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Inflation and House Prices: Theory and Evidence from 35 Major Cities in China

Weida Kuang
Professor of Real Estate Finance and Economics, School of Business, Renmin University of China.

Peng Liu
Associate Professor of Real Estate Finance, School of Hotel Administration, Cornell University.

In recent years, housing prices and inflation have been growing constantly in China. Higher house prices and higher inflation affect both household consumption and economic growth. We have developed a four-sector general equilibrium model of consumers, developers, firms, and the central bank to illustrate the relationship of house prices with inflation. The theoretical model demonstrates that house prices and inflation are positively correlated and endogenously determined. By using panel databases of 35 major cities in China during the period of 1996-2010, we find that the association between house prices and inflation is asymmetric. The impact of inflation on housing prices is greater than that of housing prices on inflation, which implies that housing prices effectively hedge inflation. Secondly, household income positively affects housing prices, but interest rates negatively influence housing prices. Accordingly, to curb soaring housing prices, policymakers not only should balance supply and demand, but also control for inflation. Thirdly, economic growth has less of an impact on inflation than housing prices. Hence, abnormal housing price increases are more likely to exacerbate inflation than economic growth. In addition, housing prices have a greater impact on inflation than rental prices, albeit the latter is a component of the consumer price index (CPI). Finally, money supply has much greater effects on inflation than housing prices and economic growth.

Keywords

Housing Price, Inflation, Endogeneity Issue

1.   Introduction

1.1   Background

It is well known that the Chinese housing reform of 1998 has accelerated housing market development. In recent years, housing prices have dramatically increased in China. According to the National Bureau of Statistics of China, the Chinese housing price had increased from 1853.56CHY (yuan, hereinafter) per square meter in 1998 to 4725.02 yuan per square meter coupled with an annual growth rate of 8.11% in 2010. Meanwhile, the housing price growth rates in 70 large and medium cities are 7.6%, 5.5%, 7.6%, 6.5%, 1.5% and 6.4% during the period of 2005 to 2010, respectively. As a result, the price to ratio increased from 6.39 in 1998 to 7.81 in 2010, which gave rise to a severe lack of affordable housing in current China. Thus, the Chinese central government has carried out various policies to curb housing price inflation. For instance, the central bank and China Banking Regulatory Commission (CBRC) issued new regulations on mortgage underwriting in 2007, which required an increase in the minimum mortgage down payment ratio of first-time home purchase financing from the previous 20% to 30%, while the minimum down payment ratio for a second home is 40%. In addition, the central bank has increased the interest rate several times since 2004, which directly influences the mortgage rate (Deng and Liu 2009). Moreover, the state council issued a decree in April 2010, which restricted housing purchases in some of the cities that had inflated housing prices. Although various policies have been implemented, the high housing prices persevere despite attempts to reduce prices.

Meanwhile, consumption prices have also sharply increased, which have given rise to higher inflation rates. Figure 1 shows that household consumption prices have increased 1.5%, 4.8%, 5.9%, -0.7%, and 3.3% from 2006 to 2010, respectively. Generally speaking, the Chinese long-term target inflation rate is around 3%, albeit the annual target inflation rate is dynamic. Hence, inflation stability is an important target of the monetary policy. As houses have become an important part of current Chinese household wealth, a significant number of Chinese people are motivated to buy houses to hedge against high inflation. As a matter of fact, higher housing prices and inflation not only affect household consumption, but also economic growth. In addition, Figure 1 shows that the housing price index (HPI) and the consumer price index (CPI) have been increasing during the period of 2006-2010 as a whole. Resultant of the global financial crisis, the HPI and CPI sharply plummeted in 2009. The HPI, however, has grown more than the CPI; its peak was in 2004, but the CPI arrived at its peak in 2008. Accordingly, it is vital to explore the relationship between housing price and inflation. In this paper, an attempt will be made to provide theoretical basis and empirical evidence for this relationship.

**Figure 1   Housing and Consumer Price Indexes in China over the
                  Period of 1998-2010**
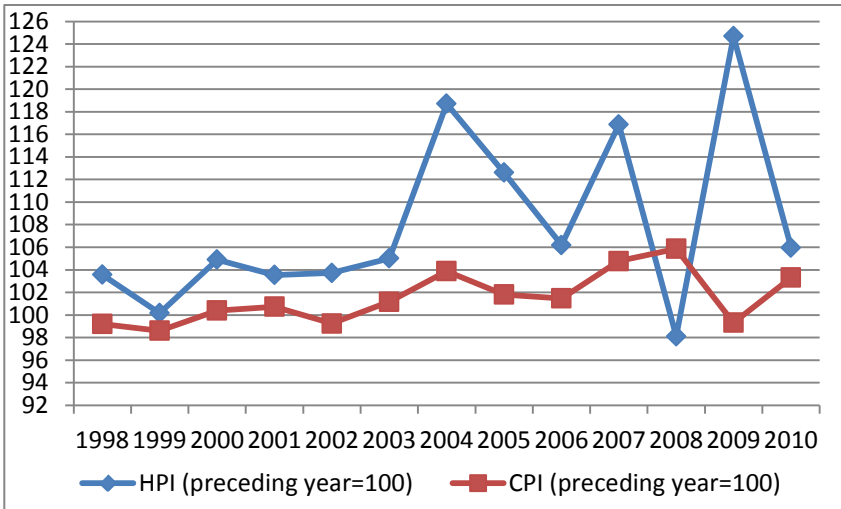
Note: HPI and CPI denote housing price index and consumer price index, respectively.

1.2   Literature Review

There is a scarcity of work in the extant literature that investigates the inter-relationship between housing prices and inflation. On the one hand, a body of literature finds that inflation affects housing prices. Bond and Seiler (1998) find that owning a house can hedge inflation; that is, expected or unexpected inflation. Kenny (1999) also finds that inflation can cause a housing price increase. By using American data from the spring of 1970 through to the fall of 1986, Case and Shiller (1990) find that non-housing consumption prices can explain and predict housing prices. In employing Chinese macro data, Duan (2007) finds that consumption prices in the short and long terms significantly impact housing prices.

On the other hand, the research has principally regarded real estate prices as part of asset prices and examined the impact of real estate prices on inflation. Prior studies discuss whether housing prices should be taken into account in the inflation index. For instance, Alchian and Klein (1973) argue that because asset prices reflect the current pecuniary price of current and future consumption, an accurate inflation index should encompass asset prices. Furthermore, they propose an intertemporal cost-of-living index. Based on this intertemporal cost-of-living index, Shibuya (1992) derives a dynamic equilibrium price index by using the geometrically weighted average of current asset prices and the product price index.

