence of the endogenous nature and investigate the interaction between housing price and land price. Ozanne and Thibodeau (1983) measured price variation among 54 metropolitan areas in the U.S., dividing the real estate market into the housing and rental markets and verifying the link between housing price and rent. Potepan (1996) suggested that the housing, land, and rent markets are three interrelated submarkets and that housing price, land price, and housing rent are three endogenous variables which interact with each other. The simultaneous-equations model is constructed for these three submarkets, and 2SLS is used to estimate equations. Housing price, land price, and housing rent are determined by exogenous and endogenous factors. Similarly, Hwang and Quigley (2006) created a simultaneous-equations model on housing price, housing supply, and vacancy rate.

Most studies look at intercity land or housing price separately. Scholars who focus on housing price often take land price as the exogenous variable, and those who focus on land price usually take housing price as the exogenous variable, so the endogenous problem of land and housing prices could not be resolved in the traditional analysis framework. Empirical studies on the Chinese real estate market generally use the Granger causal test and the co-integration model with national time-series data and often obtain qualitative conclusions. Without considering the endogenous relationship between urban land price and housing price, quantitative conclusions obtained simply by using one-equation regression are uncertain and require further investigation.

Therefore, this paper adopts the simultaneous-equations model to conduct an empirical study on the relationship between the housing price and land price of 21 cities in China. From the supply and demand of the housing and land markets, the determinants of house and land prices are identified from the city level. Given the serial correlation between land and housing prices, two lagged dependent variables are set as predetermined variables. Based on model estimation by 2SLS and the evaluation of endogenous relationship through the Hausman test, a comparative analysis of the relationship and determinants of housing and land prices is conducted with regard to all 21 cities (8 eastern coastal and 13 inland).

Model and data

Specification of simultaneous-equations model

Function-form

Taking housing and land prices as two endogenous variables, this paper develops a simultaneous-equations model with two linear form equations, including 2 predetermined variables (i.e., lagged endogenous variables) and 10 exogenous variables. The land price equation contains the lagged endogenous variable $LP(-1)$ and five exogenous variables, and the housing price equation contains the lagged endogenous variable $HP(-1)$ and seven exogenous variables. Specific expressions of the simultaneous-equations model are as follows:

$$LP = \alpha_0 + \alpha_1 HP + \alpha_2 LP(-1) + \alpha_3 PP + \alpha_4 LBA + \alpha_5 II + \alpha_6 PGR + \alpha_7 PDI + u_1 \tag{1a}$$

$$HP = \beta_0 + \beta_1 LP + \beta_2 HP(-1) + \beta_3 IEE + \beta_4 ABA + \beta_5 LPA + \beta_6 PGR + \beta_7 OER + \beta_8 PDI + \beta_9 PLP + u_2 \tag{1b}$$

where LP is the urban land price and HP is the urban housing price. The 10 exogenous variables are explained in the next section.

Model estimation

As two equations in this work are over-identified, 2SLS can be used to estimate the simultaneous-equations model. The estimation process of the land price equation is taken as an example.

Stage 1

Accounting for the possible correlation between HP and u_1, the regression of HP is performed on all exogenous variables.

$$HP = \gamma_0 + \gamma_1 LP(-1) + \gamma_2 HP(-1) + \gamma_3 PP + \gamma_4 LBA + \gamma_5 II + \gamma_6 IEE + \gamma_7 ABA + \gamma_8 LPA + \gamma_9 PGR + \gamma_{10} OER + \gamma_{11} PDI + \gamma_{12} PLP + \tilde{u} \tag{2}$$

$\tilde{u}$ is the usual residual by ordinary least squares (OLS) and $\widetilde{HP}$ is the predicted value for HP.

$$\widetilde{HP} = \gamma_0 + \gamma_1 LP(-1) + \gamma_2 HP(-1) + \gamma_3 PP + \gamma_4 LBA + \gamma_5 II + \gamma_6 IEE + \gamma_7 ABA + \gamma_8 LPA + \gamma_9 PGR + \gamma_{10} OER + \gamma_{11} PDI + \gamma_{12} PLP \tag{3}$$

Therefore, $HP = \widetilde{HP} + \tilde{u}$. Random HP consists of two components: $\widetilde{HP}$ as a linear combination of 12 exogenous random variables and the random error term $\tilde{u}$. According to OLS, $\widetilde{HP}$ and $\tilde{u}$ are not correlated.

