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Equilibrium-Oriented Housing Supply: A Case Study of Chengdu City, China

Summary: There is a growing concern regarding housing supply management because of soaring housing prices consequent to recent market failure in China. This study is aimed at presenting an equilibrium-oriented housing supply management model that integrates housing supply and demand with time lag and reasonable vacancy area. For validity test of the model, Chengdu City was selected as a sample. The study establishes the feasibility of this model by demonstrating that optimized housing supply can narrow the gap between housing supply and demand. The implication of this finding is that planning of housing supply is an important management tool and that in applying this tool, local government should intervene in housing market to ensure scientific consideration of city's development position, economic growth and housing demand.

Key words: Housing supply management, Housing market, Housing price, Dynamic economics model, China.

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Managing housing supply has been a matter of increasing concern in the context of soaring housing prices consequent to recent market failure in China. China has undergone a transition from centrally planned economy to market economy. Market mechanisms play a fundamental role in housing allocation and the transition gave China's housing market an unprecedented prosperity. For instance, the statistics of National Bureau of Statistics of China (NBSC) show that the housing sector's share in GDP increased annually by 5.6%, 5.7%, 5.8%, 6.0% and 6.6% over the period 2005-2009 (National Bureau of Statistics of China 2011). However, market mechanism is not always effective in housing supply, owing to market failure, which leads to imbalance between housing supply and demand and consequent increase in housing price. During the period 2004-2007, average housing prices in China increased sharply from 2608 RMB/m^2 to 4459 RMB/m^2, with a nominal rate of 17.1% per year or 13.2% in real terms (NBSC 2011). The growth rate of housing prices exceeds that of urban residents' disposable income and GDP. This not only poses a high risk to China's economic development but also creates some serious social problems, such as urban sprawl, environmental degradation and wealth gaps. Market failure requires the governments to intervene in the housing market by supply management to bring housing supply and demand into equilibrium.

So, this study focuses on finding a housing supply management model and testing its feasibility. The contents of this paper are organized as follows: The next

section (Section 1) reviews the literature related to this subject; Section 2 presents the empirical model and data used in this study; Section 3 describes the findings of this study and Section 4 presents the conclusions and policy implications, followed by discussion and conclusions.

1. Literature Review

Interest in housing supply has been growing ever since China opened up its housing sector and adopted the policy of reform that transformed the housing sector from a government-controlled sector to a market-determined one. Earlier studies concentrated mostly on qualitative analysis of the factors that affect housing supply, including economic growth, property tax, land use planning or urban planning, elasticity of housing supply or demand and housing affordability. For example, On-Kwok Lai (1998) believes it is rapid economic growth that triggers the demand for more housing construction. Shunfeng Song, George S. F. Chu, and Rongqing Cao (1999) hold that property tax may affect welfare distribution and correct structural imbalance in housing supply. While Hung-Gay Fung et al. (2006) and Hong Zhang (2008) altogether with Allen Goodman (2002), Kate Barker (2008) and Michael Ball (2011) argue that land supply or land use planning, which determines the quota, plot ratio and story height, has a significant influence on housing supply. Additionally, Jun Wei, Steve N. Robinson, and Michael Y. Zou (2009) conclude that Property Law of China helps to stimulate the housing supply because it can reduce the risks in property rights. Geoffrey Carliner (1973), based on his estimate of the long run income elasticity of housing demand, concluded that permanent income elasticity is less biased than annual income. Albert Saiz (2008) and Joseph Gyourko (2009) hold that elasticity of housing supply could be well-characterized as functions of physical and regulatory constraints, which in turn are endogenous to prices and past growth. Stephen Mak, Lennon Choy, and Winky Ho (2012) observe that affordability could restrict the marginalized groups from accessing housing market, but Alain Bertaud (2009) argues that the point of contention is not current affordability of housing, but acceptable standard in the society.