A stream of literature shows that real estate prices can forecast inflation. Kent and Lowe (1997) show that asset price inflation could give rise to appreciation

expectations with regard to future product and service prices. Smet (1997) argues that unexpected changes in asset prices will affect inflation expectations by virtue of the transmission mechanism and price information disclosure. Shiratsuka (1999) documents that asset prices are the Grange cause of inflation. Goodhart and Hofmann (2000) argue that real estate prices are usually conducive to forecasting future inflation. By employing the Wilshire 500 and the S&P 500 for stock prices and the repeat sales index for housing prices, Filardo (2000) finds that housing prices can predict inflation in some sense. Goodhart (2001) discovers that real estate price variation is closely linked with the ensuing output and inflation. In terms of the impact of housing prices on aggregate demand and inflation, Kontonikas and Montagnoli (2004) find that housing price variation is highly correlated with future variations in consumption price. Tkacz and Wilkins (2006) examine the predictive powers of housing and stock prices, respectively, on Canadian inflation and find that housing prices are favorable for predicting inflation. By using quarterly data from the HPI and the CPI over the period of 1998-2010, Qiu (2011) finds that the HPI Granger-causes the CPI.

Conversely, a family of studies have argued that real estate prices contain no valuable information on inflation forecasting. For instance, Filardo (2000) deems that a definite relationship between asset price appreciation and product price increase does not exist. Stock and Watson (1999) use 168 economic indicators to predict inflation, but find no indicators, including real estate prices, that can reliably predict future inflation. Similarly, Gilchrist and Leahy (2002) find that asset prices contain no valuable information for future price prediction.

Our study makes the following contribution to the literature. While the majority of the existing literature primarily investigates the relationship between housing prices and inflation from an empirical perspective, very few study the theoretical underpinning of the relationship. In addition, it is assumed in the extant literature that inflation policies are exogenous, and the interplay of central banks with consumers and firms is neglected. On the other hand, the endogeneity issue between housing prices and inflation has not been considered in empirical research. Accordingly, we take the central bank into account and develop a four-sector general equilibrium model with consumers, developers, firms, and the central bank to demonstrate the relationship of housing prices with inflation. Meanwhile, by using housing and inflation data from 35 major cities in China during the period of 1996-2010, we investigate the relationship between housing prices and inflation in a generalized method of moments (GMM) framework in an effort to address the endogeneity problem. Furthermore, we specifically model the production of real estate into residential and commercial sectors and provide some theoretical linkage between the two real estate sectors. The remainder of the paper is organized as follows: Section 2 provides the constructs of the theoretical model; Section 3 provides an empirical analysis; and Section 4 concludes and offers some policy implications.

2.   The Model

To endogenously model the behaviors of the central bank, we model a four-sector general equilibrium economy with consumers, developers, firms, and the central bank. Specifically, the four types of agents interact to determine the optimal utility of consumers, optimal profit condition of firms, and the target inflation function of the central bank, respectively.

2.1   Consumers

For consumers, the impact of inflation on housing prices is determined by consumer income allocated to housing consumption and non-housing consumption under utility maximization. For simplicity, we assume：(1) the utility function of consumers includes housing consumption and a numeraire good, and the two goods are logarithms which are additive; (2) housing is a normal good with a price of P_H ; (3) non-housing consumption is referred to as the numeraire with a price of P_C ; (4) there are N homogenous consumers; (5) the life time of each consumer is T and the initial wealth endowment of a consumer is W_0 ; and (6) the aggregate wage of a consumer is Y_t for each period. The consumer can borrow, but will pay off all debt at the end of life T.[1]

In light of the above assumptions, the optimal utility function of the life of the representative consumer j can be expressed as:

$$\underset{C_{jt}, H_{jt}^C}{MaxU(C_{jt}, H_{jt}^C)} = Max\left(\sum_{t=1}^{T}(\ln C_{jt} + \ln H_{jt}^C) \right)$$

$$s.t. \ P_{H_t}H_{jt}^C + \sum_{t=1}^{T}(P_{C_t}C_{jt} + uc_t P_{H_t}H_{jt}^C) = W_{j0} + \sum_{t=1}^{T}Y_{jt}$$

$$uc_t = r_t + \tau_t + m_t + d_t - g_t^e$$

where H_t^C and C_t denote housing consumption and non-housing consumption, respectively; housing expenditure contains purchasing expenses and user cost (uc_t). According to Hendershott and Slemrod (1983) and Himmelberg et al. (2005), user cost normally consists of a risk-free interest rate r_f , the risk premium of owning housing γ , property tax rate τ , maintenance cost m, housing depreciation rate d , and expected housing growth rate g^e . By assuming that mortgages are fairly priced, the mortgage rate can be written as $r = r_f + \gamma$. Therefore, the user cost can be written as: $uc = r + \tau + m + d - g^e$.

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[1] For simplicity, we assume consumer consumption is subject to a permanent income hypothesis.

From the Lagrange equation, we can obtain:

$$H_t^C = \frac{P_{C_t} C_t}{P_{H_t} \left(1 + uc_t\right)}$$

(2-1)

2.2   Developers

Developers supply both residential real estate (housing consumption for households) and commercial real estate (for production of numeraire goods). We further assume: (1) real estate markets are competitive, and there are M homogenous developers in the real estate markets; (2) housing and commercial real estate are produced by capital, labor, and land, and the production function is a Cobb-Douglas function[2]; (3) capital K is produced and used by the developers themselves, with the price normalized to 1; (4) wages are represented by Y, and all of the labor is supplied by the consumers in the economy，in which N_1 and N_2 are allocated into the housing sector and the commercial real estate sector, respectively; (5) the quantity of land is fixed as L, in which L_1 and L_2 are allocated into housing and commercial real estate production, respectively; (6) housing production is completed in one period; and (7) each developer has initial capital endowment W_1, and is allowed to borrow B_1, and the borrowing interest rate of the developer is the same as that of the consumers.