Stage 2

Putting $\widetilde{HP}$ into equation (1a), the over-identified land price equation can be written as follows:

$$LP = \alpha_0 + \alpha_1\left(\widetilde{HP} + \tilde{u}\right) + \alpha_2 LP(-1) + \alpha_3 PP + \alpha_4 LBA + \alpha_5 II + \alpha_6 PGR + \alpha_7 PDI + u_1 = \alpha_0 + \alpha_1\widetilde{HP} + \alpha_2 LP(-1) + \alpha_3 PP + \alpha_4 LBA + \alpha_5 II + \alpha_6 PGR + \alpha_7 PDI + u_1^* \quad (4)$$

where $u_1^* = u_1 + \alpha_1\tilde{u}$. The only difference between equations (1a) and (4) is that *HP* is replaced by $\widetilde{HP}$. Although *HP* and u_1 may be relevant, $\widetilde{HP}$ is considered uncorrelated with u_1^* under large sample conditions; thus, consistent parameters of equation (4) can be estimated by using OLS. The over-identified housing price function can also be estimated by using 2SLS.

Data and variable definition

For the empirical analysis, this paper selected annual data for 21 provincial capitals in China from 2000 to 2005. Economic development in China has clear spatial variation, with eastern coastal cities undergoing rapid economic development and Midwest inland cities being relatively economically backward. City samples are geographically divided into two categories: eastern coastal cities (Beijing, Shanghai, Hangzhou, Guangzhou, Tianjing, Shenyang, Nanjing, and Jinan) and Midwest inland cities (Taiyuan, Haerbin, Fuzhou, Zhengzhou, Wuhan, Zhangsha, Nanning, Chongqing, Chengdu, Kunming, Xian, Lanzhou, and Urumchi). Constructing models on all 21 cities (8 eastern coastal and 13 inland) facilitates comparative analysis.

Endogenous variables

This model uses two endogenous variables. *HP* is the index of the price level of urban housing, which derived its value from the average sale price of urban housing in the *China Statistical Yearbook* (unit: yuan/m^2). *LP*, reflecting the price level of urban land, uses the city data of residential land price level from the urban land price monitoring system of China's Ministry of Land and Resource (unit: yuan/m^2).

Exogenous variables

The seven exogenous determinants of urban *HP* in the simultaneous equations are the investment of real estate development (*IEE*), the completed building area (*ABA*), the purchased land area (*LPA*), the local per capita GDP (*PLP*), the per capita disposable income (*PDI*), the population growth rate (*PGR*), and the employment rate (*OER*). The five exogenous variables of urban land price (*LP*) in the simultaneous equations are the per capita area of arable land (*PP*), the land development area (*LBA*), the infrastructural investment (*II*), the per capita disposable income (*PDI*), and the population growth rate (*PGR*). These 10 variables can be quantified and obtained from the *Statistical Yearbook* directly or indirectly.

The definitions of all variables are as follows:

IEE is the investment amount of all construction projects for housing construction, land development, and land acquisition cost completed from January 1 to the final day in a year (unit: billion yuan).
ABA is the completed building area (unit: 10,000 m^2).
LPA is the amount of all lands purchased through various ways of access to land use rights in a year (unit: 10,000 m^2).
PLP denotes the final average results of production activities in a region in a certain period of time (unit: yuan).
PDI is per capita income plus net transfer payments (such as welfare spending), less per capita personal income tax (unit: yuan).
PGR is the natural population growth rate (unit: %).
OER is calculated as [(urban employment population/total population)*100%] (unit: %).
PP is the per capita area of arable land (unit: m^2).
II is local government expenditure in urban infrastructure (unit: billion yuan).
LBA is the total area of land that has completed pre-development engineering and is ready for building construction in a year (unit: 10,000 m^2).