Later studies concentrate mainly on how the above-mentioned factors affect housing supply by utilizing quantitative tools. For instance, Songtao Wang, Suhan Chan, and Bohua Xu (2010) propose a stock-adjustment model for estimating the elasticity of housing supply in the range of 1.21 to 2.42. Hongyan Du, Yongkai Ma, and Yunbi An (2011) utilize cointegration analysis and Granger causality test to ascertain the impact of land policy on housing supply. They conclude that land policy may have a short term impact on housing supply, but not a long term one. Jing Wu, Gyourko, and Yongheng Deng (2012) introduce a price index model to calculate how the price change affects housing supply. They find that even a moderate decline in expected appreciation may lead to price decline of over 40%, which can greatly affect the developers' investment expectations.

Objectively, housing supply studies have never been more conspicuous than what they are now, but almost all of them fall into the following categories: (i) identifying the economic, social or geographical factors that affect housing supply and how their impact can be analyzed or measured; (ii) studying housing supply from

nation-wide or metropolitan perspective; (iii) establishing econometric models to explore quantitative correlation between one or more independent variables and one dependent variable. Previous workers laid a good foundation for studying housing supply management but neglected some key points: (a) most of them concentrated on either housing supply or demand, instead of focusing on both; (b) housing market characteristics, such as locational fixity, durability, and time lag in housing supply, as also their role in housing demand and supply were not studied in their entirety; (c) dynamic economics model serves better than some static econometric models in optimizing housing supply, because it requires fewer maintained hypotheses; besides, it does not need causal relationship between dependent and independent variables.

As has been mentioned, to make up for the above-mentioned deficiencies, this paper attempts to develop an equilibrium-oriented model that integrates housing supply and demand with time lag and reasonable vacancy areas by recursive methods of dynamic economics. Chengdu City was selected as a sample to test the feasibility of the model by using the city-level data for the period 1999-2010.

2. Methodology

2.1 Model

When it comes to housing market equilibrium, housing supply and housing demand are considered the most important impact factors, followed by housing vacancy and time lag. Unlike previous studies which concentrate mainly on how the housing market is affected by housing supply or demand, this paper worked out a model, based on integrating housing supply and demand with reasonable housing vacancy area and time lag. Reasonable vacancy area is the resultant vacancy in housing market if supply and demand are in balance and the level to which vacancy area will be restored over a long term. It is also a market benchmark beyond which actual vacancy area is considered too high.

The following assumptions were made: (1) housing supply, as an exogenous variable, is determined by previous vacancy areas and demand; housing demand, as an endogenous variable, is determined by previous demand; (2) over the period $(0,T)$, actual housing vacancy area at the beginning is X_0, reasonable vacancy area after t years is $\overline{X}_t$ and actual vacancy area is X_t; (3) housing supply is S_t and demand D_t. To achieve housing market equilibrium under the consideration of housing vacancy and time lag, the housing supply should simultaneously satisfy the following two conditions: (i) minimize the gap between housing supply and demand; (ii) minimize the gap between actual housing vacancy and reasonable housing vacancy. Obviously, at the equilibrium point, reasonable vacancy equals actual vacancy. Therefore, the objective function and constraint condition that can balance housing market is made out as follows:

$$\begin{cases} \min F(S,X) = \sum_{t=0}^{T-1} [k_1 (S_{t+1} - D_{t+1})^2 + k_2 (X_{t+1} - \overline{X_{t+1}})^2] \Delta t \\ \dfrac{X_{t+1} - X_t}{\Delta t} = S_{t+1} - D_{t+1} \end{cases} \tag{1}$$

where *F(X,S)* denotes objective function, and *X* and *S* the parameters to be solved, k_1 and k_2 the weight of the imbalance caused by actual housing supply/demand and actual/reasonable vacancy areas respectively, and Δt the time interval.