The optimal profit condition of representative developer i can be expressed by:

$$\underset{H_t^F, h_t^F}{Max}\ \pi_{it} = P_{H_t} H_{it}^F + P_{h_t} h_{it}^F - (1 + r_t)\left(\frac{(N_{1t} + N_{2t})Y_t + P_{L_{1t}}^C L_{1t} + P_{L_{2t}}^F L_{2t}}{M}\right)$$

$$s.t.\ H_t^F = A_1 \left(\frac{N_{1t}}{M}\right)^{\alpha_1} \left(\frac{L_{1t}}{M}\right)^{\beta_1} (K_{1t})^{\gamma_1};\ h_t^F = A_2 \left(\frac{N_{2t}}{M}\right)^{\alpha_2} \left(\frac{L_{2t}}{M}\right)^{\beta_2} (K_{2t})^{\gamma_2};$$

$$N_{1t} + N_{2t} + N_{3t} = N_t;\ L_t = L_{1t} + L_{2t};$$

$$K_{1t} + K_{2t} + \frac{(N_{1t} + N_{2t})Y_t + P_{L_1}^C L_{1t} + P_{L_2}^F L_{2t}}{M} = W_{1t} + B_{1t}$$

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[2] The Cobb-Douglas production function is widely used in modeling the behavior of producers because the average costs of the housing construction industry are observed to be independent of firm size which is consistent with the constant returns to scale assumption (Epple et al., 2010).

where H_t^F and h_t^F stand for residential real estate (housing) production and commercial real estate production, respectively; $P_{L_t}^C$ and $P_{L_t}^F$ stand for land prices of housing and commercial real estate, respectively; A_1, A_2 denote total factor productivity (TFP) for residential and commercial real estate, respectively; α, β, and γ denote the production elasticity coefficients of labor, land, and capital, respectively, and $0 < \alpha, \beta, \gamma < 1$.

The first order condition yields:

$$P_{H_t} = \frac{(1+r_t)[\beta_1(P_{L_{1t}}^C - P_{L_{2t}}^F)N_1 Y_t + \alpha_1 L_{1t}]}{\alpha_1 \beta_1 (P_{L_{1t}}^C - P_{L_{2t}}^F)MH_t^F} \tag{2-2}$$

$$P_{h_t} = \frac{(1+r_t)[\beta_2(P_{L_{2t}}^F - P_{L_{1t}}^C)N_2 Y_t + \alpha_2 L_{2t}]}{\alpha_2 \beta_2 (P_{L_{2t}}^F - P_{L_{1t}}^C)Mh_t^F} \tag{2-3}$$

From Equations (2-2) and (2-3), we can derive:

$$\frac{P_{H_t}}{P_{h_t}} = -\frac{\alpha_2 \beta_2 [\beta_1(P_{L_{1t}}^C - P_{L_{2t}}^F)N_1 Y_t + \alpha_1 L_{1t}]h_t^F}{\alpha_1 \beta_1 [\beta_2(P_{L_{2t}}^F - P_{L_{1t}}^C)N_2 Y_t + \alpha_2 L_{2t}]H_t^F} \tag{2-4}$$

In terms of Equation (2-4), housing price is positively associated with commercial real estate price, whereas the ratio of housing price to commercial real estate price is negatively associated with the ratio of housing production to commercial real estate production. On the one hand, commercial real estate price exhibits the same trend along with housing price (co-movement). On the other hand, residential and commercial real estate prices are negatively correlated with their production. Moreover, residential real estate price is positively correlated with the production of commercial real estate, while commercial real estate price is positively correlated with the housing production. In other words, there seems to be a crowding effect between housing production and commercial real estate production. In short, the residential and commercial real estate markets interact in their production and their prices.

Housing market equilibrium requires that $MH_t^F = NH_t^C$. Hence, from Equations (2-1) and (2-2), we can obtain:

$$P_{C_t} = \frac{(1+r_t)(1+uc_t)[\beta_1(P_{L_{1t}}^C - P_{L_{2t}}^F)N_1 Y_t + \alpha_1 L_1]}{\alpha_1 \beta_1 (P_{L_{1t}}^C - P_{L_{2t}}^F)NC_t} \tag{2-5}$$

2.3 Consumption Good Producers

For firms that produce consumption goods, the impact of housing prices on inflation is realized by using commercial real estate as an input factor of consumption production under profit maximization. We assume that: (1) there are Z homogenous firms; each firm produces both consumption and capital goods, with the former produced by capital, labor, and commercial real estate space while the latter is produced by themselves;(2) consumer good and capital markets are competitive; (3) the capital is K_3, with price normalized to1; (4) all labor comes from consumers and the number is N_3; (5) the firms are the owner and user of the commercial real estate space for the production of consumption goods; (6) the production function is a Cobb-Douglas function and the production cycle is only one period; and (7) each firm has an initial capital endowment W_2, and is allowed to borrow B_2, and the borrowing interest rate of firms is the same as that of consumers.

The optimal profit condition of the representative firm can be written as:

$$Max\pi_t = P_{C_t} q_{kt} - (1+r_t)(\frac{N_3 Y_t}{Z} + P_{h_t} h_{kt}^f)$$
$$q_{kt}$$

$$s.t. \ q_t = A_3 \left(\frac{N_3}{Z}\right)^{\alpha_3} \left(h_t^f\right)^{\beta_3} \left(K_3\right)^{\gamma_3}$$

$$K_3 + \frac{N_3 Y_t}{Z} + P_{h_t} h_{kt}^f = W_2 + B_2$$

where q_t denotes the production of common consumption goods at time t, and h_t^f denotes commercial real estate demand at time t.

The first order condition yields:

$$P_{C_t} = \frac{(1+r_t)(\beta_3 N_3 Y_t + \alpha_3 P_{h_t} Z h_t^f)}{\alpha_3 \beta_3 Z q_t} \qquad (2\text{-}6)$$

Commercial real estate market equilibrium requires that $Mh_t^F = Zh_t^f$.

From Equations (2-3) and (2-6), we get:

$$P_{C_t}^e = \frac{(1+r_t)\left(\alpha_2 \beta_2 \beta_3 (P_{L_{2t}}^F - P_{L_{4t}}^C)N_3 Y_t + \alpha_3(1+r_t)[(P_{L_{2t}}^F - P_{L_{4t}}^C)N_2 Y_t + \alpha_2 L_2]\right)}{\alpha_2 \alpha_3 \beta_2 \beta_3 Z q_t} \qquad (2\text{-}7)$$

The equilibrium of common consumption goods requires that $Zq_t = NC_t$.

