Aalto University
School of Business

Is there a bubble in Chinese housing market? Empirical study on Chinese major housing markets

Economics

Master's thesis

Xiaogeng Xu

2014

Department of Economics
Aalto University
School of Business

Abstract

This paper investigates whether there is bubble in Chinese housing market, a question that has attracted domestic and global attention in recent years. Study of this paper focuses on four glamorous housing markets in Beijing, Shanghai, Guangzhou and Shenzhen with data spreading from 2005 to 2013.

Beginning with definition of bubble this paper summarizes various strands of bubble definition and bases study on definition featured by deviation from fundamentals. Then after comparing previous studies on housing bubble and introducing features of Chinese housing markets this paper presents analysis on three conventional ratios of house price dynamics: price-income ratio, price-rent ratio and imputed-actual rent ratio. For each of the three ratios comparison between current China and bubble-phase US is carried on and results show that price-income ratio and imputed-actual rent ratio are both considerably higher than the two ratios for US housing market during its bubble phase while only price-rent ratio in Beijing housing market displays comparable level with that in bubble-phase US. And ADF test on stationarity is also conducted on first two ratios and results show that price-income ratio is non-stationary in all of the four markets while price-rent ratio is only non-stationary in Beijing and Shanghai.

The other perspective of detecting bubble is cointegration model that is constructed in this paper to test if economic fundamentals- local GDP, disposable income, rent, stock index, vacant dwelling and land purchase- can justify the high house prices in the four markets. Methodology underlying this cointegration model is panel cointegration test that has proved reliable after being employed to test US bubble in previous studies. Results of cointegration model show that house price has deviated from set of economic fundamentals since test statistic obviously lies outside critical interval.

After employing various methods that can be found in incumbent literature on housing bubble, final conclusion of this paper is that there exists bubble in Chinese major housing markets. However, one bold suppose about this bubble is that due to inelastic housing demand and exuberance of Chinese aggregate economy the bubble will not burst in near future.

Key words:

Housing bubble · User cost formula · US housing bubble · ADF test ·

Cross-sectional dependence test · Cross-sectional ADF test · Panel data cointegration test