Equation (1) can be solved by Hamilton function as indicated below:

$$H = \sum_{t=0}^{T-1} \left\{ [k_1 (S_{t+1} - D_{t+1})^2 + k_2 (X_{t+1} - \overline{X_{t+1}})^2] \Delta t + \lambda_t (S_{t+1} - D_{t+1}) \right\} \tag{2}$$

where λ_t is marginal reasonable housing vacancy area, which means the change in reasonable housing vacancy that results from supplying an added unit of housing. The following equations can be derived from discrete maximum principle:

$$\begin{cases} \dfrac{-\partial H}{\partial X_t} = \dfrac{\lambda_{t+1} - \lambda_t}{\Delta t} = -2k_2 (X_{t+1} - \overline{X_{t+1}}) \\ \dfrac{\partial H}{\partial \lambda_t} = \dfrac{X_{t+1} - X_t}{\Delta t} = S_{t+1} - D_{t+1} \\ \dfrac{\partial H}{\partial S_t} = 2k_1 (S_{t+1} - D_{t+1}) + \lambda_t = 0 \end{cases} \tag{3}$$

If $\Delta t = 1$, Equation (3) is to be rearranged to yield:

$$\begin{cases} S_{t+1} = D_{t+1} - \dfrac{\lambda_t}{2k_1} \\ X_{t+1} = X_t - \dfrac{\lambda_t}{2k_1} \\ \lambda_{t+1} = \lambda_t - 2k_2 (X_{t+1} - \overline{X_{t+1}}) \end{cases} \tag{4}$$

Differential equations in X_t and λ_t can be obtained by solving Equation (4) using the recursive approach:

$$\begin{cases} X_{t+1} - (2 + \dfrac{k_2}{k_1}) X_t + X_{t-1} = 2k_2 (\overline{X_{t+1}} - \overline{X_t}) \\ \lambda_{t+1} - (2 + \dfrac{k_2}{k_1}) \lambda_t + \lambda_{t-1} = -\dfrac{k_2}{k_1} \overline{\lambda_t} \end{cases} \tag{5}$$

where $\overline{\lambda_t}$ is the characteristic root of the differential equation.

The following results can be achieved through classical solution:

$$\begin{cases} X_t = A_1\alpha_1^{'} + A_2\alpha_2^{'} + \overline{X_t} \\ \lambda_t = B_1\alpha_1^{'} + B_2\alpha_2^{'} - 2k_1(\overline{X_{t+1}} - \overline{X_t}) \end{cases} \tag{6}$$

where A_1, A_2, B_1 and B_2 are constant coefficients of differential equations, and $\alpha_1^{'}$ and $\alpha_2^{'}$ their solutions. By solving Equations (5) and (6), the optimized housing supply, disregarding time lag in housing supply, can be represented as shown below:

$$S_{t+1} = D_{t+1} + (\overline{X_{t+1}} - \overline{X_t}) - \frac{B_1\alpha_1^{'} + B_2\alpha_2^{'}}{k_1} \tag{7}$$

where

$$\alpha_1 = \frac{2k_1 + k_2 + \sqrt{k_2(4k_1 + k_2)}}{2k_1}; \alpha_1 = \frac{2k_1 + k_2 - \sqrt{k_2(4k_1 + k_2)}}{2k_1}$$

$$A_1 = -\frac{\alpha_2^T(\alpha_2 - 1)\alpha_0}{\alpha_1^{T+1} - \alpha_1^T - \alpha_2^{T+1} + \alpha_2^T}; A_2 = \frac{\alpha_1^T(\alpha_2 - 1)\alpha_0}{\alpha_1^{T+1} - \alpha_1^T - \alpha_2^{T+1} + \alpha_2^T}$$

$$B_1 = \frac{2\alpha_2^T k_2\alpha_0}{-\alpha_1^{T+1} + \alpha_1^T + \alpha_2^{T+1} - \alpha_2^T}; B_2 = -\frac{2\alpha_1^T k_2\alpha_0}{-\alpha_1^{T+1} + \alpha_1^T + \alpha_2^{T+1} - \alpha_2^T}$$

Assuming that the time lag between the start of housing construction and housing sale is t_0, two types of housing are defined, namely multiple story (greater than seven stories) and high story (no more than seven stories), which were assigned the weights β_1 and β_2 respectively. The time lag of housing supply in the former is t_1 and in the latter t_2, both of which can be obtained from statistical departments or by field survey. Then,

$$t_0 = \beta_1 t_1 + \beta_2 t_2 \tag{8}$$

Considering the time lag of housing supply, the developers should build the houses t_0 years in advance in accordance with the optimized housing supply to meet the demand at $t+1$. Therefore, Equation (7) can be modified taking into consideration the time lag:

$$O_{t-t_0+1} = D_{t+1} + (\overline{X_{t+1}} - \overline{X_t}) - \frac{1}{2k_1}(B_1\alpha_1^{'} + B_2\alpha_2^{'}) \tag{9}$$

where O_{t-t_0+1} represents the optimized housing supply under consideration of time lag of housing supply t_0.

