J Real Estate Finan Econ (2006) 33: 299–327
DOI 10.1007/s11146-006-0335-2

Housing Price Bubbles in Hong Kong, Beijing and Shanghai: A Comparative Study

Eddie C. M. Hui · Shen Yue

Abstract This study investigates whether there was a housing price bubble in Beijing and Shanghai in 2003. The existence of a bubble can be interpreted from (abnormal) interactions between housing prices and market fundamentals. This paper introduces an enhanced framework, with the combination of standard econometric methodologies: i.e., Granger causality tests and generalized impulse response analysis, and the reduced form of housing price determinants. A test case in Hong Kong, between 1990 and 2003, is included to test the reliability of our methods because Hong Kong has experienced the formation and bursting of a huge housing bubble around the year 1997. It is found that the pattern and magnitude of the estimated bubbles conform quite well to the discrepancies between the actual and predicted prices. Also, the findings suggest that there appeared a bubble in Shanghai in 2003, accounting for 22% of the housing price. By contrast, Beijing had no sign of a bubble in the same year. The bubble phenomenon, of course, should be taken with cautions. Nonetheless this study has laid the groundwork for further investigations in abnormal housing price phenomena in Mainland China.

Keywords Price bubble · Cointegration test · Granger causality · Generalized impulse response function

Introduction

Over the last two decades, China has achieved rapid economic growth, accompanied by rapid development of the real estate market. Although the Asian financial crisis

E. C. M. Hui (✉)
Department of Building and Real Estate, The Hong Kong Polytechnic University, Hong Kong, China
e-mail: bscmhui@polyu.edu.hk

S. Yue
Institute of Real Estate Studies, Tsinghua University, Beijing, China

damaged the real estate markets in Southeast and East Asia, it had little impact on the real estate markets in Beijing and Shanghai. As a result of rapid economic growth and urbanization, demand for urban land and new dwellings have increased accordingly, leading to the sustained growth of housing prices. For example, Shanghai Housing Price Index (SHHPI) in the China Real Estate Index System (CREIS) was only 656 points in January 2001, and it rose by 63% to 1,084 points in December 2003.

Fluctuations in housing prices not only affect the financial well-being of many corporations and households, but also play an important role on the macroeconomic level. Changes in housing prices would trigger or reinforce the fluctuations in the economy on the macro scale. Therefore, to maintain a stable relationship between housing prices and the economy is of great importance. The burst of the Japanese land price bubble and the Asian financial crisis in recent years have resulted in a sharp drop in property prices in many countries and regions and their economies were badly hit. The case of Hong Kong can be used as an ideal illustration of how the property prices can affect the economy as a whole.

Figure 1 shows the trend of residential property price, household income and inflation rate in Hong Kong during 1990 and 2003. The residential property price rose from 1990 to 1997 with only minor setbacks in the process. Eventually a great bubble was formed in the year 1997 and it is marked by an obvious surge of housing price on the graph during that year. The Asian financial crisis broke out in the same year and the property prices in Hong Kong plummeted as a result. The downward trend of property prices continued to the year 2003.

The property market crash had a considerable negative impact on the economy. This is demonstrated with the red line in Fig. 1. The average monthly household income in Hong Kong followed a steady upward trend from 1990 to 1997, which was

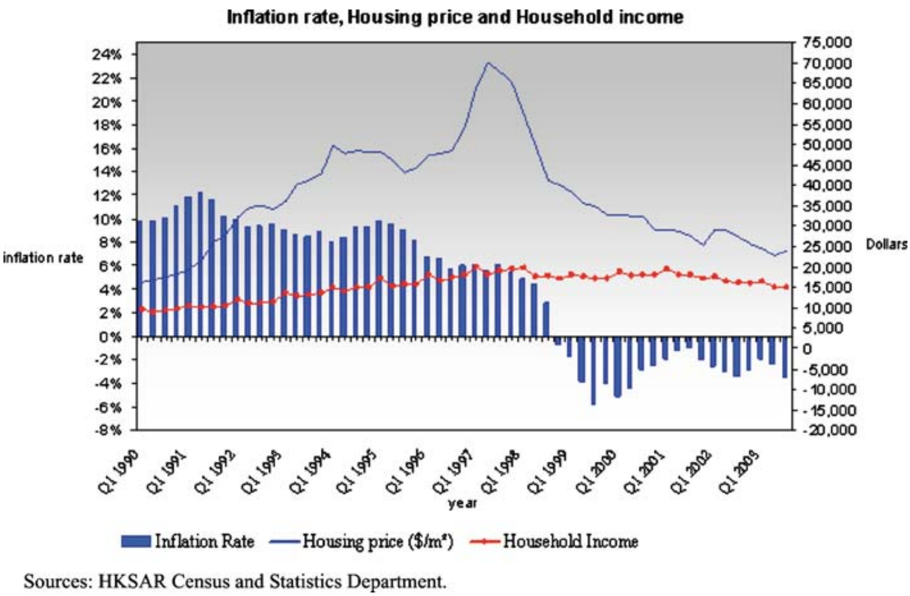


Fig. 1 Housing price, household income and inflation rate in Hong Kong from 1990 to 2003

consistent with the trend of the property prices. However, this situation was reversed in the year 1997 and the household income in Hong Kong decreased during the year 1997 to 2003, which is also in line with the trend of the housing price. The household income was at its 1995 level in the year 2003.

The impact of the property market on an economy can be even more vividly shown by looking at the inflation rate. The Bar Chart in Fig. 1 shows the inflation rates in Hong Kong from 1990 to 2003. The property market crash led to a reversal in price movement. Inflation used to be the norm in Hong Kong until the breakout of the Asian financial crisis. From 1999 onward deflation has persisted in Hong Kong and there was still no sign of its end in the year 2003.

Given the tremendous impact of the property market on the economy, it is important to investigate whether bubbles exist in the housing market in China, one of the largest nations in the world. Since 2002, many government officials and economists have claimed that some cities in China should be wary of signs of housing price bubbles. As two of the most popular areas for real estate development in China, Beijing and Shanghai have become the key cities under scrutiny. The main objective of this paper is to investigate the relationship between housing prices and market fundamentals in the two cities, and to find out the size of housing price bubbles there, if there is any.

The structure of this paper is laid out as follows: Section 1 is the introduction. Section 2 presents a literature review of previous studies on bubbles. The data used in this study are described in Section 3. Section 4 explores the interactions between housing prices and market fundamentals for the three cities. Following that the bubble term in 2003 is estimated in Section 5. The last section provides a conclusion for the paper. Appendix 1 discusses the econometric methodologies employed in the paper, and Appendix 2 gives the results of 4 Vector Error Correction Models (VECM).

Literature Review

Although the definition of bubble appears straightforward, testing for its existence could be a difficult task. How to determine if there are bubbles in real estate markets? The most frequently used method is to compare the price and the market's "fundamentals". The "fundamentals" are usually classified into two categories: fundamental value and market fundamentals.

An asset's fundamental value is measured by three determinants: the cash flow received over time, the terminal value of the asset at the end of the holding period, and the discount rate to be used for translating future cash into current value (Peng & Hudson-Wilson, 2002; Stiglitz, 1990). However, it is difficult to specify the intrinsic value determined by the three determinants for the absence of data extending infinitely into the future (Flood & Hodrick, 1990). Therefore the concept of an asset's fundamental value is used in theoretical analysis rather than empirical studies. For example, Noguchi (1994) defined the bubble as the part of land price exceeding the theoretical land value and concluded that price bubbles were found in 54% of the land price in Tokyo in 1987.

Given the difficulties in calculating the fundamental value of an asset, researchers have been looking for indirect evidence of bubbles, which leads to another kind of "fundamentals" interpreted as exogenous macroeconomic variables fundamental to the market. That is to say, the existence of price bubbles can be implied by the relationship between real estate prices and macroeconomic variables. If real estate prices are in line with variations of macroeconomic variables, or a price change can be explained by both fundamentals and reasonable shifts, the assumption of a price bubble can be rejected.

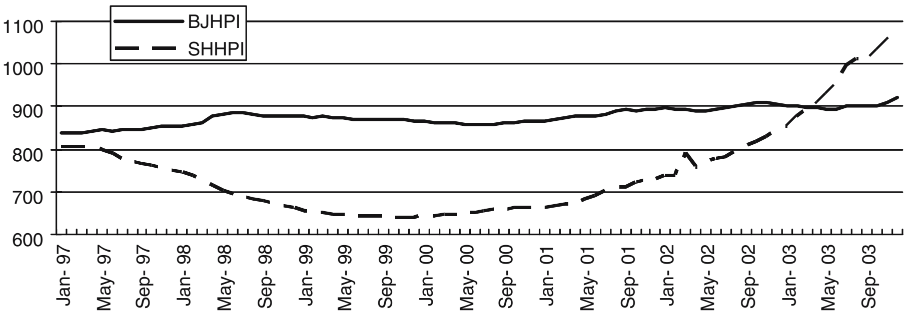
A variety of methodologies have been employed in empirical studies of real estate asset price bubbles. With an equilibrium price equation including housing price index and exogenous variables, such as GDP, stock price index and urban household consumption expenditure, Kim and Suh (1993) tested the existence of growing real estate bubbles in Korea and Japan. Peng and Hudson-Wilson (2002) conducted an empirical analysis of Tokyo office market during 1977–1999 with a pricing model that consists of two separate but related equations: income and price. The variables included net operating income (NOI), office vacancy rate, price index and general economic indicators such as GDP, CPI, interest rates and inflation rate. Over time, new econometrical methods have been developed, such as cointegration analysis, Granger causality analysis, impulse response function. For example, Kim and Lee (2000) examine, with cointegration tests, the existence of real estate price bubbles in Korea.