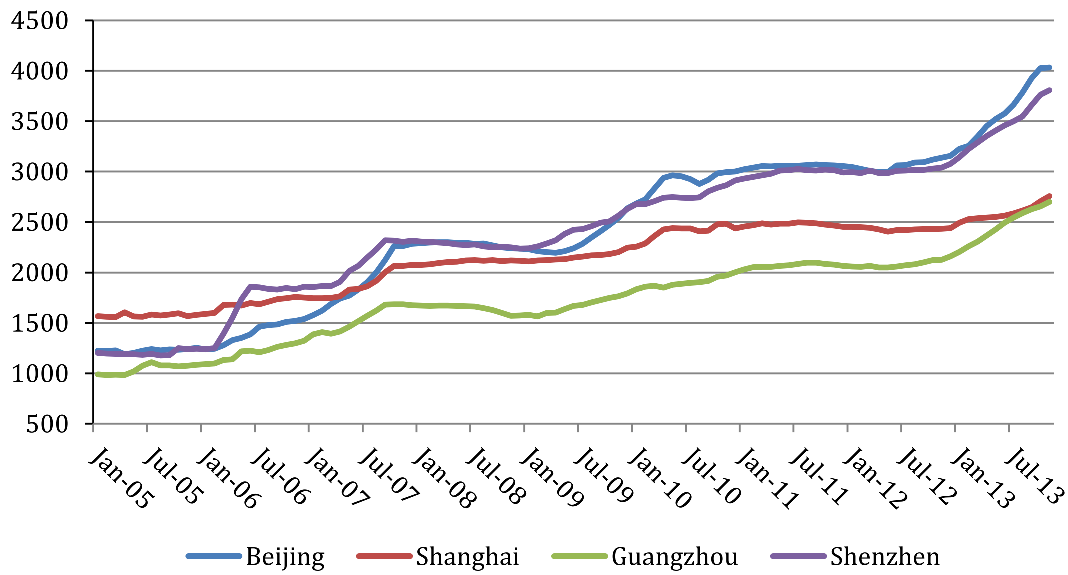
Table of Content

List of Figures

List of Tables

1 Introduction

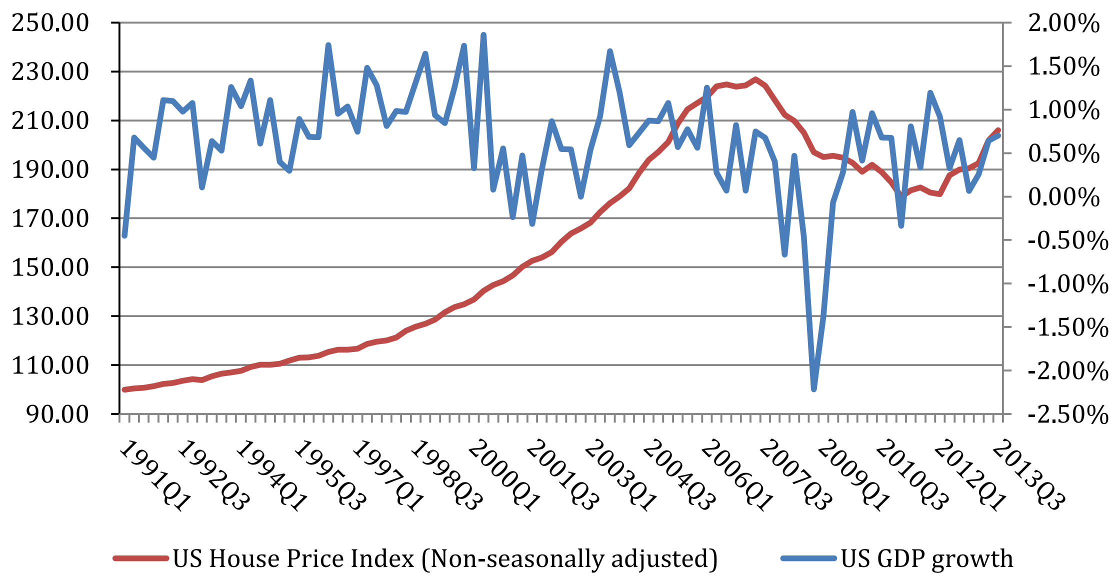
Over the last three decades, China has witnessed rapid economic growth, accompanied by dramatic development of real estate market. Although financial crisis originating from US in 2008 has damaged global economy, it seems have little impact on Chinese real estate market. Due to tremendous economic growth and fast urbanization in China demand for new dwellings has increased with large margin, leading to sustained growth in house price in Chinese metropolitan areas in recent years. As seen in Figure 1 house price in the four glamorous housing markets experienced 20% increase in 2013 meanwhile growth of disposable income there is just around 10%.



Source: China Real Estate Index System CREIS

Figure 1 House price index in Chinese four major housing markets Jan05-Nov13

Not only well-being of households, fluctuations in house price also plays important role at macroeconomic level. Unstable house price would trigger or reinforce fluctuations in economic development that will further leave huge negative influence on national or even global economy. For example, after burst of bubble in land market in late 80s Japanese economy suffered long term recession known as the *lost two decades* and influence of crashing-down of high house price in US 2007 is more dramatic for both US and worldwide economy. Since housing bubble in 2007 growth of GDP maintained negative levels for two years as shown in Figure 2 and recovery is still slow even after the *Stimulus Act* 2009.



Source: Federal Housing Finance Agency and US Bureau of Economic Analysis

Figure 2 US HPI vs. US GDP growth 1991Q1-2013Q3

Given the tremendous impact of housing market on economy, it is of great importance to investigate whether there is bubble in housing market of China, the second largest economic entity in the world. Since 2002 many governmental officials and economists have been wary of signs of housing bubble in Chinese first-tier cities. With ten years having passed, there is no drop in house price contrarily remarkable increase of house price prevails in those cities during recent years. Therefore, whether there is bubble in Chinese major housing markets becomes research question of this paper. The main objective of this paper is to answer this question with as many methods as possible that have successfully forecast or confirmed housing bubbles that had happened in reality.

Structure of this paper is laid out as follows: Section 1 is the introduction. Section 2 presents literature review of incumbent studies on housing bubbles, including brief summary of characters of real estate, definition of bubble and methods used to detect housing bubble. Section 3 introduces background and main features of Chinese housing market. Section 4 described data used in this paper and their descriptive statistics. Subsequently, analysis on three conventional ratios of house price dynamics is presented in Section 5 where statistical tests and comparison between Chinese current situation and US bubble phase are demonstrated. Section 6 explores relationship between house price and economic fundamentals by conducting a panel cointegration test. Finally, Section 7 summarizes main findings of this paper and provides answer to research question. Appendix 1-4 show econometric methodologies and derivation of test statistics employed in this paper.