Equation (9) not only takes housing supply and demand into account, but also considers the reasonable vacancy area and the time lag so that the optimized housing supply area can be obtained by solving it. In other words, this model considers almost all important factors that affect housing market equilibrium; therefore, the result is equilibrium-oriented. If local governments plan housing supply in accordance with the equilibrium-oriented result and direct the developers to supply housing as per the plan, the housing market can achieve equilibrium.

2.2 Data Collection

As housing market is city-specific, nation-wide studies or studies with a metropolitan perspective may conceal significant spatial features. It is impossible to achieve housing market equilibrium at national level. So, studying housing supply from a city's perspective is much more reasonable, practical and instructive. Chengdu City, which lies at the center of Sichuan basin, is a leading financial center, transport center and aerostatic center in West China, and one of the famous historical and tourist cities in the world.

In recent years, Chengdu registered an economic growth rate that was much higher than the average growth rate of the state or of other cities in West China (see Table 1). The rapid economic growth has led to unprecedented boom in the housing market, which led to a rapid increase in housing prices (see Table 2). The share of value added to GDP by the housing sector in Chengdu City is greater than that by the entire nation and China's western regions (see Table 3). Chengdu City was chosen for this study because by achieving housing supply and demand equilibrium it could successfully slow down the rapidly rising housing prices.

Table 1 Per Capita GDP Growth Rate of China, West China and Chengdu City

Unit: RMB, %

Year	Real per-capita GDP			Real GDP growth rate		
	China	West China	Chengdu City	China	West China	Chengdu City
2000	7086	4606	11471	8.1	8.5	10.8
2001	7651	5043	13004	7.5	9.1	13.1
2002	8214	5515	14536	8.3	10.4	13.1
2003	9101	6306	16454	9.3	10.7	13.2
2004	12336	7725	20625	10.1	11.9	13.6
2005	14185	9163	21912	10.2	11.6	13.5
2006	16500	10960	24927	11.6	12.7	13.8
2007	20170	13281	30006	14.2	14.2	15.3
2008	23708	16142	34873	9.6	11.2	14.3
2009	25576	18314	39765	9.2	12.8	14.1
2010	29524	21927	39209	10.3	13.2	15.2

Source: China Statistical Yearbook (2011).

Table 2 Housing Price in Chengdu City 2000-2010

Unit: RMB, %

Year	Nominal price	Nominal growth rate	Real price	Real growth rate
2000	2420	16.94	1905	13.3
2001	2830	15.90	1966	11.0
2002	3280	15.24	2604	12.1
2003	3780	19.58	3064	15.9
2004	4520	15.27	3955	13.4
2005	5210	18.81	4477	16.2
2006	6190	10.02	5697	9.2
2007	6810	-13.07	6320	-12.1
2008	5920	17.74	4637	13.9
2009	6970	11.91	6327	10.8
2010	7800	16.94	6774	14.7

Source: Chengdu Statistical Yearbook (2011).

Table 3 Share of Value Added to GDP by the Housing Sector of China, West China and Chengdu City

Year	China	West China	Chengdu City
1999	0.03	0.05	0.07
2000	0.03	0.05	0.08
2001	0.04	0.06	0.08
2002	0.03	0.05	0.10
2003	0.03	0.05	0.07
2004	0.04	0.04	0.11
2005	0.04	0.04	0.11
2006	0.04	0.04	0.10
2007	0.04	0.04	0.10
2008	0.04	0.04	0.09
2009	0.05	0.04	0.07
2010	0.05	0.05	0.08

Source: China Statistical Yearbook (2011).