Descriptive statistics are shown in Table 1, and expected signs of variables are shown in Table 2.

Results and discussion

Nationwide model for 21 cities in China

Model estimated results

2SLS regression of the land price equation in stage one is estimated by using the stepwise method with *HP* as dependent variable on 12 exogenous variables of *HP*(−1), *LP*(−1), *IEE*, *ABA*, *LPA*, *PLP*, *PDI*, *PGR*, *OER*, *PP*, *LBA*, and *II* (Table 3). $\widetilde{HP}$ is expressed as:

$$\widetilde{HP} = 296.833 + 0.332\,LP(-1) + 0.651\,HP(-1) + 0.070\,PDI - 0.334\,LBA + 531.068\,OER + 0.378\,IEE + 0.011\,PLP \quad (5a)$$

With the estimated value ($\widetilde{HP}$) instead of the endogenous variable of *HP*, regression analysis (i.e., stepwise method) is conducted to estimate the land price equation (Table 3). The land price equation can be written as

$$\widetilde{LP} = -1083.373 + 0.332\,\widetilde{HP} + 33.314\,PGR + 0.135\,PDI \quad (5b)$$

Similarly, the regression of housing price equation is estimated (Table 4). $\widetilde{LP}$ is expressed as

$$\widetilde{LP} = 1087.49 + 1.23\,LP(-1) + 0.107\,PDI - 0.382\,IEE + 0.112\,ABA - 0.471\,LBA + 119.848\,PP \quad (5c)$$

The housing price equation can be written as

$$\widetilde{HP} = -396.362 + 0.369\,\widetilde{LP} + 0.179\,HP(-1) - 0.051\,LPA + 760.952\,OER + 0.071\,PDI \quad (5d)$$

Result analysis on nationwide model

(1) Test of endogenous relationship between housing price and land price

Through respective estimations of 2SLS on the housing and land price equations, the simultaneous-equations model for 21 cities is expressed as

$$LP = -1083.373 + 0.322\,HP + 33.314\,PGR + 0.135\,PDI \quad (6a)$$

$$HP = -396.362 + 0.369\,LP + 0.719\,HP(-1) - 0.051\,LPA + 760.952\,OER + 0.071\,PDI \quad (6b)$$

The Hausman test is used to investigate the endogenous relationship between *HP* and *LP*. In stage one, $\widetilde{HP}$ and its residual $\tilde{\nu}$ were obtained. *LP* is regressed on the $\widetilde{HP}$ and its residual $\tilde{\nu}$. Results are as follows:

Table 1
Descriptive statistics.

Variable	21 Nationwide cities				8 Eastern coastal cities				13 Midwest inland cities			
	Mean	Std. dev.	Min	Max	Mean	Std. dev.	Min	Max	Mean	Std. dev.	Min	Max
Endogenous variable												
LP	1268.13	676.54	450	4556	1718.25	869.544109	912	4556	991.13	278.35	450	1801
HP	2778.37	1103.97	1351	6842	3719.50	1213.53177	1825	6842	2199.21	433.20	1351	3575
Exogenous variable												
IEE	230.95	288.99	16.06	1525.01	413.29	387.90	50.53	1525.01	118.75	101.24	16.06	517.73
ABA	696.86	707.60	58.36	3770.88	1092.38	916.11	190.78	3770.88	453.47	378.17	58.36	2209.82
LPA	520.32	432.68	40.04	2092.50	708.92	451.82	131.16	2092.50	404.25	378.79	40.04	1637.19
PLP	21,590.36	11,051.67	5157	56,271	31,559.10	10,992.77	16,432	56,271	15,455.74	4944.41	5157	26,238
PDI	9775.57	2855.18	5632	18,645	11,939.02	3184.92	5850	18,645	8444.22	1526.11	5632	12,661
PGR	3.20	3.12	−3.20	15.12	1.15	2.05	−3.20	4.84	4.46	2.99	−1.89	15.12
OER	0.2704	0.0884	0.1305	0.5515	0.2834	0.1029	0.1695	0.5515	0.2624	0.0778	0.1305	0.5122
PP	0.73	0.48	0.23	2.81	0.64	0.40	0.23	1.78	0.78	0.51	0.33	2.81
LBA	296.97	248.35	7.36	1162.72	408.27	276.64	57.14	1162.72	228.47	202.32599	7.36	916.26
II	26.32	54.42	0.50	369.21	54.10	79.29	1.30	369.21	9.22	13.90	0.50	73.34