Distinguished from previous literature, this paper uses advanced and well executed econometric methods to explore the interactions between housing prices and market fundamentals for Hong Kong, Beijing, and Shanghai. Our study aims to investigate if there are abnormal interactions. It also employs the reduced form equation of housing price determination to test whether there are housing prices bubbles, followed by an estimation of bubbles terms. Indeed, little or no similar vigorous academic work has been done on housing price bubbles for the three cities. This makes the current study unique. Its findings may thus make possible contribution to existing knowledge and in particular provide very useful information and a better understanding of the three real estate markets at work.

The Data

The reliability of housing price index depends on the quality and appropriateness of the data. Given the need of quality control, major indices used in previous researches are those of hedonic, repeated sales and hybrid housing price indices (Henry, 1995). However, since there are always some limitations of the indices, a mismatch between the price index and the analytical objective could provide misleading results. In this study, a national uniform data source that permits quality control is needed to study housing prices in Beijing and Shanghai.

The monthly housing price index of new dwellings of Beijing (BJHPI) and Shanghai (SHHPI) in the China Real Estate Index System (CREIS) used in this paper is a kind of Laspeyres Index with a base point of 1,000 in Beijing in November 1994, calculated on the basis of market investigations on selling prices of typical new dwellings in different cities. In other words, the data in CREIS are fundamentally transaction based indices reporting market price trends, whether smooth or not. The CREIS system is designed to control variations in quality with prices adjusted. New developments are dotted around, though as a matter of fact, mostly in new parts of the city. As this index is based on new dwellings of similar qualities, it reflects the housing price trend of new dwellings much better than other real estate price indices



Notes: 1) BJHPI and SHHPI represent monthly housing price index of new dwellings of Beijing and Shanghai respectively.

2) Data source: SouFun.com.

Fig. 2 Housing price indices in Beijing and Shanghai for January 1997–December 2003

in China. Figure 2 reports housing price indices in the two cities for January 1997–December 2003. It can be seen that the BJHPI is less volatile than the SHHPI.

Except housing price indices, another important variable related to the housing market is the stock of vacant new dwellings (VAC), which is an indicator of market equilibrium. In short, it is the balance between supply and demand in the housing market. Variables on the side of economic fundamentals are disposable income of urban households (INC), local GDP and Shanghai stock price index (SHANG). Among such variables, disposable income influences affordability of urban households and the demand for new dwellings, while the stock of vacant new dwellings has a direct impact on the supply side. Local GDP is the major proxy of economic performance and Shanghai stock price index represents the nationwide stock market. The descriptive statistics of the variables for the two cities are reported in Tables 1 and 2. Nominal values of local GDP and disposable income are used in this study as inflations in the two cities in recent years have been minimal and hence could be ignored. There is no noticeable difference between the real value and nominal value.

Table 1 Descriptive statistics of the variables in Beijing, January 1997–December 2003

Variables	Average	Standard deviation	Maximum	Minimum
Housing price index	876.40	19.86	923.00	839.00
Disposable income of urban households (Yuan)	873.05	166.73	1,185.29	645.00
Local GDP (billion Yuan)	212.21	58.68	339.50	89.50
Shanghai Stock Price Index	1,526.99	309.89	2,218.03	964.74
Stock of vacant new dwellings (million m^2)	398.35	214.39	835.89	50.50

Disposable incomes of urban households for both cities are exponentially smoothed, and so is the local GDP in Beijing

The data on local housing markets and economic fundamentals are gathered from numerous sources. These sources include Beijing Statistical Information Net (http://www.bjstats.gov.cn), Shanghai Statistical Information Net (http://www.stats-sh.gov.cn), China Infobank (http://www.bjinfobank.com) and China Securities Regulatory Commission (http://www.csrc.gov.cn)

Table 2 Descriptive statistics of the variables in Shanghai, January 2001–December 2003

Variables	Average	Standard deviation	Maximum	Minimum
Housing price index	817.39	123.83	1,084.00	665.00
Disposable income of urban households (Yuan)	1,113.48	93.53	1,303.30	936.15
Local GDP (billion Yuan)	459.36	70.26	613.66	326.97
Shanghai Stock Price Index	1,656.71	247.79	2,218.03	1,348.30
Stock of vacant new dwellings (million m^2)	594.28	120.52	843.37	412.27

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And for Hong Kong, we have the quarterly data of housing price in terms of dollars per metre square, median household income, quarterly GDP (all three items are measured at nominal price), Hang Seng Stock Price Index, and the number of vacant residential units at year end (see Table 3). This paper will perform a number of statistical tests and procedures in the following order: PP tests, JJ tests, Granger causality tests, and Impulse Response functions.

Table 4 reports the correlations among the selected variables of the three cities. Generally speaking, there should be strong positive correlations between housing prices and variables such as GDP and disposable income, strong negative correlations between housing prices and the stock of vacant new dwellings. However, strong positive correlation between housing price and vacant new dwellings is found for Beijing while rather weak positive correlation between housing price and disposable income is found for Shanghai, which is contradictory with the theoretical hypothesis. Therefore, there exists circumstantial evidence of housing price bubbles in the two mainland cities, particularly in Shanghai.

Interactions between Housing Prices and Market Fundamentals

Table 4 provides a concise view of the interactions between housing prices and market fundamentals. Although some anomalies are found, the evidence is not

Table 3 Descriptive statistics of the variables in Hong Kong, Q1, 1990–Q4, 2003

Variables	Average	Standard deviation	Maximum	Minimum
Housing price (HK$/$m^2$)	37,070.31	13,192.42	70,077	16,186
Mean household income (HK$)	15,360.71	3,108.035	20,000	8,900
Local GDP (million HK$)	279,472.9	43,390.81	369,271	193,485
Hang Seng stock price index	9,500.518	3,877.115	17,369.63	2,791.26
Vacant unit	43,302.27	13,476.79	68,781	21,008.75

Sources: HKSAR Census and Statistics Department

Table 4 Correlations among the selected variables of the three cities

Variables	Beijing (January 1997–December 2003)					Shanghai (January 2001–December 2003)[a]					Hong Kong (Q1,1990–Q4,2003)				
	HP	INC	GDP	VAC	STOCK	HP	INC	GDP	VAC	STOCK	HP	INC	GDP	VAC	STOCK
HP	1.000	0.841	0.831	0.713	0.188	1.000	0.421	0.862	−0.722	−0.804	1.000	0.595	0.249	−0.074	0.553
INC	0.841	1.000	0.905	0.889	0.478	0.421	1.000	0.324	−0.179	−0.352	0.595	1.000	0.873	0.637	0.939
GDP	0.831	0.905	1.000	0.923	0.485	0.862	0.324	1.000	−0.655	−0.667	0.249	0.873	1.000	0.892	0.860
VAC	0.713	0.889	0.923	1.000	0.624	−0.722	−0.179	−0.655	1.000	0.701	−0.074	0.637	0.892	1.000	0.685
STOCK	0.188	0.478	0.485	0.624	1.000	−0.804	−0.352	−0.667	0.701	1.000	0.553	0.939	0.860	0.685	1.000

[a] Please refer to the Appendix for further details

Table 5 PP tests of the variables of Beijing for January 1997–December 2003

Variable	Level		First difference		Results
	Model specification (lags)	PP test statistic (5%, 1% c. v.)	Model specification (lags)	PP test statistic (5%, 1% c. v.)	
lnBJHPI	None (2)	2.00 (−1.94, −2.59)	Intercept (2)	−5.15 (−2.90, −3.51)	I (1)[a]
lnINC	Intercept and trend (2)	−2.33 (−3.47, −4.07)	Intercept (2)	−6.80 (−2.90, −3.51)	I (1)[a]
lnVAC	Intercept and trend (2)	−2.74 (−3.47, −4.07)	Intercept (2)	−10.8 (−2.90, −3.51)	I (1)[a]
lnGDP	Intercept and trend (2)	−3.78 (−3.47, −4.07)	Intercept (2)	−7.92 (−2.90, −3.51)	I (1)[a]
lnSHANG	Intercept (2)	−2.45 (−2.90, −3.51)	None (2)	−8.32 (−1.94, −2.59)	I (1)[a]

Generally three kinds of model specification exist in the PP test: no intercept and no trend; only intercept; intercept and trend

PP Tests are the unit root test, similar to ADF tests

[a] Denotes the 99% significance level

enough to justify the existence of bubbles. What are the causal relationships between housing prices and market fundamentals? What is the degree of the impact of the determinants and the feedbacks on housing prices? Answering these questions is crucial, because it can give clearer insights into the interactions between housing prices and market fundamentals. Granger causality test and generalized impulse response function are employed in this section.