As mentioned above, to obtain optimized housing supply by solving Equation (7), data regarding housing demand, housing supply and actual housing vacancy area in Chengdu City for the period 1999-2010 is required in advance. For this study, the required data was sourced from China Statistical Yearbook 2011 and Chengdu Statistical Yearbook 2011 (See Table 4). Table 5 shows the descriptive statistics of the data.

Table 4 Housing Demand and Supply and Actual Vacancy Areas in Chengdu 1999-2010

Unit: million m^2

Year	Housing demand	Housing supply	Actual vacancy area
1999	3.17	3.75	0.86
2000	5.21	4.65	1.01
2001	6.18	7.16	1.15
2002	8.26	7.90	1.32
2003	10.48	8.98	1.30
2004	12.29	7.00	0.59
2005	14.22	5.98	0.63
2006	16.78	9.59	0.52
2007	22.69	8.85	0.55
2008	13.97	8.18	1.21
2009	28.67	14.63	1.86
2010	25.32	13.01	1.62

Source: Chengdu Statistical Yearbook (2011).

Table 5 Descriptive Statistics of Independent Variables for 1999-2010

Unit: million m^2

Variable	Mean	Max	Min	SD
Actual demand	13.94	25.32	3.17	7.74
Actual supply	8.31	14.63	3.75	2.99
Actual vacancy areas	1.05	1.86	0.52	0.42

Source: Author's calculations.

Table 4 shows that, during the period 1999-2010 in Chengdu City, both housing demand and housing supply increased, and the gap between the two grew wider year after year. For instance, the actual housing demand increased by a factor of 7.99, from 3.17 million m^2 in 1999 to 25.32 million m^2 in 2010, and that of housing supply by 3.46 times, from 3.75 million m^2 to 13.01 million m^2.

That there was a big gap between housing demand and supply is obvious; the former is much greater than the latter. Housing prices in Chengdu City increased dramatically in recent years because of the demand-supply gap. Additionally, the area of housing vacancy increased from 0.86 million m^2 to 1.32 million m^2 over the period 1999-2002, and then it declined from 1.30 million m^2 to 0.55 million m^2. After 2007, it once again rose from 1.21 million m^2 to 1.62 million m^2. This reflects the existence of considerable gap between housing supply and demand in Chengdu City over the period covered.

3. Results

A total of 172 housing projects, which accounted for 80.12% of the housing projects in Chengdu City in 2010, were chosen by random sampling for field survey to obtain the above-mentioned parameters. The following are the results: $\overline{X_t} = 5\% D_t$,

β_1=30%, β_2=70%, t_1=3, and t_2=2. However, results for weights k_1 and k_2 could not be obtained by field survey. To make up for this, it was assumed that $k_1 = k_2 = 0.5$. Based on this assumption, t_0 could be calculated from Equation (8), the solution being $t_0 = 2.3 \approx 2$. By solving Equation (9) with the above parameters, both optimized vacancy areas and optimized housing supply areas without time lag over the period 2013-2017 were found to be:

$$X_t = 0.02 \times 2.618^t + 161.75 \times 0.33^t + 0.06 D_t \ (t = 1 \sim 5) \tag{10}$$

$$S_t = 1.06 D_t - 0.06 D_{t-1} + 0.0033 \times 2.62^{t-1} - 50.41 \times 0.618^{t-1} \ (t = 1 \sim 5) \tag{11}$$

Taking the time lag into account, the optimized housing supply over the period 2011-2015 was determined to be:

$$O_{t-2} = 1.06 D_t - 0.06 D_{t-1} + 0.0033 \times 2.62^{t-1} - 50.41 \times 0.618^{t-1} \ (t = 1 \sim 5) \tag{12}$$

Eviews 6.0 was employed to solve the above-listed equations. For assessing the results, first, the housing demand over the period 2011-2015 was forecasted, based on actual housing demand over the period 1999-2010; second, the optimized housing supply area over the period 2006-2010 was traced back by Equation (12); finally, the absolute gap between actual housing demand and the forecast demand or that between actual housing supply and optimized housing supply was worked out. The results are presented in Table 6 below.