From Equations (2-1) and (2-7), it can be derived that:

$$P_{H_t}^e = \frac{(1+r_t)\left(\alpha_2\beta_2\beta_3(P_{l_{2t}}^F - P_{l_{4t}}^C)N_3Y_t + \alpha_3(1+r_t)[(P_{l_{2t}}^F - P_{l_{4t}}^C)N_2Y_t + \alpha_2L_2]\right)}{\alpha_2\alpha_3\beta_2\beta_3(1+uc_t)NH_t^C} \quad (2\text{-}8)$$

From Equations (2-7) and (2-8), we can obtain three-sector equilibrium housing price and the price of the common consumption good:

$$P_{H_t}^E = \frac{Zq_t P_{C_t}^E}{(1+uc_t)NH_t^C} \quad (2\text{-}9)$$

In light of Equations (2-7), (2-8) and (2-9), we can derive Proposition 1.

Proposition 1： If the above assumptions (1) to (7) hold, then
$$\frac{\partial P_{H_t}^E}{\partial P_{C_t}^E} > 0, \ \frac{\partial P_{H_t}^E}{\partial Y_t} > 0, \ \frac{\partial P_{C_t}^E}{\partial Y_t} > 0, \ \frac{\partial P_{H_t}^E}{\partial r_t} < 0, \ \frac{\partial P_{C_t}^E}{\partial r_t} > 0.$$

Proposition 1 implies that while consumers, developers, and firms are in equilibrium, housing prices are positively correlated with consumption good prices. In addition, higher consumer income means higher housing and consumption good prices. Furthermore, lower borrowing interest rate means lower financing cost and higher housing demand and supply. However, the impact of the former is greater than that of the latter, which yields higher housing prices. Similarly, higher borrowing interest rate means both reduced consumption demand and consumption supply. However, the impact of the former is less than that of the latter, which leads to higher prices of common consumption goods.

2.4　Central Bank

As mentioned above, most of the other studies regard the behavior of central banks as exogenous. On the other hand, the function of central banks in targeting inflation does not take into consideration housing prices. In fact, as an important asset class, housing prices affect the macro-economy via the wealth effect, Tobin's Q, and financial accelerators. For instance, Bordo and Jeanne (2002) argue that central banks should make positive corresponding policies while asset prices are falling. Lopez (2005) has studied the Columbian housing market and finds that monetary policies for targeting inflation are more effective in controlling housing prices. Accordingly, we introduce housing prices into the function of target inflation, and develop an extensive function of target inflation as follows:

$$f_t - f_t^* = a\left(g_{Q_t}^E - g_{Q_t}^*\right) + b\left(g_{H_t}^E - g_{H_t}^*\right)$$

From the above equation, we can get:

$$\frac{P_{C_t}^E - P_{C_{t-1}}^E}{P_{C_{t-1}}^E} - \frac{P_{C_t}^* - P_{C_{t-1}}^E}{P_{C_{t-1}}^E}$$

$$= a\left(\frac{Q_t^E - Q_{t-1}^E}{Q_{t-1}^E} - \frac{Q_t^* - Q_{t-1}^E}{Q_{t-1}^E}\right) + b\left(\frac{P_{H_t}^E - P_{H_t-1}^E}{P_{H_t-1}^E} - \frac{P_{H_t}^* - P_{H_t-1}^E}{P_{H_t-1}^E}\right)$$

$$P_{C_t}^E = P_{C_t}^* + a'\left(Q_t^E - Q_t^*\right) + b'\left(P_{H_t}^E - P_{H_t}^*\right) \qquad (2\text{-}10)$$

$$a' = \frac{aP_{C_{t-1}}^E}{Q_{t-1}^E}, \quad b' = \frac{bP_{C_{t-1}}^E}{P_{H_t-1}^E}$$

where a (a') and b (b') stand for the response of the inflation policy to economic growth and housing price growth, respectively, and $a, b, a', b' > 0$; f_t^* , $g_{Q_t}^*$ and $g_{H_t}^*$ stand for the target inflation rate, target economic growth rate and the target housing price growth rate, respectively; $P_{H_t}^E$, Q_t^E , and $P_{C_t}^E$ stand for equilibrium housing prices, equilibrium economic output (numeraire production), and equilibrium prices of common consumption goods, respectively; $P_{C_t}^*$, Q_t^* , and $P_{H_t}^*$ stand for the target prices of common consumption goods, target economic output, and target housing prices, respectively.

The substituting of Equation (2-9) into (2-10) yields:

$$P_{C_t}^E = \left(\frac{a'(1+uc_t)NH_t^C}{P_{C_t}^E} + b'\right)P_{H_t}^E + P_{C_t}^* - a'Q_t^* - b'P_{H_t}^* \qquad (2\text{-}11)$$

From Equation (2-11), we can obtain Proposition 2 as follows.

Proposition 2: If the above assumptions (1) to (7) hold, then $\dfrac{\partial P_{C_t}^E}{\partial P_{H_t}^E} > 0$

It is implied in Proposition 2 that if the inflation policy (central bank behavior) is taken into account, the equilibrium prices of consumption goods are also positive to equilibrium housing prices, which means that the inflation policy will respond positively to housing prices. Therefore, inflation and housing prices are endogenously determined.

3.   Empirical Analysis

Motivated by the general equilibrium model developed in the last section, we investigate the empirical relationship between real estate prices and inflation by using data from 35 cities in China.

3.1   Data

We use the housing market and inflation databases of 35 large and medium cities in China during the period of 1996-2010. The dataset collected from the *China City Statistical Yearbook* and *Statistical Yearbook* contains the HPI, CPI, GDP index, disposable income per capita, family size, rental price index (RI), and household savings for 35 cities. The 35 cities include Beijing, Tianjin, Shijiazhuang, Taiyuan, Shenyang, Changchun, Harbin, Shanghai, Nanjing, Hefei, Fouzhou, Nanchang, Jinan, Zhengzhou, Wuhan, Changsha, Guangzhou, Nanning, Haikou, Chongqing, Chengdu, Guiyang, Kunming, Xi'an, Xining, Yinchuan, Dalian, Tsingdao, Ningbo, Xiamen, Shenzhen, Hohehot, Urumqi, Hangzhou, and Lanzhou.