Granger Causalities

Granger (1969) puts forward the definition of causality, which is based entirely on the predictability of some series, say x. If a series y contains information in past terms that helps in the predication of x and if this information is contained in no other series used in the predictor, then y is said to cause x. Generally speaking, if x and y are stationary series, unrestricted Vector Autoregressive (VAR) models are

Table 6 PP tests of the variables of Shanghai for January 2001–December 2003

Variable	Level		First difference		Results
	Model specification (lags)	PP test statistic (5%, 1% c. v.)	Model specification (lags)	PP test statistic (5%, 1% c. v.)	
lnSHHPI	Intercept and trend (2)	−0.97 (−3.55, −4.24)	Intercept and trend (2)	−10.48 (−3.55, −4.24)	I (1)[a]
lnINC	Intercept and trend (2)	−3.40 (−3.55, −4.24)	None (2)	−5.67 (−1.95, −2.63)	I (1)[a]
lnVAC	Intercept and trend (2)	−2.61 (−3.55, −4.24)	Intercept (2)	−5.46 (−1.95, −2.63)	I (1)[a]
lnGDP	Intercept and trend (2)	−3.05 (−3.55, −4.24)	Intercept (2)	−5.60 (−1.95, −2.63)	I (1)[a]
lnSHANG	Intercept and trend (2)	−2.34 (−3.55, −4.24)	None (2)	−6.13 (−1.95, −2.63)	I (1)[a]

Generally three kinds of model specification exist in the PP test: no intercept and no trend; only intercept; intercept and trend

PP Tests are the unit root test, similar to ADF tests

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Table 7 PP tests of the variables of Hong Kong for Q1, 1990–Q4, 2003

Variable	Level		First difference		Results
	Model specification (lags)	PP test statistic (5%, 1% c. v.)	Model specification (lags)	PP test statistic (5%, 1% c. v.)	
lnHP	Intercept and trend (2)	−1.95 (−3.49, −4.13)	None (2)	−3.87 (−1.95, −2.60)	I (1)[a]
lnINC	Intercept (2)	−2.43 (−2.91, −3.55)	Intercept and trend (2)	−17.05 (−3.49, −4.13)	I (1)[a]
lnVAC	Intercept and trend(2)	−2.43(−3.49,−4.131)	None(2)	−2.80(−1.95,−2.60)	I (1)[a]
lnGDP	Intercept and trend (2)	−2.33 (−3.49, −4.131)	Intercept (2)	−5.83 (−2.91, −3.55)	I (1)[a]
lnStock	Intercept (2)	−2.24 (−2.91, −3.55)	Intercept and trend (2)	−8.60 (−3.49, −4.13)	I (1)[a]

Generally three kinds of model specification exist in the PP test: no intercept and no trend; only intercept; intercept and trend

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usually assumed to implement the Granger causality test, and Wald Chi-square tests and F tests are employed to test the null hypothesis of no Granger causality. However, if the variables are cointegrated, the bivariate dynamic relation between them would be misspecified if the researcher simply uses traditional Vector Autoregressive (VAR) model to test the existence of Granger causality. As Engle and Granger (1987) pointed out, this kind of test should be carried out with Vector Error Correction (VEC) Models.

As a preliminary step of cointegration analysis, the order of integration of the variables should be tested. If the levels of time series are nonstationary, but stationary after first differencing, they are defined as being integrated of order one $I(1)$. The Phillips-Perron (PP) integration test is employed with respective variables in log form. The results of the PP test indicate that the variables are stationary after first differencing, as Tables 5, 6 and 7 shows.

Cointegration test is usually used to investigate the long-term relationships between nonstationary variables. Generally, this paper analyses four different specifications. Model2 represents deterministic data trend with an intercept but no trend in the cointegration equation (CE). Model 3 has linear data trend with an intercept but no trend in the CE. Model 4 has a linear data trend with both an intercept and a trend in the CE. Model 5 represents quadratic data trend with an intercept and a trend in the CE.

Table 8 JJ tests of the variables of Beijing for January 1997–December 2003

Variables	Lagged differences	Model specification	Trace test		Max-eigenvalue test		Results
			r=0	r=1	r=0	r=1	
lnBJHPI &lnINC	12	M3	34.62[a]	1.64	27.69[a]	0.30	1
lnBJHPI&lnGDP	12	M5	25.27[a]	2.78	22.49[a]	2.78	1
lnBJHPI & lnVAC	14	M3	20.41[a]	1.80	18.61[b]	1.80	1
lnBJHPI & lnSHANG	12	M5	21.63[b]	0.51	21.12[b]	0.51	1

[a] Rejection of the null hypothesis at the 99% significance level

[b] Rejection of the null hypothesis at the 95% significance level

Table 9 JJ tests of the variables of Shanghai for January 2001–December 2003

Variables	Lagged differences	Model specification	Trace test		Max-eigenvalue test		Results
			r=0	r=1	r=0	r=1	
lnSHHPI &lnINC	9	M5	70.73[a]	2.67	68.05[a]	2.67	1
lnSHHPI& lnGDP	9	M5	40.50[a]	0.74	39.76[a]	0.74	1
lnSHHPI & lnVAC	9	M5	19.77[b]	1.27	18.50[b]	1.27	1
lnSHHPI & lnSHANG	9	M5	66.26[a]	0.08	66.18[a]	0.08	1

[a] Rejection of the null hypothesis at the 99% significance level

[b] Rejection of the null hypothesis at the 95% significance level

If two variables are cointegrated in the model without trend in the cointegration equation (M2 or M3), certain linear combinations of the variables would make them deviate not too far from each other, although the individual economic variables would fluctuate considerably. In this paper cointegration test is employed to test whether a stable and long-run equilibrium relationship exist between housing prices and key macroeconomic variables. If equilibrium relationship exists between the variables and there is no trend in the model specification, the possibility of a price bubble can be excluded. Although this approach is not entirely free of the problem of misspecification, the procedure is much simpler because the bubble term does not have to be estimated (Kim & Lee, 2000).

Employing the well-known Johansen and Juselius (1990) procedure, the results of cointegration tests between housing prices and other variables are presented in Tables 8 and 9. Although housing prices are all cointegrated with the fundamental variables, half of the cointegration relationships for Beijing and all the relations for Shanghai are based on M5. In other words, with the trend term specified, housing prices have moved (or would move) far from the fundamentals, especially for the city of Shanghai. The results illustrate some evidence of housing price bubbles in the two cities. The results of Hong Kong are shown in Table 10.

Since the variables are proved to be integrated and cointegrated, error correction models (ECM) could be formulated. Each pairwise combination of housing prices and one of the fundamental variables is tested, as shown in Appendix 2. Then Granger Causality tests are employed to examine the causality relationships between housing prices and the fundamental variables, as summarized in Table 11.

Table 10 JJ tests of the variables of Hong Kong for Q1, 1990–Q4, 2003

Variables	Lagged differences	Model specification	Trace test		Max-eigenvalue test		Results
			r=0	r=1	r=0	r=1	
lnHP &lnINC	8	M2	21.15[b]	5.39	15.76[b]	5.39	1
lnHP & lnGDP	8	M3	25.54[a]	1.47	24.07[a]	1.47	1
lnHP & lnVAC	8	M3	31.08[a]	0.39	30.69[a]	0.39	1
lnHP & lnStock	8	M4	29.93[b]	2.94	26.99[a]	2.94	1

[a] Rejection of the null hypothesis at the 99% significance level

[b] Rejection of the null hypothesis at the 95% significance level

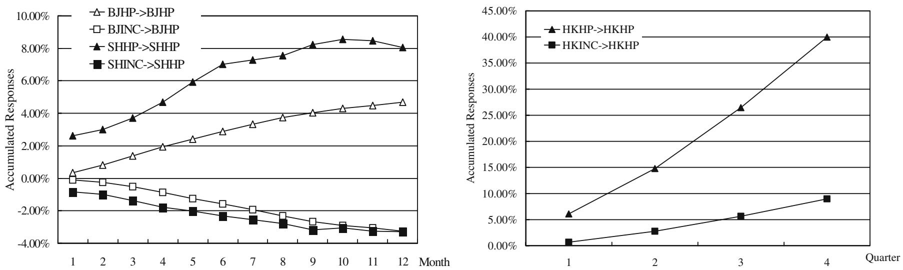
Table 11 Summary of Granger causality test

	Beijing			Shanghai			Hong Kong		
	Chi-square	*P* value	Result	Chi-square	*P* value	Result	Chi-square	*P* value	Result
INC ⇒ HP	22.09	0.04	Y	1.68	0.99	N	15.96	0.04	Y
HP ⇒ INC	13.97	0.30	N	110.85	0.00	Y	15.05	0.06	Y
GDP ⇒ HP	13.65	0.32	N	3.73	0.93	N	8.03	0.43	N
HP ⇒ GDP	9.13	0.69	N	21.34	0.01	Y	29.09	0.00	Y
VAC ⇒ HP	34.49	0.00	Y	6.06	0.73	N	25.35	0.00	Y
HP ⇒ VAC	13.83	0.46	N	44.17	0.00	Y	9.81	0.28	N
STOCK ⇒ HP	8.95	0.71	N	30.48	0.00	Y	12.42	0.13	N
HP ⇒ STOCK	34.81	0.00	Y	19.17	0.02	Y	33.64	0.00	Y

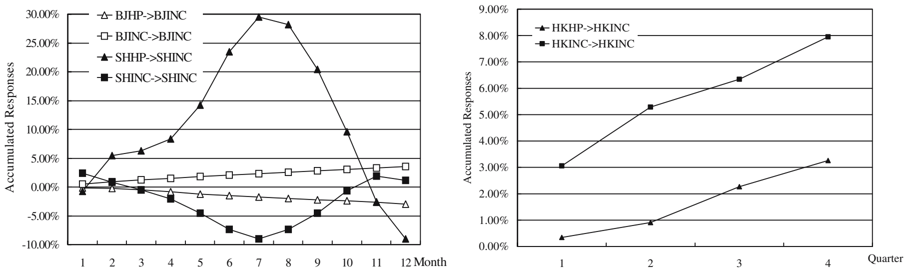
x ⇒ y means the null hypothesis that x does not Granger causes y