Table 6 Absolute Gap between Housing Demand and Supply in Chengdu City 2006-2015

Unit: million m²

Year	Housing demand	Forecasted demand	Housing supply	Optimized supply	Gap between demand and supply	Gap between actual/forecast demand and optimized supply
2006	16.78		9.59	13.56	7.19	3.22
2007	22.69		8.85	16.74	13.84	5.95
2008	13.97		8.18	16.82	5.79	2.85
2009	28.67		14.63	18.46	14.04	10.21
2010	25.32		13.01	19.31	12.31	6.01
2011		21.75		22.15		0.39
2012		22.43		22.75		0.32
2013		23.13		23.38		0.25
2014		23.46		23.57		0.11
2015		23.71		23.78		0.08

Source: Author's calculations.

The results show that housing supply and demand tend to become balanced after optimizing housing supply by the model. From 2006 through 2010, the absolute gap that prevailed between housing demand and housing supply was much greater than that between housing demand and the optimized housing supply. The demand and supply were 7.19 and 3.22 million m^2 in 2006, 13.84 and 5.95 million m^2 in 2007, 5.79 and 2.85 million m^2 in 2008 14.04 and 10.21 million m^2 in 2009, and 12.31 and 6.01 million m^2 in 2010. Had the government taken any measure that encouraged developers to supply more houses as per the optimized housing supply areas, the housing market would have attained equilibrium, and the housing prices would not have increased so rapidly. Over the period 2011-2015, the absolute gap between the forecasted housing demand and the optimized housing supply narrowed to almost the same as in 2015. They were 0.39 million m^2, 0.32 million m^2, 0.25 million m^2, 0.11 million m^2 and 0.08 million m^2. The results show that the equilibrium-oriented housing supply management model that integrates housing supply and demand with reasonable vacancy areas and time lags of housing supply is useful for optimizing housing supply. In short, the model is a feasible housing supply management tool to achieve housing market equilibrium.

4. Conclusion, Policy Implication and Discussion

Market mechanisms play a fundamental role in housing allocation, but they are not always efficient owing to market failure. Market failure requires that government intervene in the housing market to control the increase in actual housing vacancy area and housing prices and thereby make housing affordable to the public. In view of housing market's complexity, hysteresis and integration, bringing housing market into equilibrium is not easy for the government. Compared with other tools used by the government to intervene in the housing market, such as price control, monetary regulation and market license, housing supply management is a more efficient tool, because it can affect the housing market directly. This paper provides an equilibrium-oriented housing supply management model that not only takes housing supply and demand into account, but also considers the time lag and reasonable vacancy area. Empirical studies on Chengdu City show that optimized housing supply, determined by using this model, can narrow the gap between housing supply and housing demand. It thus proves to be a feasible housing supply management tool to achieve housing market equilibrium.

The policy implications of adopting housing supply planning as a management tool are that local governments intervene in the housing market to avoid market failure, and that planning be made on scientific basis considering the development position of the city, its economic growth and demand for housing. In the case of Chengdu City, housing supply should be so planned as to make available the area of 22.75 million m^2 to meet the demand for 22.43 million m^2 in 2012. The equilibrium-oriented housing management can minimize the gap between actual housing demand and supply. As far as housing supply management is concerned, the two extreme situations of excessive housing supply and stringent housing supply should be avoided. Excessive housing supply leads to urban sprawl, excessive farmland acquisition and environment degradation, besides disorderly competition, housing price fluctuation and

poor utilization of resources. Stringent housing supply leads to price appreciation, labor migration and unsustainable development of housing sector, besides increasing housing vacancy.

The scope of this paper is confined to studying housing supply based on the same weights (k_1 equals k_2). Additionally, housing supply and demand are determined theoretically by multiple factors, such as price, location and fiscal and monetary policy expectation (Philip Arestis 2011). Further studies are warranted to probe into what the results would be when the above factors are considered.

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