Money supply and lending interest rates over the five years are from the website of the People's Bank of China (http://www.pbc.gov.cn/). The stock price index (SPI) comes from the China Stock Market & Accounting Research Database (CSMAR). The household disposable income and household savings are computed as follows: household disposable income=disposable income per capita×family size; household savings=savings per capita×family size.[3]

3.2   Descriptive Analysis

We select eight representative cities (i.e. Beijing, Shanghai, Guangzhou, Shenzhen, Chongqing, Xi'an, Wuhan, and Changchun) to demonstrate the HPI and CPI trends. In terms of geographic location and economic development status, Beijing, Shanghai, Guangzhou and Shenzhen represent the eastern cities; Chongqing and Xi'an represent the western cities; and Wuhan and Changchun represent the midsized cities. Figure 2 indicates that the HPI and CPI both exhibit an increasing trend during the period of 1996-2010 as a whole. In particular, the HPI is higher than the CPI after 2003, which implies that housing prices can hedge inflation to a certain extent. It is noteworthy that the HPI indices in Shenzhen, Shanghai, Chongqing, and Changchun are more volatile than those of the CPI, which indicates that their housing price risks are higher. Second, the HPI is far higher than the CPI after 2003 in Beijing, which means that housing prices can effectively hedge inflation in Beijing. However, the HPI of Guangzhou, Xi'an, and Wuhan vary in parallel with their CPI.

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[3]The measurement units for disposable income, household saving and the money supply are yuan, yuan and 100 million yuan (RMB), respectively; the HPI, CPI, GDP index, RI and SPI are all percentage indices (preceding year equals 100).

Figure 2   HPI and CPI during the Period of 1996-2010
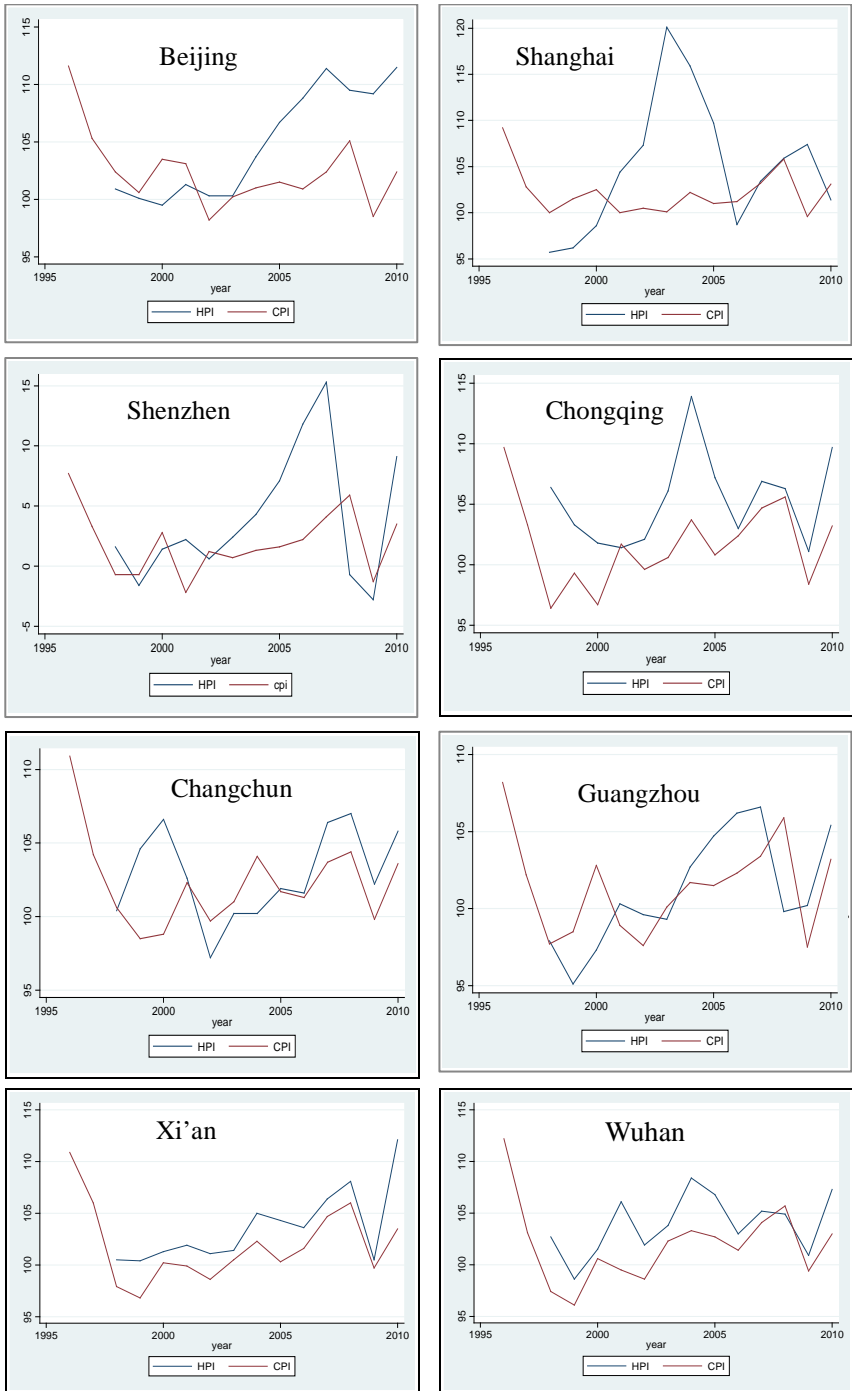
3.3   Econometric Setting

In light of the theoretical model, not only is the relationship between the housing price level and the inflation level examined in the empirical analysis, but also that between the housing price growth rate and the inflation rate. For convenience in analyzing the ratio variables, the econometric model is set up in a logarithm pattern. Hence, we take the logarithm of disposable income and the money supply, respectively. In addition, to reflect the dynamic motions of housing prices and inflation, we introduce their lags and switch to dynamic panel data models. In terms of Equations (2-10) and (2-11), we can set up the following logarithm models of housing prices and inflation, respectively[4]:

$$HPI_{jt} = a_0 + a_1 HPI_{jt-1} + a_2 CPI_{jt} + a_3 \ln Y_{jt} + a_4 r_{jt} + a_5 \ln S_{jt} + a_6 SPI_{jt} + u_t$$
(3-1)

$$CPI_{jt} = b_0 + b_1 CPI_{jt-1} + b_2 \ln HPI_{jt} + b_3 g_{jt} + b_4 \ln M_{jt} + b_5 RI_{jt} + \varepsilon_t$$
(3-2)