$$\widetilde{LP} = -319.29 + 0.571\widetilde{HP} + 0.486\tilde{\nu}t$$
$$= (-0.7006) \quad (2.9673) \quad (5.6427) \qquad (7)$$

As the *t*-value of $\tilde{\nu}$ is statistically significant (*p* value was 0.000), the endogeneity hypothesis between *LP* and *HP* cannot be rejected. Thus, housing price and land price have an endogenous relationship, and housing price and land price interact with each other.

(2) Analysis of exogenous factors for urban land price

To facilitate the analysis of the factors for house price and land price, all variable coefficients are standardized and sorted by using the Wald test with coefficient restriction. According to equations (6a) and (6b), the coefficients of point elasticity are calculated at the means.[1] All results are listed in Table 5.

At 10% significance, two of the five exogenous variables enter the land price equation, but the predetermined variable of lagged land price does not enter it. As expected, these two variables, (*PDI* and *PGR*), positively influence urban land price.

The standardized coefficient of *PDI* is 0.5710 (its elasticity coefficient is 1.0229), which shows that *PDI* has the highest impact on urban land price, but the standardized coefficient of *PGR* is only 0.1536 (the semi-elasticity coefficient is 0.0249), which is much smaller than that of *PDI*. Two exogenous variables are all demand-side variables, and other three supply-side variables of *PP*, *LBA*, and *II* cannot enter the land price equation, which indicates that, to a certain extent, land price increase is due to land demand increase at this stage.

(3) Analysis of exogenous factors for urban housing price

At 10% significance, three of the seven exogenous variables and the lagged endogenous variable of *HP*(−1) entered the urban housing price equation. The signs of these four variables are consistent with our expectations, which shows that *PDI*, *OER*, and lagged housing price have a positive impact and *LPA* has a negative impact on urban housing price.

With a standardized coefficient of 0.7189 and an elasticity coefficient of 0.6571, the degree of impact of lagged housing price is highest on housing price and far greater than that of other variables, which indicates that the expected effect of house price is the main cause of price increase. With a standardized coefficient of 0.1843 and an elasticity coefficient of 0.2514, *PDI* has a significant impact on house price. Local per capita GDP, also on behalf of economic development conditions, does not enter the housing price equation mainly because *PDI* and per capita GDP are correlated with the coefficient as high as 0.9086 at the 1% significance level. *LPA*, a variable of the supply side, enters the housing price equation with a standardized coefficient of −0.0202 and an elasticity coefficient close to zero; thus, along with increasing purchase of land area, housing price is slightly reduced. Thus, rising housing prices cannot be controlled solely by increasing land supply during this period.

(4) Analysis of interactive impact between housing price and land price

According to the standardized coefficients in Table 5, the factor for housing price on land price is 0.5417, but that of land price on housing price is only 0.2261. Every unit increase in housing price can add 0.5417 units to land price, and the increment is 2.40 times that of land price on housing price. The elasticity of housing price is

[1] Given that the unit of *PGR* is ‰ and that of *OER* is %, the coefficients of semi-elasticity are calculated for these two variables.