Y means the rejection of the null hypothesis and N means the acceptance of the null hypothesis

The results indicate that disposable income of urban households Granger causes housing prices in Beijing and Hong Kong but this does not apply to Shanghai, which means that housing price booms in Beijing and Hong Kong are to an extent based on the growth of disposable income, while in Shanghai recent housing prices have soared much faster than the growth of disposable income. On the contrary, the feedback is not discernable in Beijing but exists in Shanghai and Hong Kong, which is due to persistent appreciations in housing prices resulting in capital gains. By 2002, the urban homeownership rate in China reached 80% and there would be a huge wealth effect with the boom of housing prices, especially in Shanghai, which



(a) Accumulated responses of housing prices



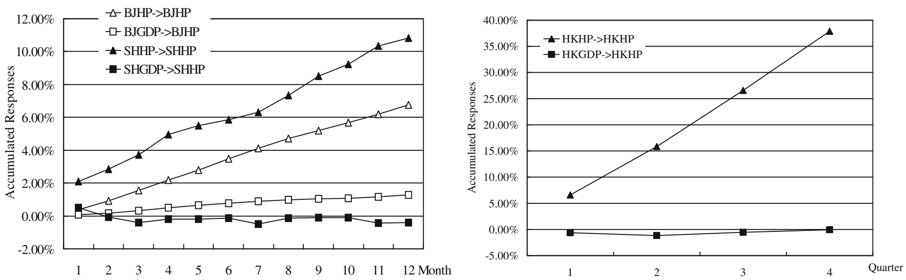
(b) Accumulated responses of disposable income

Fig. 3 Impulse response analyses between housing prices and disposable income would stimulate much more speculations in the housing market and lead to housing price bubbles.

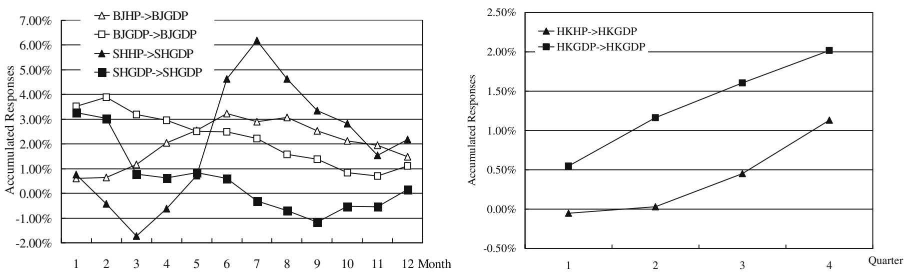
Although the causal relationships between housing prices and GDP are ambiguous, high growth rate of GDP usually generates expectations of future economic growth and usually will induce a market boom especially in the developing countries like China. No causal relationships exist between housing prices and GDP in Beijing and only one-way causality from housing prices to GDP exists in Shanghai and Hong Kong. Since the growth of local GDP in Shanghai and Hong Kong depends more on the surge of housing prices, the real estate industry in the latter two cities plays a more important role in the local economy than in Beijing.

An appreciation of housing prices may mean a decline in housing affordability among households, probably resulting in a corresponding increase in vacant new dwellings. A large vacancy stock indicates an over supply in the housing market and, in theory, will lead to a decrease in the average selling price of new dwellings. In Beijing and Hong Kong the vacant units Granger causes housing prices without a feedback, while in Shanghai the housing prices Granger causes the vacant units with no feedback. If housing price bubbles exist in a local housing market, a price boom will stimulate market speculations and lead to a decrease in vacant units, which is the situation in Shanghai now.

For urban households, the housing market could be taken as a substitute for the stock market. The boom of housing prices sometimes accompanies the boom of stock market and vice versa. The findings suggest a two-way causality relationship



(a) Accumulated responses of housing prices



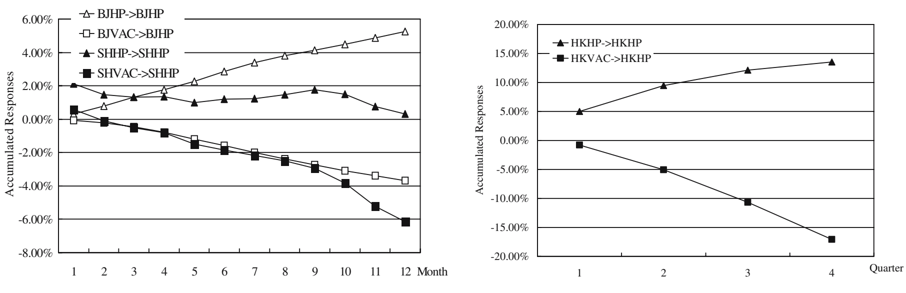
(b) Accumulated responses of local GDP

Fig. 4 Impulse response analyses between housing prices and local GDP between housing prices and Shanghai Stock Price Index, and housing prices in Beijing and Hong Kong Granger cause the stock price index without the feedback. That is to say, the course of housing prices in Beijing and Hong Kong is not closely related to the movement of the stock price index.

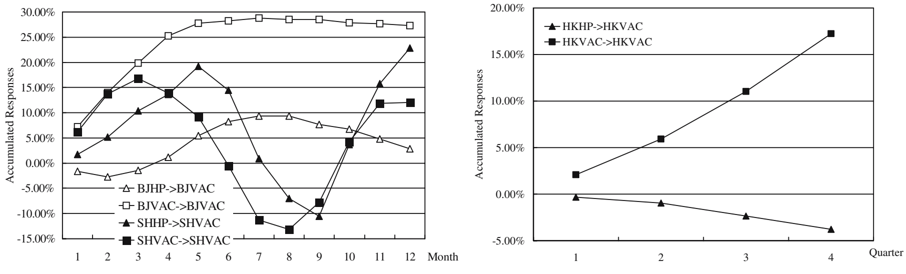
Generalized Impulse Response Analysis

An impulse response function traces the effect of a one standard deviation shock to one of the innovations on current and future values of the endogenous variables in a VAR(VEC) model. A shock to the *i*-th variable directly affects the *i*-th variable itself, and is also transmitted to all of the endogenous variables through the dynamic structure of the VAR(VEC). So impulse response function can be used to describe the dynamic response of the system, which helps to analyze the two-way dynamic relations of the variables. This approach is not, however, invariant to the ordering of the variables. Generalized Impulses as described by Pesaran and Shin (1998) constructs an orthogonal set of innovations that does not depend on the VAR(VEC) ordering, employed in this paper.

Generally speaking, an impulse response function provides a different method in depicting the system dynamics by tracing the effects of the shock of an endogenous variable on the variables in the VEC Model. That is to say, an impulse response function shows how the variables in the VEC system respond to a standard exogenous change of another variable under investigation. Compared with Granger causality test, this methodology offers an advantage that it may indicate whether the



(a) Accumulated responses of housing prices

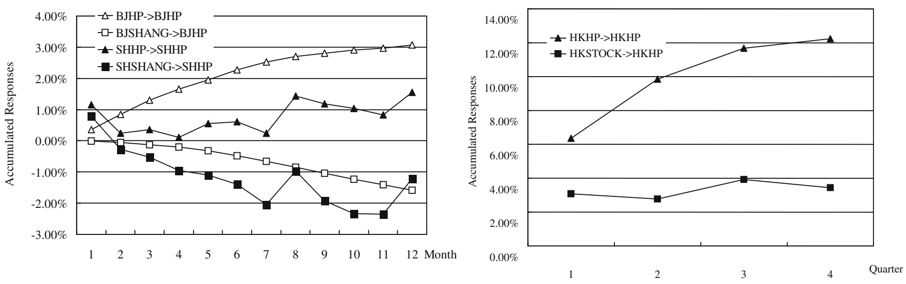


(b) Accumulated responses of vacant dwellings

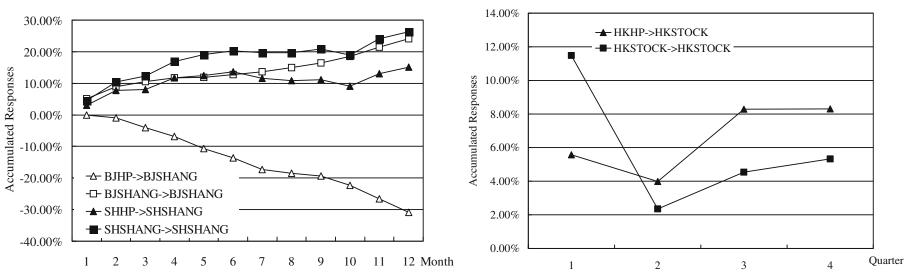
Fig. 5 Impulse response analyses between housing prices and vacant new dwellings impacts are positive or negative, and whether such impacts are temporary or long-termed. Assuming that the endogenous systems just comprise housing prices and one of the four fundamental variables and the impacts of other economic and political forces are neglected, accumulated responses are calculated on the basis of the VEC Models in Appendix 2.

Figures 3, 4, 5 and 6 reports the two-way generalized responses between housing prices and the selected endogenous variables in the three cities. In all of the figures the standard deviation of housing price itself would lead to positive increases in future housing prices in the next year, indicating that current changes in housing prices do affect peoples' expectations in the short run in the three cities. The accumulated response of housing prices in Beijing is less sensitive than that in Shanghai. The findings suggest that the fluctuation of response in the 12 months under study is between 3%–7% in Beijing, while it is between 0%–11% in Shanghai. In the more developed housing market of Hong Kong, the accumulated response in four quarters is between 5%–40%. The rate is much larger than the two mainland cities, indicating housing prices fluctuations do greatly affect peoples' expectations.