where Y_{jt} and the CPI denote household income and inflation, respectively; as the rental price (RI) is one component of the CPI, and the money supply (M) affects inflation, we introduce them into the CPI model; HPI_{jt} denotes the HPI in city j at year t ; r_{jt} denotes the loan rate over five years at year t , thus reflecting the impact of interest rates on housing prices. In contemporary China, the higher down-payment ratio (at least 20%) for residential mortgages is almost all from household savings, which has a significant impact on new housing prices, so we introduce household savings (S_{jt}) into the housing price model. On the other hand, in light of the existing literature (e.g. Skinner, 1989; Engelhardt, 1996; Gan, 2007), housing price variation affects household savings as well, so we view household savings as the endogenous variable of HPI in the regression. We allow the stock price to interact with housing prices, introduce SPI_{jt} into the housing price model and regard them as endogenous variables in the regression; g_{jt} denotes the GDP index in city j at year t , thus reflecting the impact of economic growth on inflation. Finally, we take housing prices and inflation as endogenous variables and the others as

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[4]Although it is useful to conduct formal Granger causality testing to ascertain the causality direction between house prices and inflation, in terms of our theoretical model, we attempt to illustrate the interactive mechanism of current housing prices and the current inflation policy rather than the lead-lag relationship between them in this paper. On the other hand, our sample size is limited; we merely have around 12-years of tested samples (1999-2010). As the result, the co-integration and Granger causality tests for most of the Chinese majority cities are insignificant. Hence, it is inappropriate to conduct time trend analysis for this short time period. The results of the co-integration and Granger causality tests are available upon request.

exogenous variables in the regression. The summary statistics are shown in Table 1.

3.4   Unit Root and Co-integration Tests

To avoid spurious regression, it is necessary to conduct a unit root test for the variables. Typically, a unit root test entails the Levin-Lin-Chu (LLC), Im-Pesarann-Shin (IPS), Fisher- augmented Dickey–Fuller (ADF) and Fisher-Phillips–Perron (PP) tests. The first test is a homogenous panel test and the latter three are heterogeneous panel tests. As our data are heterogeneous, we adopt the IPS and Fisher-ADF approaches. Tables 2 and 3 show that the HPI, disposable income, household savings and the money supply exist as unit roots. Although all of the variables are stable series at $I(1)$, we also need to implement a co-integration test to confirm the final model specification.

Engle and Granger (1987) have proven that we can regress level variables modeled under co-integration. Accordingly, in this paper, the panel co-integration tests proposed by Westerlund （2007） are adopted for testing co-integration. Table 4 shows that there exists long-term co-integration between the dependent and the independent variables. Therefore, the variable level-value models are consistent with our economic specifications.

Table 1A   Summary Statistics of 35 Large and Medium Sized Cities in China during 1996-2010

Variable	Number of Observations	Mean	Standard Deviation	Minimum	Maximum
HPI_t	456	104.19	4.26	95.1	144.2
CPI_t	525	2.05	3.00	-4.1	12.6
$\ln Y_t$	515	10.28	0.53	8.24	11.56
r_t	525	11.25	0.68	9.30	13.63
$\ln S_t$	525	7.43	2.44	5.76	14.22
SPI_t	525	121.51	48.20	34.60	230.43
g_t	525	13.26	2.98	2.6	30.9
RI_t	463	2.10	4.92	-10.25	66.6
$\ln M_t$	525	10.42	0.74	9.51	11.78

Table 1B   Mean of Major Variables of 35 Large and Medium Sized Cities in China during 1996-2010

City	Region	Province	Population (10,000)	GDP (billion CHY)	GDP Growth Rate (%)	HPI (preceding year=100)	CPI (preceding year=100)	Household Savings (CHY)
Beijing	North	n/a	1052.92	543.77	11.26	104.86	102.44	172470.70
Tianjin	North	Tianjin	721.87	315.11	13.82	104.53	100.24	86912.47
Shijiazhuang	North	Hebei	202.69	65.70	12.49	103.34	102.25	89630.56
Taiyuan	North	Shanxi	251.62	67.23	11.97	103.28	102.24	85406.74
Hohhot	North	Inner Mongolia	109.14	45.19	18.00	103.80	102.45	77009.30
Shenyang	Northeast	Liaoning	493.11	183.35	13.45	105.28	101.82	85804.54
Changchun	Northeast	Jilin	316.08	108.03	15.99	102.82	102.31	72742.35
Harbin	Northeast	Heilongjiang	372.75	111.51	12.75	103.25	101.97	71954.53
Shanghai	East	n/a	1220.56	775.35	11.56	104.98	102.18	157641.70
Nanjing	East	Jiangsu	429.47	187.59	13.32	104.91	101.92	77952.04
Hangzhou	East	Zhejiang	330.36	199.32	12.67	106.32	102.29	121339.40
Hefei	East	Anhui	162.20	64.24	16.41	103.52	101.98	62291.97
Foochow	East	Fujian	164.92	72.40	13.37	102.57	1.91	114973.70
Nanchang	East	Jiangxi	192.29	63.09	13.45	105.45	102.47	60489.51
Jinan	East	Shandong	314.28	130.04	14.26	104.51	101.87	67899.52
Zhengzhou	Central	Henan	256.21	70.32	13.15	103.32	102.39	97917.95
Wuhan	Central	Hubei	464.48	200.83	13.59	103.93	101.96	68012.05
Changsha	Central	Hunan	197.94	92.85	14.56	103.94	102.05	81122.02

(Continued…)

(Table 1B Continued)