Table 2
Expected signs of variables.

LP equation		*HP* equation	
Variable	Expected sign	Variable	Expected sign
HP	+	*LP*	+
LP(−1)	+	*HP*(−1)	+
PP	−	*IEE*	?
LBA	−	*ABA*	−
II	+	*LPA*	−
PGR	+	*PGR*	+
PDI	+	*OER*	+
		PDI	+
		PLP	+

0.7109 and that of land price is 0.1698, which shows that each 1% increase in housing price causes land price to increase by 0.7109% and that the increment is 4.19 times that of land price on housing price. As far as the whole market of 21 cities in China is concerned, a positive interaction exists between housing price and land price, and housing price has a much greater influence on land price than land price does on housing price.

LP(−1) does not have a significant impact on land price, but *HP*(−1), with a standardized coefficient of 0.7189 and elasticity of 0.6571, has great impact on housing price, far exceeding the impact of land price on housing price. With strong housing market demand, when housing price increases in the current period, the public would expect housing price to continue rising. Expected housing price greatly affects the purchase behavior of consumers, transforming potential demand into current demand ahead of schedule, and creates strong investment demand because of housing arbitrage, both of which inevitably increase effective demand in the housing market.

Comparative analysis of regional models

This section repeats the same 2SLS analysis for 8 coastal cities and 13 inland cities. Results estimated for two regional models are shown in Appendix Tables 1 and 2. Standardized coefficients, the order by the Wald test, and the coefficients of point elasticity are shown in Table 6.

Table 3
Estimation results of land price equation (nationwide model).

Variable	Coefficient	*t*-Value
Stage one		
Constant	−296.833**	−1.712
LP(−1)	0.332***	3.841
HP(−1)	0.651***	12.631
PDI	0.070***	3.385
LBA	−0.334***	−2.709
OER	531.068***	2.672
IEE	0.378***	2.794
PLP	0.011***	5.176
R^2	0.941	
Adjusted R^2	0.937	
D–W value	1.962	
F value	222.22***	
Stage two		
Constant	−1083.373**	−2.185
HP	0.332***	5.898
PDI	0.135***	3.248
PGR	33.314***	2.821
R^2	0.779	
Adjusted R^2	0.729	
D–W value	1.760	
F value	15.601***	

Note: *significant level is 10%; **significant level is 5%; ***significant level is 1%.

Table 4
Estimation results of housing price equation (nationwide model).

Variable	Coefficient	*t*-Value
Stage one		
Constant	−1087.491*	−1.720
LP(−1)	1.229***	10.461
PDI	0.107*	1.729
IEE	−0.382***	−3.141
ABA	0.112***	7.828
LBA	−0.471*	−1.882
PP	119.848*	1.923
R^2	0.731	
Adjusted R^2	0.714	
D–W value	1.625	
F value	44.321***	
Stage two		
Constant	−396.362**	−2.214
LP	0.369***	4.311
HP(−1)	0.719***	20.567
PDI	0.071***	3.994
OER	760.952**	2.190
LPA	−0.051**	−1.988
R^2	0.939	
Adjusted R^2	0.936	
D–W value	1.625	
F value	304.845***	

Note: *significant level is 10%; **significant level is 5%; ***significant level is 1%.

Test of endogenous relationship between housing price and land price

Analogously, the endogenous relationship between *HP* and *LP* is tested by using the Hausman test, and *LP* is regressed on the $\widetilde{HP}$ and its residual $\tilde{\nu}$. Results of the coastal city model and the inland city model are as follows:

Coastal city model

$$\begin{aligned}\widetilde{LP} &= -421.592 + 0.582\widetilde{HP} + 1.012\tilde{\nu}t \\ &= (-1.1524) \quad (4.0288) \quad (4.5400)\end{aligned} \tag{8}$$

Inland city model

$$\begin{aligned}\widetilde{LP} &= 90.969 + 0.407\widetilde{HP} + 0.183\tilde{\nu}t \\ &= (1.0608) \quad (6.7378) \quad (4.1989)\end{aligned} \tag{9}$$

Formulas (8) and (9) show that the *t*-value of $\tilde{\nu}$ is statistically significant (*p* value is 0.000); thus, the endogenous hypothesis between *LP* and *HP* cannot be rejected. Therefore, the endogenous relationship also exists in the two regional models, and interactive influences exist between housing price and land price.