The response of housing prices to the standard deviation of the selected fundamental variables differs in a great deal. Generally speaking, the increase of disposable income has a positive effect on housing prices, proved by the case in Hong Kong in Fig. 3a. But Fig. 3a displays negative effects in the two mainland cities. The only possible explanation is that housing prices are not increasing quite in parallel with disposable income. Figure 4a indicates in the three cities the response of housing prices to GDP is not large and this result is the same as the Granger



(a) Accumulated responses of housing prices



(b) Accumulated responses of Shanghai Stock Price Index

Fig. 6 Impulse response analyses between housing prices and Shanghai Stock Price Index

Causality analysis. The next two figures indicate that consistent with theoretical hypothesis, the accumulated responses to vacant dwellings (VAC) and the stock price index are both negative.

The wealth effect of housing price booms in Shanghai is apparent as the response of disposable income to the standard deviation of housing prices rises to 29.5% in the seventh month. But Fig. 3b also predicts that this wealth effect could not last long since in the 12th month the accumulated response will decrease to −9.00%. The positive wealth effect is also evident in Hong Kong while on the contrary, we find negative effects in Beijing. The response of GDP in Shanghai to housing prices is similar to that of income, with the maximum value of 6.2% in the seventh month, while the maximum response of GDP to the impulse of housing prices in Beijing is just half of that in Shanghai, and the maximum response in Hong Kong is even weaker.

The accumulated response of vacant new dwellings to the impulse of housing prices in Shanghai is somewhat complicated. It reaches the first maximum value of 19.2% in the fifth month (see Fig. 5b). As the speculation activities are stimulated by the price booms, the stock of vacant new dwellings would decrease to −10.5% in the ninth month, and then it would rise again. The accumulated response of vacant new dwellings in Beijing to housing prices reaches its maximum of 9.4% in the seventh month. For the city of Hong Kong, significant negative responses of vacant units to housing prices are found.

Also, responses of Shanghai stock price index to the standard deviation of housing prices in the two mainland cities can be measured, as presented in Fig. 6b. A standard deviation originated from housing prices in Shanghai produces an accumulative total of 15.1% increase in Shanghai stock price in the 12th month without the impact of other economic forces, which is double of the response of Hang Seng price index to housing prices in Hong Kong. However the impact of housing prices in Beijing to Shanghai stock price index differs greatly, as the accumulated response of Shanghai Stock price keeps going down to a minimum −30.8% in the 12th month. The results indicate there is a big difference in the relationship between housing prices and the stock price index among the three cities.

Estimate of the Bubble Term in 2003

Consider a competitive housing market, prices are determined by the housing supply and demand (Quigley, 1999). The interactions can be represented by

$$PH = f\left(H^D, H^S\right) \tag{1}$$

where P^H is the housing prices, and H^D and H^S are the quantities of housing that are demanded and supplied. Housing demand is a function of housing prices, disposable income, local GDP, Shanghai stock price index and a vector of exogenous variables X, and housing supply is a function of prices and vacant new dwellings as well as a set of exogenous variables Y. The supply and demand functions for housing can be expressed as

$$H^D = d(PH, INC, GDP, SHANG, X) \tag{2}$$

Table 12 Models of housing price determination for Beijing, Shanghai and Hong Kong

Variables	Beijing		Shanghai		Hong Kong	
	Coe.	*t* ratio	Coe.	*t* ratio	Coe.	*t* ratio
lnHP(−1)	1.15	10.02[a]	0.65	3.73[a]	0.88	17.11[a]
lnHP(−2)	−0.21	−1.76[b]				
lnINC	0.02	2.35[c]	−0.09	−1.87[b]	−0.09	−0.51
lnGDP	0.01	1.85[b]	0.07	1.20	0.01	0.05
lnSHANG	0.00	1.37	−0.04	−0.89	0.11	1.88[b]
lnVAC	−0.01	−3.87[a]	−0.12	−2.18[c]	−0.20	−2.03[b]
C	0.25	0.97	3.70	2.49[c]	3.13	1.92[b]
R^2	0.98		0.96		0.97	
Adjusted R^2	0.98		0.95		0.96	

[a] Significance at the 99% level

[b] Significance at the 90% level

[c] Significance at the 95% level

$$H^S = s(PH, VAC, Y) \tag{3}$$

Substituting Eqs. 2 and 3 into Eq. 1 and solving for housing prices, we can get the reduced form Eq. 4 of housing prices determination, where Z represents a vector of exogenous variables and $L()$ is the lag operator.

$$PH = f(L(PH), INC, GDP, SHANG, VAC, Z) \tag{4}$$

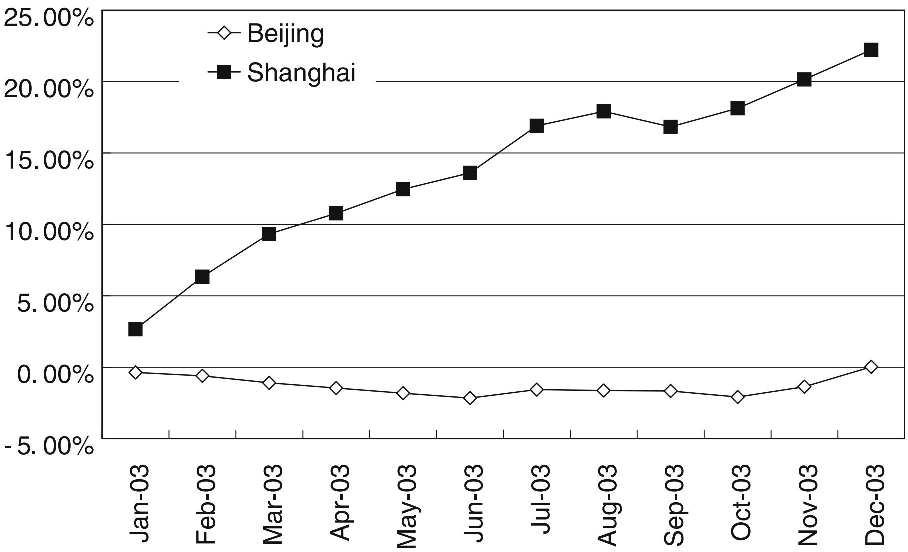
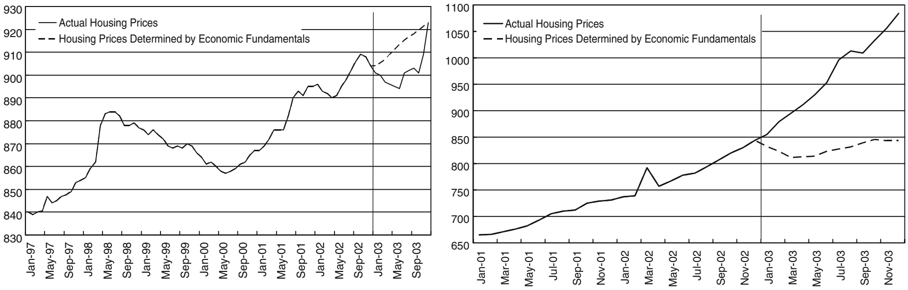


Fig. 7 Actual and predicted housing price in the two cities



(a) Beijing (b) Shanghai

Fig. 8 Estimated housing price bubbles for the two cities in 2003

The additional bubble term in the i-th month (ΔPH_i^b) can be defined as the difference between the actual measured housing prices (PH_i) and predicted housing prices (PH_i^*). The percentage accumulated housing price bubbles (PH_i^b) could be represented as follows:

$$PH_i^b\% = \Delta PH_i^b / PH_i \quad \left(PH_i - PH_i^*\right) / PH_i = 1 - PH_i^* / PH_i \tag{5}$$

Table 12 reports the regression models based on Eq. 4 for Beijing (January 1997–December 2003), Shanghai (January 2001–December 2003) and Hong Kong (January 1990–September 2003). The strong autocorrelation in prices is consistent with prior studies (e.g., Case & Shiller, 1990; Quigley, 1999). The coefficients of market fundamentals appear to be in accordance with the results of Granger causality test and impulse response analysis. With the three regression models we can predict