City	Region	Province	Population (10,000)	GDP (billion CHY)	GDP Growth Rate (%)	HPI (preceding year=100)	CPI (preceding year=100)	Household Savings (CHY)
Guangzhou	South	Guangdong	556.70	414.14	13.47	101.16	101.43	208019.20
Nanning	South	Guangxi	186.10	48.88	12.49	102.86	101.35	64285.04
Haikou	South	Hainan	108.24	26.19	11.33	105.89	101.44	99371.30
Chongqing	Southwest	Chongqing	1086.85	195.21	11.87	105.32	101.74	35757.24
Chengdu	Southwest	Sichuan	425.18	149.80	12.79	104.38	102.44	82691.52
Guiyang	Southwest	Guizhou	197.98	38.05	13.15	104.15	102.00	57804.15
Kunming	Southwest	Yunnan	217.32	75.46	11.32	102.14	102.68	90051.59
Xi'an	Northwest	Shanxi	470.29	109.19	14.03	103.58	101.93	77015.15
Lanzhou	Northwest	Gansu	192.92	44.59	10.65	104.64	102.07	69167.63
Xining	Northwest	Qinghai	97.54	15.28	12.83	103.12	103.27	57253.34
Yinchuan	Northwest	Ningxia	73.73	18.56	11.99	105.50	102.41	63039.68
Urumqi	Northwest	Xinjiang	178.02	53.68	10.99	103.65	102.01	74990.69
Dalian	Northeast	Liaoning	278.33	152.76	14.04	103.55	101.78	121521.70
Tsingdao	East	Shandong	251.39	132.88	13.84	106.06	102.57	88534.88
Ningbo	East	Zhejiang	177.29	120.62	12.93	107.63	102.19	98863.45
Xiamen	East	Fujian	143.44	91.85	15.09	104.22	101.73	102910.10
Shenzhen	Central	Guangdong	165.65	401.04	15.19	103.90	101.96	476626.30

Table 2   Unit Root Test of Panel Variables

Variable	Level Equation		Difference Equation	
	IPS	Fisher-ADF	IPS	Fisher-ADF
HPI_t	-1.54	0.65	-2.41***	62.64*
	(0.39)	(1.00)	(0.00)	(0.07)
CPI_t	-2.88***	264.56***	-3.82***	529.20***
	(0.00)	(0.00)	(0.00)	(0.00)
$\ln Y_t$	-1.31	2.6016	-2.566***	132.31***
	(0.86)	(1.00)	(0.00)	(0.00)
$\ln S_t$	0.75	7.59	-7.128 ***	224.74***
	(0.77)	(1.00)	（0.00）	（0.00）
g_t	-2.06***	104.73***	-3.19***	310.47***
	(0.00)	(0.00)	(0.00)	(0.00)
RI_t	-1.36***	165.17***	-2.54***	358.48***
	(0.00)	(0.00)	(0.00)	(0.00)

Note: 1. Parentheses are *p* values;
　　　2. ***, ** and * denote significance at 1%, 5% and 10% levels respectively.

Table 3   Unit Root Test of Time-Series Variables

Variable	Statistic	1% Critical Value	5% Critical Value	10% Critical Value
r_t	-5.131	-3.750	-3.000	-2.63
SPI_t	-3.664	-3.750	-3.000	-2.63
$\ln M_t$	0.406	-3.750	-3.000	-2.63
$\Delta \ln M_t$	-4.678	-3.750	-3.000	-2.63

Table 4   Panel Data Co-integration Testing of 35 Large and Medium Cities in China, 1996-2010

Statistic	Statistical Value	Z Value	P Value
Gt	-2.270	-7.357	0.000
Ga	-7.277	-4.519	0.000
Pt	-11.275	-7.073	0.000
Pa	-7.108	-12.426	0.000

Note: 1. The null hypothesis is "co-integration does not exist".
　　　2. Estimation equations include the intercept term, lags, and time trend terms.

3.5   GMM Analysis

As the lag dependent variable is correlated with the error term, the ordinary least squares (OLS), random effects (RE), and fixed effects (FE) estimations are biased. To avoid spurious regression, this paper adopts the system GMM approach as in Arellano and Bover (1995) and Blundell and Bond (1998).

First, the system GMM resolves the variable stability problem via first-order difference. Second, the system GMM solves endogeneity problems via an instrumental variable approach. Finally, the GMM resolves time-series problems by introducing a lag dependent variable. In the regression, the HPI, CPI, savings and the SPI are handled as endogenous variables and the others as exogenous variables. The two-step system GMM results are shown in Table 5.

Table 5   GMM Results of Housing Price and Inflation Levels for 35 Large and Medium Cities in China, 1996-2010

Variable	HPI_t		CPI_t
	Model 1	**Model 2**	**Model 3**
HPI_t			0.25*** （30.81）
HPI_{t-1}	0.36*** （27.67）	0.38*** （11.29）	
CPI_t	0.86*** （23.88）	0.85*** （20.69）	
CPI_{t-1}			0.08*** （10.76）
$\ln Y_t$	0.58*** （2.95）		
r_t	-1.59*** （-25.78）	-1.31*** （-11.99）	
g_t			0.18*** （9.80）
RI_t			0.04*** （5.84）
$\ln M_t$			0.61*** （9.68）
$\ln S_t$		0.34** (1.98)	
SPI_t		0.00*** (3.04)	
Constant	-16.90*** （-5.76）	-16.83*** (-6.82)	54.23*** （46.73）
Wald Chi2 (Prob> chi2)	4047.31 (0.00)	4691.16 (0.00)	3198.24 (0.00)
Sargan Value	30.45 (1.00)	31.92 (1.00)	31.43 (1.00)
$AR(1)$	-3.76 (0.00)	-4.26*** (0.00)	-3.11 (0.00)
$AR(2)$	1.19 (0.23)	-1.94** (0.05)	-0.15 (0.88)
Observations	419	419	446

Note: 1. Parentheses are z values.

2. ***, ** and * denote significance at the 1%, 5% and 10% levels respectively.

In the housing price level model, the coefficient signs of the majority variables are consistent with the theoretical models. Model 1 shows that the impact of the CPI on housing prices is greater than that of disposable income. A one-percent increase in the CPI increases the HPI by 0.86%. A one-percent increase in disposable income increases the HPI by 0.58%. Hence, housing prices can effectively hedge inflation. On the other hand, policymakers should control for inflation to curb housing prices. Second, the impact of the loan rate on housing prices is significantly negative, which implies that monetary policies effectively prevent housing prices from increasing. To confirm the robustness of the relationship between housing prices and inflation, Model 2 introduces two more variables – household savings and stock price into Model 1. Model 2 shows that the results of housing prices and inflation are similar to Model 1, which implies that the relationship between housing prices and inflation is robust. It is worthy to note that household savings have a significant impact on housing prices, while stock price has no effects on housing prices.