Comparative analysis of exogenous factors for urban land price

Comparing land price equations in the three models (Tables 5 and 6):

Land price is not sensitive to *II*, but *PDI* has greater impact on land price. With a significance level of 10%, the variable of *II* does not enter the land price equation of the three models. Although infrastructure spending (*II*) is a component cost of urban land price, land price is determined by market demand and supply, not by so-called land costs. Therefore, *II* does not have a significant impact on land price. By contrast, the variable of *PDI* enters the land price equation in all three models, and its standardized coefficients are 0.5710, 0.8131, and 0.2779 (the elasticity coefficients are 1.0229, 1.5022, and 0.4796), which all show that *PDI* has a high impact on urban land price (in the first or second place). *PDI* is an important indicator of economic development and reflects effective demand and consumption capacity. Along with the continuous

Table 5
Standardized and elasticity coefficients (nationwide model).

LP equation				*HP* equation			
Variable	Standardized coef.	Order after test	Coef. of elasticity	Variable	Standardized coef.	Order after test	Coef. of elasticity
PDI	0.5710	1	1.0229	*HP*(−1)	0.7189	1	0.6571
HP	0.5417	1	0.7109	*LP*	0.2261	2	0.1698
PGR	0.1536	2	0.0249[a]	*PDI*	0.1843	2	0.2514
				OER	0.0609	3	0.2655[a]
				LPA	−0.0202	4	0.0000

[a] Semi-elasticity.

Table 6
Standardized and elasticity coefficients (two regional models).

LP equation				*HP* equation			
Variable	Standardized coefficient	Order after test	Coef. of elasticity	Variable	Standardized coefficient	Order after test	Coef. of elasticity
Coastal model							
PDI	0.8131	1	1.5022	*HP*(−1)	0.6951	1	0.7977
PP	−0.4574	2	−0.3372	*IEE*	−0.3941	2	−0.1821
HP	0.3462	2	0.5176	*LP*	0.2271	3	0.1887
LBA	−0.2826	2	−0.2108	*PDI*	0.1978	3	0.3065
Inland model							
LP(−1)	0.4994	1	0.4796	*HP*(−1)	0.6414	1	0.5901
PDI	0.2779	1	0.4566	*LP*	0.1846	2	0.1289
HP	0.1718	1	0.2561	*PDI*	0.1636	2	0.1777
				PLP	0.1522	2	0.0928
				OER	0.1402	2	0.3447[a]
				IEE	0.1394	2	0.0343
				PGR	0.1222	2	0.0078[a]
				LPA	−0.1220	2	−0.0266

[a] Semi-elasticity.

development of China's economy, increased household income effectively increases urban land price.

PP and *LBA* have greater impact on land price in coastal cities. Only in the simultaneous-equations model of coastal cities do *PP* and *LBA* enter the land price equation and have standardized coefficients of −0.4574 and −0.2826, respectively. *PP* reflects potential land supply, and *LBA* represents the short-term supply of the land market. Compared with other cities, coastal cities are more developed and hold less land area that can be empowered in the future, but its market demand is far from satisfied. In such circumstances, supply reduction inevitably leads to rising land price. Therefore, in coastal cities, the supply-side variables of *PP* and *LBA* become two important factors for land price. Land price in coastal cities is also affected by the two sides of market supply and demand.