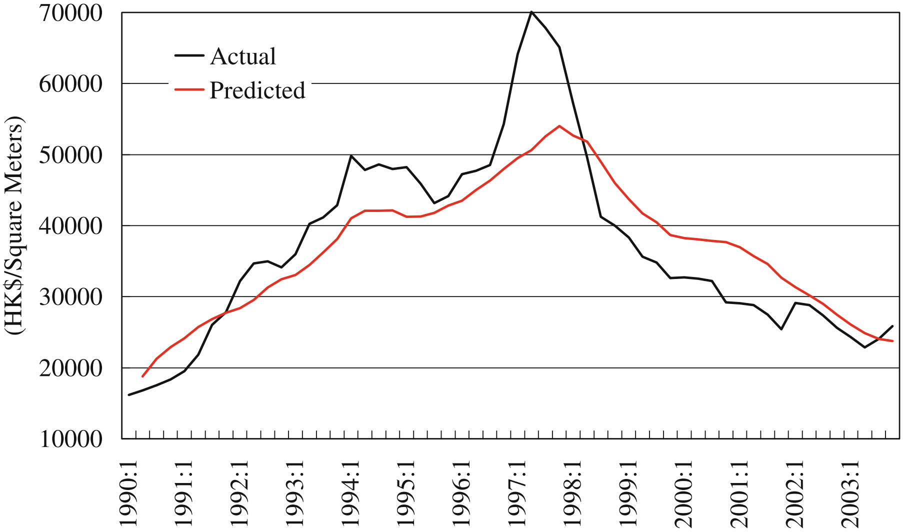


Fig. 9 Actual and predicted housing price in Hong Kong from 1990 to 2003

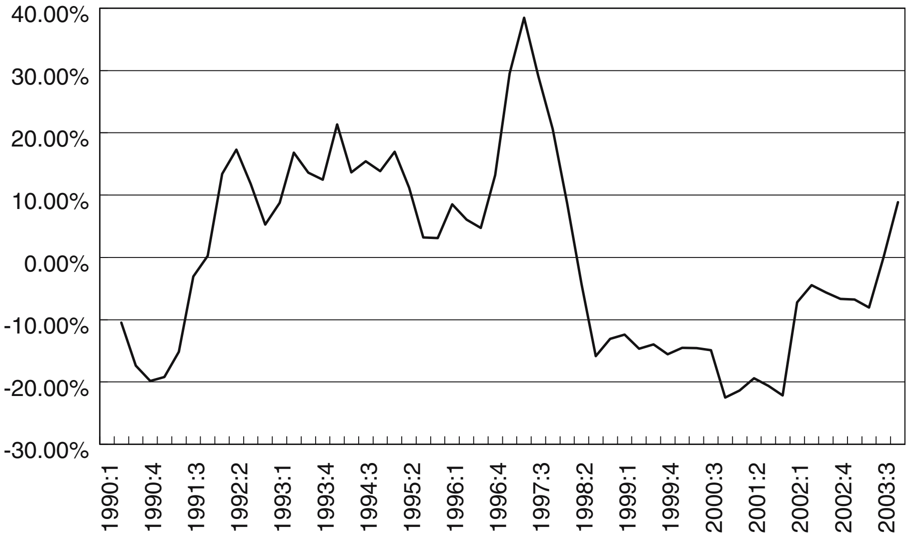


Fig. 10 Estimated housing price bubbles for Hong Kong from 1990 to 2003

the trends in housing prices of the three cities, and then by the use of Eq. 5, the bubble term could be estimated.

Figure 7 compares the actual and predicted housing price trends in the Beijing and Shanghai respectively for the year 2003. In Beijing the housing price determined by economic fundamentals is slightly higher than the actual housing price. Therefore, there seems to be no housing price bubbles in Beijing where actual housing price is in line with asset values determined by market fundamentals. But for Shanghai, the actual housing price moves much far away from the predicted value. It is safe to say that housing price bubbles did exist in Shanghai in 2003. At the end of 2003, about 22.2% of the housing price can be attributed to the bubble term, as shown in Fig. 8.

The accuracy of the model can be verified by its application on the past data of Hong Kong. Figures 9 and 10 show the actual and predicted housing price and the estimated housing price bubbles in Hong Kong from 1990 to 2003. It can be seen that the pattern and magnitude of the estimated bubbles conform quite well to the discrepancies between the actual and predicted prices. Therefore, it is reasonable to say that our model is reliable. It is safe to state that a substantial bubble exists in the housing market of Shanghai and it faces a considerable risk of downward change in housing price. On the other hand, there seems to be no bubble in the Beijing housing market and therefore the risk of a downward change in housing price is minimal.

Conclusion

This paper has investigated whether there were housing price bubbles in Beijing and Shanghai in 2003. Beyond being the first to vigorously study these three cities, we make a number of contributions to the general literature of real estate price bubbles. This paper provides an enhanced framework in detecting the real estate price bubbles, by incorporating econometrical methodologies, such as Granger causality test and impulse response analysis, in the Reduced Form Equations for housing price determinants. The reliability of our model specification and approach has been supported, via a trial case on housing price bubbles in Hong Kong. Hong Kong is a good test case city where its real estate prices at times do not fit the model has experienced bubbles and irrational pricing in the past. It is found that the pattern and magnitude of the estimated bubbles conform quite well to the discrepancies between the actual and predicted prices, which prove the vigor of our methodology.

Our findings first indicate that housing prices seem to have interacted abnormally with market fundamentals, such as disposable income, the stock of vacant new dwellings, and local GDP. This is particularly the case for Shanghai in recent years. Then, the results suggest that while there was no bubble in Beijing, while Shanghai seemed to have a housing price bubble in 2003, representing a sizeable 22% of the price. Our findings agree with the Beijing study by Yang and Lu (2003).

Understandably, recent speculations in Shanghai might have caused market prices to deviate from their long-run equilibrium levels. Investors thus should be cautious of any possible down-side risks in the Shanghai property market. On the other hand, such risk is minimal for Beijing as there was apparently no bubble term appearing in 2003. Attentions should, however, be paid to abnormal interactions, particularly between housing prices and the vacant new dwellings. It should be noted that our calculation assumes the market before 2003 had been in equilibrium, which means there were no bubbles to begin with. No bubble was found in Beijing for the year 2003. However, this does not necessarily mean that there were no bubbles before 2003 in the Beijing housing market.

This study has laid the groundwork for further investigations on the abnormal housing price phenomenon in Mainland China, i.e., price bubbles. We may here suggest possible areas for future research. First, future studies may further work on different model specifications for comparison, or on direct estimations of assets' fundamental value. The latter is proved to be very difficult, if not impossible, because of the lack of reliable data. The second area is to further investigate whether there were bubbles in the two cities before 2003, as stated above. Finally, we suggest a larger data set to be used, preferably covering a longer period of time. This should improve the accuracy and reliability of the findings. This research, however, is constrained by time and resources available. The current data set is used because it is available on the public domain, which means it is generally reliable and acceptable.

Acknowledgments Special thanks to the anonymous referees for their valuable comments and suggestions. We also thank Mr. Benjamin Chan and Mr. Ka-hung Yu for their kind assistance. The work described in this paper was fully supported by the Hong Kong RGC funding (BQ664) and PolyU funding (APD36).

Appendix 1

Table 13 VECM of housing prices and disposable income

		Beijing: 1997.01–2003.12				Shanghai: 2001.01–2003.12				Hong Kong: 1990.Q1–2003.Q4			
		Coe.	*t* ratio	Coe.	*t* ratio	Coe.	*t* ratio	Coe.	*t* ratio	Coe.	*t* ratio	Coe.	*t* ratio
Cointegrating	lnHP(−1)	1.00				1.00				1.00			
Eq.	lnINC(−1)	−0.15	−11.28[a]			0.19	4.52[a]			−2.76	−4.65[a]		
	t					−0.02							
	C	−5.73				−7.69				16.22	2.84[a]		
Error correction		D(lnHP)		D(lnINC)		D(lnHP)		D(lnINC)		D(lnHP)		D(lnINC)	
CointEq1		−0.22	−2.91[a]	−0.29	−2.66[a]	−0.76	−0.66	−7.80	−7.31[a]	0.01	0.29	0.08	3.46[a]
D(lnHP(−1))		0.64	4.54[a]	0.17	0.86	−0.10	−0.08	10.23	9.26[a]	0.39	2.08[b]	−0.03	−0.27
D(lnHP(−2))		0.21	1.25	0.07	0.29	0.16	0.11	9.62	7.33[a]	0.29	1.45	0.07	0.70
D(lnHP(−3))		−0.02	−0.12	−0.24	−1.01	0.61	0.41	10.96	7.91[a]	−0.10	−0.49	−0.16	−1.66
D(lnHP(−4))		0.06	0.39	0.20	0.86	1.01	0.54	12.38	7.22[a]	−0.23	−1.20	0.02	0.20
D(lnHP(−5))		0.21	1.34	0.58	2.52[a]	0.99	0.47	15.18	7.73[a]	−0.24	−1.30	−0.22	−2.30[b]
D(lnHP(−6))		0.00	−0.02	−0.16	−0.66	0.80	0.34	16.56	7.65[a]	0.24	1.19	−0.01	−0.05
D(lnHP(−7))		0.16	0.96	0.11	0.45	0.78	0.35	16.02	7.72[a]	0.22	1.13	−0.03	−0.32
D(lnHP(−8))		−0.02	−0.09	0.35	1.51	0.86	0.51	11.07	7.03[a]	−0.09	−0.46	−0.15	−1.56
D(lnHP(−9))		0.10	0.69	0.12	0.56	0.79	0.80	6.62	7.28[a]				
D(lnHP(−10))		−0.02	−0.11	−0.09	−0.41								
D(lnHP(−11))		0.49	3.47[a]	0.06	0.32								
D(lnHP(−12))		−0.15	−1.02	0.09	0.41								