2 Literature Review

2.1 Characters of real estate

Compared to other assets, real estate possesses distinctive characters that make housing market different from other asset markets in the following four respects[1]. First, as tangible asset real estate is immobile with low transaction frequency and high costs of search and transaction for both buyers and sellers. Since frequencies of price changes and of transactions are inconsistent in housing market expectations play significant role in purchase decision and in demand variance of the market.

Second, housing purchasing is inexorably linked to purchase of other goods such as neighborhood, public services, and workplace accessibility. So price is affected not only by interaction between demand and supply but by these bundled components of housing. These linkages make it unconvincing to compare different houses simply by market prices thus constant quality price or a composite price index is in need for studying house prices.

Third, substantial rental market exists side-by-side with market for owner housing in urban areas. Although rental units are not perfect substitute of owned units, homebuyers-the large part of demand for real estate-tend to consult rent of houses with similar quality of commodity unit. If rental units are more cost-effective homebuyers may postpone purchase thereby house price would decrease when rents are apparently lower than prices. Therefore, rent is hardly an ignorable part in analysis of evolution of house prices.

Fourth, due to relatively long production time housing supply cannot immediately adjust to growing prices so temporary unsatisfied demand may lead to upward trend of prices for prolonged time. And what possibly happens is that housing developers overreact to growing prices so that there is excessive housing production facing low price level that might be even

[1] Characters are partly referred to summary of Goodman (1989) in "The Economics of Housing Market", p50-51.

lower than their construction costs. The late adjustment of housing supply provides possibility of irrational expectations that foreshadow existence of bubble in market.

Because of those particular characters dynamics of housing prices present a different picture from other assets and commodities: overpricing namely bubble occurs less often in housing market than stock market but once bubbles emerge in housing market prices may be declining for several years before returning equilibrium[2] and economic impacts of bubble busts are more intensive and extensive than bubble in other assets[3]. Therefore, study on how to spot and verify a bubble in housing market is of great significance not only for housing market individually but for the whole economy.

2.2 Definitions of bubble

Since house prices crashed in US prior to subprime crisis issues revolving bubble have been the focus of media and many studies in recent years. Definition of bubble may well be demonstrated ahead of any attempt to spot it in market. One recent mention regarding bubble definition suggests that bubbles are best identified by credit excesses[4] (Chanos, 2010), a bubble indicator more appropriate for recent housing bubble of US. When defining bubbles different scholars emphasize specific aspects of bubble: rapidly rising prices (Baker, 2002) or simply intensively

[2] The dramatic 1980s boom of home prices in urban Japan ended with declining prices for ten years after the peak. Plus house prices have not returned to pre-subprime crisis level since 2008 (Cohen, et al., 2012).

[3] When Dot-com bubble burst in 2000 many internet companies saw dramatic drop in their stock prices but they remained stable and profitable like Cisco and real economy of US was not largely affected by boom or bust of Dot-com bubble cycle (Henderson, 2012; Shiller, 2005). In contrary, following burst of real estate bubble in Japan in late 1980s was famous liquidity trap in the Lost Decade. Similarly negative effects of bust of house prices of US in subprime crisis in 2008 would be more complex and prolonged as various financial products had been supported by rising prices.

[4] James Chanos stated his opinion on existence of bubble in China's housing market in his appearance on CNBC 2010. He also claimed that there was no bigger credit excess in China thus Chanos hinted there might be bubble in China's housing market.

sudden drop in prices after a period of roaring (Siegel, 2003; Kindleberger, 1989)[5]. Specially, Kindleberger points out differences among mania, bubble and boom: mania emphasizes irrationality; bubble foreshadows burst of high values; boom indicates gradually growing prices that would sustain for longer time than a bubble.