Comparative analysis of exogenous factors for urban housing price

Compared with those of the land price equation, more factors influence housing price, and the formation mechanism of housing price is more complicated. At 10% significance, housing price in coastal cities has only two significant factors, whereas housing price in inland cities has six. In all three models, the variable of *ABA* does not enter the housing price equation, which indicates that *ABA* is not sensitive to housing price. Moreover, *PDI*, which enters all three models, and its standardized coefficients are 0.1843, 0.1978, and 0.1636, has a significant positive impact on urban housing price. *PDI* is not only an important factor for land price but also has a direct impact on housing price.

Comparative analysis of mutual influence between housing price and land price

The three models all show that a significant interaction exists between urban land price and housing price. The impact of housing price on land price is approximate or greater than that of land price on housing price, and the directions of their interaction are all positive, which means that the rising housing price causes land price to increase and vice versa. Apart from the model of inland cities, the other two models show that the impact of housing price on land price is far greater than that of land price on housing price, which suggests that housing price is dominant and rising price leads to greater land price increase in China's real estate market.

As to the ratios of influence coefficients (elasticities) between housing price and land price, the largest is 2.40 (4.19) in the nationwide model, followed by 1.52 (2.74) in the coastal model, and the smallest is 0.93 (1.99) in the inland model. Compared with that of coastal cities, housing demand in inland cities is lower, and land or potential supply is larger, which makes the interaction coefficient between land price and housing price the smallest. Housing demand is dominant in the real estate market of coastal cities, whereas housing supply capacity is poor; thus, rising housing price increases demand for urban land, which leads to a greater rise in land price. That is, the stronger the housing demand, the greater the influence of housing price on land price. Moreover, the lagged housing prices of the three models are the first important factors for housing price. Their standardized coefficients are 0.7189, 0.6951, and 0.6414 (the elasticity coefficients are 0.6571, 0.7977 and 0.5901), which shows that the impact degree of lagged housing price are far greater than those of other variables and the expected effect of housing price is the main reason for the price increase. Therefore, regarding the overheated real estate industry in China, in addition to improving relevant policies and economic regulation, the public's strong preference for housing, as indicated by housing price increases, should be recognized.

Conclusion

Simultaneous-equations models have not been used to study the relationship between housing price and land price in China. This paper analyzes respective determinants of urban housing and land prices by using a simultaneous equations modeling approach and specifically investigates the relationship between housing price and land price. The results of this paper constitute the first empirical study in this research field in China. Housing price and land price have an endogenous relationship, and their interactions are all positive. As far as the whole market of 21 cities in China is concerned, the ratio of influence coefficients between housing price and land price is 2.40, which shows that housing price is in a dominant position as a whole and that its influence on land price is greater than the influence of land price on housing price.

The regional models of 8 eastern coastal and 13 inland cities show that determinants of housing price and land price have some differences in each market. The per capita area of arable land and purchased land area have a greater influence only on land price in coastal cities, and less significant factors affect housing price in coastal cities, but more factors affect housing price in inland cities. The three models all show that the influence of urban infrastructure investment on land price and the completed area of building on housing prices are not significant, but the per capita disposable income is an important factor for land price and has a direct impact on housing prices. Lagged house price has the greatest influence on housing price, which implies that the expected effect of housing price is the main cause of house price increase.

These results have important implications for analyzing the interaction mechanism of urban land and housing prices. Using the Granger causal test and VAR model, we can only come to a qualitative conclusion, and the quantitative relationship between urban land price and housing price is difficult to measure. Owing to the endogenous relationship, the mutual influence coefficients of urban land and housing prices, which were obtained from two separate regression equations, are meaningless.