D(lnINC(−1))	−0.08	−0.83	−0.23	−1.56	0.13	0.69	0.63	3.60[a]	0.41	1.33	−0.07	−0.45
D(lnINC(−2))	−0.18	−1.94[b]	−0.30	−2.17[a]	0.07	0.39	0.13	0.84	0.14	0.47	−0.30	−1.99[b]
D(lnINC(−3))	−0.27	−2.65[a]	−0.35	−2.44[a]	0.04	0.26	0.05	0.35	0.13	0.41	0.08	0.54
D(lnINC(−4))	−0.11	−1.07	−0.26	−1.78[b]	0.11	0.80	−0.28	−2.19[b]	0.34	1.15	0.56	3.73[a]
D(lnINC(−5))	−0.03	−0.29	−0.31	−2.26[a]	0.11	0.82	−0.47	−3.61[a]	0.00	0.01	−0.00	−0.01
D(lnINC(−6))	−0.31	−3.32[a]	−0.39	−2.88[a]	0.08	0.51	−0.48	−3.37[a]	−0.43	−1.47	0.13	0.88
D(lnINC(−7))	−0.20	−1.92[a]	−0.21	−1.39	0.03	0.20	0.21	1.59	−0.58	−1.90[b]	−0.28	−1. 85[b]
D(lnINC(−8))	−0.05	−0.47	−0.21	−1.46	−0.05	−0.35	0.25	2.00[b]	0.02	0.06	0.11	0.67
D(lnINC(−9))	−0.10	−1.02	−0.43	−3.17[a]	0.11	0.60	0.98	5.88[a]				
D(lnINC(−10))	−0.09	−1.03	−0.21	−1.58								
D(lnINC(−11))	−0.24	−2.37[a]	0.00	−0.02								
D(lnINC(−12))	−0.17	−1.68[b]	0.40	2.74[a]								
C	0.01	2.48[a]	0.03	3.33[a]	−0.01	−0.42	−0.05	−2.78[a]				
t					0.00	−0.30	−0.06	−8.01[a]				
R-squared	0.58		0.66		0.61		0.97		0.56		0.86	
Adj. R-squared	0.35		0.48		−0.93		0.87		0.32		0.79	
Granger causality test: Wald chi-square/prob	22.09/0.04		13.97/0.30		1.68/0.99		110.85/0.00		15.96/0.04		15.05/0.66	

[a] Significance at the 99% level

[b] Significance at the 95% level

Table 14 VECM of housing prices and local GDP

		Beijing: 1997.01~2003.12				Shanghai: 2001.01~2003.12				Hong Kong: 1990.Q1~2003.Q4			
		Coe.	*t* ratio	Coe.	*t* ratio	Coe.	*t* ratio	Coe.	*t* ratio	Coe.	*t* ratio	Coe.	*t* ratio
Cointegrating Eq	lnHP(−1)	1.00				1.00				1.00			
	lnGDP(−1)	−10.17	−4.04[a]			−3.44	−4.53[a]			4.17	2.79[a]		
	t	0.10				0.03							
	C	43.29				13.83				−62.96			
Error Correction		D(lnHP)		D(lnGDP)		D(lnHP)		D(lnGDP)		D(lnHP)		D(lnGDP)	
CointEq1		0.00	0.22	0.19	4.02[a]	0.27	1.18	1.51	4.25[a]	−0.03	−0.81	−0.01	−2.93[a]
D(lnHP(−1))		0.48	3.03[a]	−0.29	−0.19	−0.83	−2.16[b]	−2.09	−3.52[a]	0.44	2.36[b]	0.03	1.92[b]
D(lnHP(−2))		−0.03	−0.19	1.69	1.04	−0.68	−1.27	−2.21	−2.66[b]	0.08	0.39	0.05	2.57[a]
D(lnHP(−3))		−0.14	−0.79	1.22	0.74	−0.49	−0.95	−1.74	−2.16[b]	−0.08	−0.34	0.03	1.38
D(lnHP(−4))		0.07	0.43	0.53	0.32	−0.56	−0.96	−1.35	−1.48	−0.25	−1.14	−0.01	−0.67
D(lnHP(−5))		0.13	0.77	1.75	1.06	−0.51	−0.96	0.57	0.70	−0.24	−1.21	−0.01	−0.50
D(lnHP(−6))		−0.25	−1.41	−1.29	−0.77	0.09	0.16	0.43	0.51	0.09	0.45	−0.03	−1.78[b]
D(lnHP(−7))		−0.03	−0.16	1.77	1.03	0.34	0.60	0.30	0.34	0.18	0.89	0.01	0.42
D(lnHP(−8))		−0.06	−0.36	−1.73	−1.04	0.25	0.49	0.22	0.28	−0.12	−0.59	0.00	0.12
D(lnHP(−9))		0.17	1.02	1.13	0.74	−0.14	−0.30	0.15	0.21				
D(lnHP(−10))		−0.12	−0.76	0.27	0.17								
D(lnHP(−11))		0.27	1.67[b]	−0.38	−0.24								

D(lnHP(−12))	−0.30	−1.97[a]	−0.16	−0.11								
D(lnGDP(−1))	0.02	0.40	1.04	2.71[a]	0.70	1.16	4.23	4.53[a]	0.75	0.34	0.18	0.97
D(lnGDP(−2))	0.02	0.49	0.80	2.39[a]	0.63	0.95	3.45	3.33[a]	2.13	0.83	−0.26	−1.21
D(lnGDP(−3))	0.03	0.96	0.72	2.60[a]	0.56	1.19	3.21	4.36[a]	−1.15	−0.45	0.03	0.15
D(lnGDP(−4))	0.01	0.52	0.52	2.08[a]	0.54	1.02	2.78	3.36[a]	1.16	0.61	0.61	3.85[a]
D(lnGDP(−5))	0.01	0.48	0.44	2.12[a]	0.51	1.30	2.31	3.75[a]	−0.05	−0.02	−0.44	−2.55[a]
D(lnGDP(−6))	0.02	1.13	0.28	1.57	0.25	0.82	2.11	4.39[a]	−0.40	−0.16	−0.12	−0.58
D(lnGDP(−7))	0.01	0.80	0.08	0.51	0.38	1.09	1.70	3.11[b]	0.03	0.01	−0.40	−1.87[b]
D(lnGDP(−8))	0.00	0.34	−0.02	−0.21	0.25	1.16	1.06	3.14[a]	1.44	0.59	0.03	0.16
D(lnGDP(−9))	0.01	0.94	−0.25	−2.65[a]	0.29	1.42	0.80	2.55[b]	−0.04	−0.85	0.01	3.55[a]
D(lnGDP(−10))	0.03	2.86[a]	−0.34	−3.84[a]								
D(lnGDP(−11))	0.01	1.35	−0.33	−3.27[a]								
D(lnGDP(−12))	0.01	0.59	0.02	0.16								
C	0.00	−1.41	−0.01	−0.35	0.00	0.07	0.04	1.37	0.75	0.34	0.18	0.97
t	0.00	1.79[b]	0.00	−0.86	0.00	0.07	−0.01	−2.76				
R-squared	0.50		0.79		0.75		0.97		0.50		0.95	
Adj. R-squared	0.20		0.66		−0.24		0.83		0.21		0.92	
Granger Causality Test: Wald Chi-square/Prob	13.65/0.32		9.13/0.69		3.73/0.93		21.34/0.01		8.03/0.43		29.09/0.00	

[a] Significance at the 99% level

[b] Significance at the 95% level

Table 15 VECM of housing prices and vacant dwellings

		Beijing: 1997.01–2003.12				Shanghai: 2001.01–2003.12				Hong Kong: 1990.Q1–2003.Q4			
		Coe.	*t* ratio	Coe.	*t* ratio	Coe.	*t* ratio	Coe.	*t* ratio	Coe.	*t* ratio	Coe.	*t* ratio
Cointegrating Eq	lnHP(−1)	1.00				1.00				1.00			
	lnVAC(−1)	−0.06	−3.88[a]			−0.48	−3.80[a]			1.36	11.19		
	t					−0.02							
	C	−6.43				−3.22				−25.14			
Error Correction		D(lnHP)		D(lnVAC)		D(lnHP)		D(lnVAC)		D(lnHP)		D(lnVAC)	
CointEq1		0.03	0.92	2.06	3.06[a]	1.39	2.27[b]	0.85	0.47	−0.40	−5.03	−0.01	−0.36
D(lnHP(−1))		0.41	2.27[a]	−0.72	−0.18	−2.63	−3.03[b]	−0.11	−0.04	0.18	1.36	0.01	0.11
D(lnHP(−2))		−0.14	−0.73	4.34	1.01	−2.64	−2.72[b]	1.46	0.51	−0.07	−0.51	−0.10	−1.65
D(lnHP(−3))		−0.28	−1.45	−0.59	−0.14	−2.41	−2.52[b]	2.09	0.74	−0.27	−1.89[b]	0.11	1.73[b]
D(lnHP(−4))		0.44	2.26[a]	0.87	0.20	−2.24	−2.40[b]	5.25	1.90	0.18	1.29	−0.07	−1.22
D(lnHP(−5))		0.20	0.95	−6.79	−1.48	−1.59	−1.81	2.44	0.94	−0.31	−2.30[b]	−0.01	−0.17
D(lnHP(−6))		−0.53	−2.42[a]	−4.29	−0.89	−1.12	−1.44	0.86	0.38	−0.24	−1.60	−0.01	−0.16
D(lnHP(−7))		0.21	0.89	−4.33	−0.85	−0.76	−1.10	1.41	0.69	−0.08	−0.55	−0.08	−1.35
D(lnHP(−8))		−0.32	−1.39	−4.52	−0.88	−0.17	−0.29	−0.94	−0.56	−0.39	−2.45[a]	0.12	1.76[b]
D(lnHP(−9))		−0.20	−0.91	2.85	0.58	−0.09	−0.17	3.86	2.44[b]				
D(lnHP(−10))		0.15	0.68	−2.41	−0.49								
D(lnHP(−11))		−0.01	−0.07	−1.06	−0.23								
D(lnHP(−12))		−0.23	−1.24	−2.79	−0.67								
D(lnHP(−13))		0.22	1.22	−1.31	−0.32								