In the consumption price equation, Model 3 shows that the impact of housing prices on common consumption prices is significantly positive. A one-percent increase in the HPI is associated with a 0.25% increase in the CPI. Thus, higher housing prices tend to give rise to higher inflation, which indicates that monetary policies should take some consideration of housing price variation. However, the relationship between housing prices and inflation is asymmetric. The impact of the housing prices on inflation is far less than that of inflation on housing prices. In other words, housing prices are more sensitive to inflation than inflation is to housing prices. Second, the impact of economic growth on the CPI is significantly positive, but less than that of housing prices on the CPI. A one-percent increase in the economic growth rate is associated with a 0.18% increase in the CPI. Therefore, asset prices are more likely to give rise to inflation than economic growth. Fundamentally, inflation policies aim towards economic growth. Although housing prices and inflation are interactive, their relationship may vary across regions. In other words, China might be a special case in terms of the relationship between housing prices and inflation. As a matter of fact, due to the fast economic growth, there have been overheated real estate investments and significant price runs in the Chinese housing market recently, which exacerbate inflation. In particular, since there are no other attractive investment vehicles or channels in current China, a large amount of money has been poured into the real estate sectors. Third, rental prices positively affect the CPI, but their coefficients are trivial. A one-percent increase in the RI is associated with a 0.04% increase in the CPI. Thus, housing prices have a greater effect on the CPI than rental prices, even though the latter is a component of the CPI. Finally, the impact of the money supply on the CPI is far greater than that of housing prices or economic growth. A one-percent increase in the money supply is associated with a 0.61% increase in the CPI. Therefore, monetary policies are more effective for controlling inflation than economic growth or housing prices.

Table 6   GMM Results of Housing Price Growth and Inflation Growth in 35 Large and Medium Cities in China, 1996-2010

Variable	ΔHPI_t		ΔCPI_t Growth Equation
	Model 4	Model 5	Model 6
ΔHPI_t			0.24*** （22.78）
ΔHPI_{t-1}	0.36*** （21.18）	0.36*** （9.91）	
ΔCPI_t	0.84*** （16.75）	0.90*** （22.44）	
ΔCPI_{t-1}			0.07*** （8.36）
$\Delta \ln Y_t$	0.64** （2.31）		
Δr_t	-1.52*** -20.57）	-1.41*** （-10.65）	
g_t			0.19*** （11.57）
ΔRI_t			0.03*** （4.64）
$\Delta \ln M_t$			0.62*** （8.74）
$\Delta \ln S_t$		0.32** (2.12)	
ΔSPI_t		0.00* (1.85)	
Constant	4.62 （1.48）	6.78*** (2.96)	
Wald Chi2 (Prob> chi2)	1572.66 (0.00)	9361.99 (0.00)	1511.38 (0.00)
Sargan Value	33.23 (1.00)	33.77 (1.00)	34.45 (1.00)
$AR(1)$	-4.37*** (0.00)	-4.29*** (0.00)	-4.73 (0.00)
$AR(2)$	-2.08** (0.04)	-1.89** (0.06)	-3.75 (0.00)
Observations	419	419	446

Note: 1. Parentheses are z value.
2. ***, ** and * denote significance at the 1%, 5% and 10% levels respectively.

Table 6 shows another robustness test for the relationship between housing prices and inflation, which considers housing price and inflation growth. Table 6 shows that the relationship between housing price and inflation growth is

consistent with the relationship between housing price and inflation which further confirms that the relationship of housing prices with inflation is robust. In other words, the relationship between housing price and inflation growth is positively associated and asymmetric. Model 4 shows that a one-percent increase in the CPI growth is associated with a 0.84% increase in housing price growth. Model 6 shows that a one-percent increase in housing price growth is associated with a 0.24% increase in CPI growth. As mentioned above, both housing price and CPI have dramatically grown in current China. Hence, to prevent inflation from growing too fast, China's central bank should control housing price growth. In addition, Model 6 shows that a one-percent increase in the money supply growth is associated with a 0.62% increase in the CPI growth. Thus, in considering the interactive relationship between housing price growth and CPI growth, China's central bank also needs to implement effective monetary policies to control for CPI growth.

4. Conclusions and Policy Implications

In recent years, China has encountered both higher housing prices and inflation. The relationship between housing prices and inflation is widely discussed and has become an important issue in contemporary China. We have developed a four-sector general equilibrium model that involves consumers, developers, firms, and the central bank to illustrate the relationship of housing prices with inflation from three perspectives: demand-driven, cost-driven and monetary policy. The theoretical model indicates that housing prices are positively correlated and endogenously determined. In addition, housing prices and common consumption prices are positively related to household income, but the former is negatively related and the latter is positively related to interest rates, respectively.

By using a dataset of 35 major cities in China from 1996 through to 2010, we find that the relationship between housing prices and inflation is significantly positive, even though we control for household saving behavior and the stock market. Moreover, the relationship of housing prices with inflation is asymmetric. The impact of the CPI on housing prices is greater than that of housing prices on the CPI, which indicates that housing purchase has been used as an effective hedge for inflation. However, we have to control inflation in order to curb housing prices. On the other hand, inflation policies actually respond to housing price variation. Theoretically and practically, inflation policies aim at economic growth rather than asset price. The Philips curve is the compelling evidence. However, our theoretical model demonstrates that housing price positively affects the price of common consumption goods if the central bank responds to housing price variation, while the price of common consumption goods positively impacts housing price in the absence of the central bank. In addition, our empirical results justify that the relationship between housing prices and inflation is endogenous. Hence, if a housing price

bubble is severe, which indicates that housing prices have deviated from their fundamental value (i.e. economic growth), the inflation policy of the central bank should target housing price growth. Indeed, due to the fast urbanization and strong speculative investments, the housing prices in many Chinese cities have sharply increased in recent years, and the housing bubble in some cities like Wenzhou and Erdos have burst. Accordingly, to prevent real estate crises, China's inflation policy should target housing (asset) prices in the presence of a housing price bubble.

It seems that the impact of housing price appreciation is stronger than that of economic growth on the CPI. Therefore, inflation is more likely than economic growth to occur in the event of higher asset prices.

In addition, housing prices are more important than rental prices to the CPI, even though rental is a component of the CPI. Indeed, rental prices account for merely 13.6% of the CPI in 2011, but housing price variation contains the future inflation expectation. Therefore, housing prices can be used to indicate inflation expectation and can be considered in the target inflation function.

Finally, the impact of the money supply on the CPI is far greater than that of economic growth or housing prices. In addition, mortgage interest rates also serve as an effective tool for adjusting housing prices. Hence, monetary policies are more paramount than housing prices and economic growth for managing inflation.

Acknowledgments

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