These empirical results can provide a basis for relevant government departments to establish related policies. (1) Formulating policies on the real estate market should be systematic. To maintain the stable and healthy development of the real estate market in China, we should pay attention to the interaction mechanism of urban land and housing prices in constituting policies. The dominant position of housing price should be used, and the role of land price should not be overlooked. Overall, housing price and land price have a mutually causal relationship; thus, the housing and land markets are two highly correlated asset markets. Merely taking the land market as the derivative market of the housing market and making polices based on the single market (the land or housing market) usually results in inconsistency between policies and expectations. Government control on housing price should comprehensively consider the link between housing price and land price and propose systematic intervention policies. (2) Policies on the real estate market should have regional differences. The determinants of housing and land prices of coastal cities are significantly different from those of inland cities. Different housing markets in different areas are in different stages of development; the government should craft real estate policies with regional differences to promote the stable development of the housing and land markets. The mutual impact of housing and land prices may change because of the different development levels of the real estate market; thus, the local government must carefully evaluate the actual situation of the urban real estate market in policy making.

Acknowledgments

This research was supported by National Natural Science Foundation of China (No. 40801057) and Zhejiang Provincial Natural Science Foundation of China (No. Y7100155, LY12D01005).

Appendix A

Table A1
Estimation results of the coastal model.

LP equation			*HP* equation		
Variable	Coefficient	*t*-Value	Variable	Coefficient	*t*-Value
Stage one					
Constant	−1033.610***	−2.962	*Constant*	−1857.888*	−1.753
HP(−1)	0.694***	8.840	*PP*	−1843.375***	−3.533
LP(−1)	0.754***	5.238	*PDI*	0.322***	6.260
PDI	0.110***	4.136	*OER*	4241.546**	2.157
IEE	−1.725***	−3.298	*IEE*	−1.288***	−5.225
ABA	0.790***	3.348	*II*	4.396**	2.326
LBA	−0.369**	−1.833			
R^2	0.962			0.829	
Adjusted R^2	0.955			0.770	
D–W value	2.205			1.966	
F value	137.601***			14.120***	
Stage two					
Constant	−865.597	−0.831	*Constant*	−336.845***	−3.790
HP	0.248**	1.919	*LP*	0.317***	17.220
PP	−984.974**	−2.098	*HP*(−1)	0.695***	7.093
PDI	0.222**	1.856	*PDI*	0.075***	3.094
LBA	−0.888**	−2.369	*IEE*	−1.233***	−6.100
R^2	0.766			0.954	
Adjusted R^2	0.694			0.948	
D–W value	1.928			2.048	
F value	10.700***			142.041***	

Note: *significant level is 10%; **significant level is 5%; ***significant level is 1%.

Table A2
Estimation results of the inland model.

LP equation			*HP* equation		
Variable	Coefficient	*t*-Value	Variable	Coefficient	*t*-Value
Stage one					
Constant	188.183	0.498	*Constant*	−338.877***	−6.369
HP(−1)	0.571***	5.620	*LP*(−1)	0.868***	4.667
PDI	0.078***	3.925	*PDI*	0.077***	3.191
OER	652.779***	5.746	*ABA*	−0.469***	−3.254
LBA	−0.273**	−2.149	*PGR*	9.291***	3.439
PGR	12.367***	5.659	*LPA*	0.135**	2.593
ABA	−0.341***	−2.972			
IEE	1.760***	4.144			
R^2	0.721			0.901	
Adjusted R^2	0.687			0.865	
D–W value	2.292			1.832	
F value	21.057***			25.159***	
Stage two					
Constant	−188.053***	−2.795	*Constant*	−267.840	−1.046
HP	0.110*	1.941	*LP*	0.287**	1.745
LP(−1)	0.499**	2.309	*HP*(−1)	0.641***	6.703
PDI	0.051***	3.627	*PLP*	0.013**	1.982
			PGR	17.666***	5.162
			OER	781.126***	9.966
			IEE	0.596***	2.732
			LPA	−0.140*	−1.902
			PDI	0.046**	2.630
R^2	0.873			0.722	
Adjusted R^2	0.831			0.683	
D–W value	1.600			2.374	
F value	20.667***			18.198***	

Note: *significant level is 10%; **significant level is 5%; ***significant level is 1%.

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