D(lnHP(−14))	−0.21	−1.28	−4.02	−1.10								
D(lnVAC(−1))	0.00	−0.27	0.07	0.50	0.59	2.15[b]	0.54	0.67	−1.20	−2.99	0.85	5.08
D(lnVAC(−2))	−0.01	−2.47[a]	0.08	0.70	0.60	2.25[b]	−0.39	−0.49	0.82	1.54	−0.13	−0.58
D(lnVAC(−3))	−0.01	−1.97[a]	0.12	1.15	0.55	2.22[b]	−0.14	−0.20	−0.19	−0.35	0.01	0.06
D(lnVAC(−4))	0.00	−0.14	−0.13	−1.20	0.45	2.19[b]	−0.27	−0.45	−0.41	−0.77	−0.37	−1.68
D(lnVAC(−5))	0.00	−0.43	−0.10	−0.90	0.42	2.26[b]	−0.58	−1.05	−0.35	−0.69	0.19	0.88
D(lnVAC(−6))	−0.01	−1.08	0.12	1.13	0.34	2.20[b]	−0.41	−0.90	−0.20	−0.38	0.08	0.36
D(lnVAC(−7))	0.00	0.86	−0.11	−1.06	0.27	2.28[b]	−0.18	−0.51	−0.15	−0.30	−0.08	−0.40
D(lnVAC(−8))	−0.01	−1.59	−0.09	−0.98	0.21	2.15[b]	−0.29	−1.01	−0.97	−2.22	−0.14	−0.75
D(lnVAC(−9))	−0.01	−1.33	−0.26	−2.74[a]	0.12	1.57	−0.21	−0.90				
D(lnVAC(−10))	0.00	−0.89	−0.04	−0.39								
D(lnVAC(−11))	−0.01	−1.27	−0.11	−1.07								
D(lnVAC(−12))	0.00	−1.09	0.10	0.99								
D(lnVAC(−13))	0.00	−1.08	−0.08	−1.00								
D(lnVAC(−14))	0.00	−1.05	0.01	0.09								
C	0.00	2.21[a]	0.07	2.26[a]	0.18	2.28[b]	−0.09	−0.37	0.06	3.88[a]	0.01	1.74[a]
t					0.00	2.42[b]	−0.01	−2.01[b]				
R-squared	0.65		0.66		0.75		0.94		0.71		0.73	
Adj. R-squared	0.38		0.42		−0.25		0.72		0.54		0.57	
Granger Causality Test: Wald Chi−square/Prob	34.49/0.00		13.83/0.46		6.06/0.73		44.17/0.00		25.35/0.00		9.81/0.28	

[a] Significance at the 99% level

[b] Significance at the 95% level

Table 16 VECM of housing prices and the stock price index

		Beijing: 1997.01~2003.12				Shanghai: 2001.01~2003.12				Hong Kong: 1990.Q1~2003.Q4			
		Coe.	*t* ratio	Coe.	*t* ratio	Coe.	*t* ratio	Coe.	*t* ratio	Coe.	*t* ratio	Coe.	*t* ratio
Cointegrating Eq	lnHP(−1)	1.00				1.00				1.00			
	lnSHANG(−1)	0.04	5.49[a]			−0.03	−0.55			−1.74	−10.99[a]		
	t	0.00				−0.02				0.03	5.40[a]		
	C	−7.07				−6.15				4.57			
Error Correction		D (lnHP)		D (lnSTOCK)		D (lnHP)		D (lnSTOCK)		D (lnHP)		D (lnSTOCK)	
CointEq1		−0.39	−3.42[a]	−2.97	−1.85[b]	−1.98	−4.42[a]	2.68	1.55	0.10	1.34	0.62	4.63[a]
D(lnHP(−1))		0.74	5.15[a]	0.49	0.24	0.67	1.85	−1.66	−1.19	0.65	3.29[a]	−0.04	−0.11
D(lnHP(−2))		0.15	0.86	−2.69	−1.07	1.23	2.85[b]	−4.07	−2.44[b]	−0.27	−1.18	0.16	0.40
D(lnHP(−3))		0.18	1.09	2.43	1.04	1.33	2.91[b]	−2.23	−1.27	0.15	0.72	−0.36	−0.93
D(lnHP(−4))		0.32	1.89[b]	−4.52	−1.90[b]	2.10	3.43[a]	−3.61	−1.53	−0.19	−0.86	−0.57	−1.47
D(lnHP(−5))		0.37	2.04[a]	1.88	0.74	2.87	4.20[a]	−3.15	−1.20	−0.31	−1.50	−0.99	−2.61[a]
D(lnHP(−6))		−0.02	−0.09	−5.23	−2.01[b]	2.33	3.72[a]	−4.34	−1.80	−0.21	−0.92	−1.22	−2.93[a]
D(lnHP(−7))		0.19	0.99	6.69	2.54[a]	2.06	3.71[a]	−4.07	−1.90	0.14	0.62	−0.42	−1.04
D(lnHP(−8))		0.16	0.78	−5.27	−1.87[b]	1.68	3.97[a]	−2.92	−1.79	−0.11	−0.48	−0.21	−0.50
D(lnHP(−9))		0.18	0.93	−3.05	−1.15	1.65	3.99[a]	−3.72	−2.33[b]				
D(lnHP(−10))		−0.11	−0.56	−5.84	−2.13[a]								
D(lnHP(−11))		0.38	1.99[b]	−0.23	−0.09								

D(lnHP(−12))	−0.10	−0.52	−7.14	−2.57[a]								
D(lnSTOCK(−1))	0.01	0.95	−0.12	−0.90	−0.25	−2.56[b]	0.22	0.60	−0.05	−0.50	0.14	0.70
D(lnSTOCK(−2))	0.01	1.37	−0.38	−2.79[a]	−0.24	−3.32[a]	−0.17	−0.64	0.16	1.69[b]	0.33	1.93[b]
D(lnSTOCK(−3))	0.01	0.96	−0.25	−1.79[b]	−0.17	−1.99[b]	0.03	0.10	0.02	0.17	0.62	3.76[a]
D(lnSTOCK(−4))	0.00	0.52	−0.46	−3.45[a]	−0.22	−2.76[b]	−0.07	−0.23	0.21	2.11[b]	0.50	2.73[a]
D(lnSTOCK(−5))	0.00	0.18	−0.23	−1.90[b]	−0.07	−1.12	−0.41	−1.59	0.08	0.83	0.42	2.30[b]
D(lnSTOCK(−6))	0.00	0.22	−0.43	−3.49[a]	−0.08	−1.24	0.01	0.06	0.07	0.67	0.52	2.70[a]
D(lnSTOCK(−7))	0.00	−0.22	−0.27	−2.27[b]	0.12	1.93[b]	−0.54	−2.15[b]	−0.01	−0.07	0.31	1.64
D(lnSTOCK(−8))	0.00	−0.51	−0.35	−2.90[a]	−0.26	−4.58[a]	−0.11	−0.49	0.13	1.32	0.25	1.43
D(lnSTOCK(−9))	0.00	−0.65	−0.19	−1.88[b]	−0.19	−2.81[b]	−0.04	−0.15				
D(lnSTOCK(−10))	0.00	0.11	−0.21	−2.03[b]								
D(lnSTOCK(−11))	−0.01	−1.85[b]	−0.19	−1.94[b]								
D(lnSTOCK(−12))	0.00	−0.32	−0.25	−2.39[a]								
C	0.00	−1.49	0.12	3.81[a]	−0.06	−3.45[a]	−0.03	−0.49	−0.01	−0.99	−0.02	−0.84
t	0.00	1.45	0.00	−3.89[a]	−0.01	−3.24[a]	0.02	2.18[b]				
R−squared	0.52		0.64		0.92		0.88		0.53		0.66	
Adj. R-squared	0.24		0.42		0.62		0.39		0.26		0.47	
Granger Causality Test: Wald Chi-square/Prob	8.95/0.71		34.81/0.00		30.48/0.00		19.17/0.02		12.42/0.13		33.64/0.00	

[a] Significance at the 99% level

[b] Significance at the 95% level

Appendix 2

It should be noted that 3 years worth of monthly historical data (36 data points), instead of 7, are used in detecting the possible occurrence of price bubbles on Shanghai's property market. It is considered sufficient for reliable modelling from a theoretical perspective, and there are examples that illustrate the effectiveness and reliability of statistical models with a relatively small set of samples.

For instance, it was stated by Busetti (2000), that "In all cases beta and variance of regression errors have been measured using monthly (month end) data over the past three years, which is the generally accepted time period in practice, i.e., *using 36 data points*."

Another example is given through a report by Statistics South Africa (2004), which declared that "Stats SA has concluded that there is no option for retail trade but to stop publishing a seasonally adjusted series until enough data points are available to derive seasonal adjustment factors informed by the behavior of the new series. *At least 36 data points are needed* and currently only data points from January 2004 are available. However, stats SA will show an estimated trend line through the original series."

A report by Finmatrica, Inc. (2001) also corroborated the above idea, by commenting that, "Essentially, for each historical data point the DLM produces a forecast using the model estimates produced at the data point immediately before it and then compares the forecast to the actual data point. The difference between the forecast and the actual data point can be quantified (the likelihood distribution) and allows the DLM to smooth the estimates from the previous time period (this is done via the application of Bayes theorem). *This means that, for the example of 3 years worth of monthly historical data (36 data points), instead of one set ofmodel estimates there will be 36. Since the initial estimates have now been smoothed 36times, they are at their most accurate and are, therefore, the ones used in the forecasting act proper, i.e., from the end of the historical data set forward.*"

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