The two main perspectives propelling recent studies on bubble are unrealistic expectation of appreciation and deviation from fundamentals. The former strand is first traced back to *The New Palgrave: A Dictionary of Economics*: A bubble may be defined loosely as a sharp rise in the price of an asset or a range of assets in a continuous process, with the initial rise generating expectations of further rises and attracting new buyers-generally speculators interested in profits from trading in the asset rather than its use or earnings capacity (Eatwell, et al., 1987). Analogously, Case and Shiller (2004) and Himmelberg et al. (2005) both defined bubble in terms of overoptimistic expectations: Case and Shiller emphasized risk aversion to future high price while Himmelberg et al. put more emphasis on belief of lower price today than tomorrow. Bubble is also defined as a situation where price level is not only driven by expectations about future rents but also by expectations of future asset price level (Schreyer, 2009).

The other strand of defining bubble, deviation from fundamental values, is first proposed by Stiglitz (1990): When fundamental factors do not seem to justify such high price, then a bubble exists. Researchers intrigued by the bubble definition characterized by departure from fundamental values include Flood and Hodrick (1990), Rosser (1990) and Garber (2000)[6]. Other

[5] Specifically, Siegel gives an operational definition of bubble: confirmation of a bubble depends on whether the future realized return of the asset justifies the original price over a time period long enough so that present value of cash flows constitute one half of price. Thus one must wait sufficient period of time before confirming a bubble.

[6]Rosser identifies bubble with misperceived fundamental values, that is, inconsistency between fundamental values and existed prices would bring positive or negative bubbles. Garber advocates in his book *Famous First Bubbles The fundamentals of Early Manias* that the definition of bubble most often used in economic research is that part of asset

studies based on this definition further present a calculable approach to fundamental values-present value of cash flows brought by housing asset where rent is proxy of the cash flows (Krainer & Chishen, 2004; Smith & Smith, 2006).

Compared to factual evidence of price change, deviation from fundamental values as key identifier of bubble is more operational and convincing as price changes and expectations are always driven by various fundamental factors. And unreasonable expectation is possibly ineffective to identify bubble in housing market. In experimental market designed by Lei et al. (2001) where resale is not possible bubbles and crashes were still observed so bubble is possible even without overconfidence in market. Therefore, bubble definition characterized by departure from fundamental values, to large extent, grips essential part of bubble. With operability and accuracy this fundamental-based definition is commonly applied in subsequent studies whereas the key question now turns to how fundamental values of asset should be identified especially when asset of interest is real estate that is different from assets like stocks or antiques.

2.3 Methods of detecting bubble

2.3.1 No arbitrage conditions for fundamental value

In order to detect bubble in housing market, a fundamental value should be developed first and precedent studies on house price dynamics present various approaches to fundamental values with which house price is compared to verify bubble in housing market. As summary, there are mainly four methods to develop fundamental values: spatial no arbitrage condition, financial no arbitrage condition, no arbitrage between renting and owning and econometric models with relevant factors pooled.

price movement that is unexplainable based on what we call fundamentals. Furthermore, he suggests that so-called fundamental values are the long-run equilibrium that is consistent with a general equilibrium.

First, spatial no arbitrage condition argues that home buyers get equal net benefits by living in different locations as house price would be higher in more popular locations like coastal areas or good neighborhoods. This approach to equilibrium house price is supported by early scholars. Alonso (1964) based equilibrium price on Pareto principle stating that house market is in equilibrium when no user can increase profits by moving to any other location or buy more or less in quantity and no landlord can increase revenue by changing price. Muth (1969) asserted that house price declines with distance to CBD (Central Business District) and factors affecting house value-income differences, population density, neighborhoods quality and dwelling unit condition-are all more or less related to residence location. In a framework, Rosen (1979) assumed that there are three goods in market-products manufactured by households, land and amenities associated with land. Importantly, productive capacity is assumed to depend only on location and is exogenously fixed for particular place. To reach equilibrium in house market, land price is responsible for choking off demand for preferred places and impelling people to live in less desirable places. Roback (1982) suggested a model to demonstrate that locations with higher amenity attract more workers and firms thus demand and rents in these locations are higher than other places. However, equilibrium on spatial no arbitrage only explains price distribution across different locations but it is weak to answer whether house price is too high especially in national magnitude (Glaeser & Gyourko, 2007).

Second, financial no arbitrage condition suggested by Case and Shiller (1987, 1989 and 1990) advocates that investors should earn equal risk-adjusted returns from investing in house and in other assets. In this no arbitrage condition house is regarded as an asset that brings returns or services to owners. House value is derived by discounted sum of expected rents and future appreciation as dividends and premium are used in calculating stock value (Smith & Smith, 2006; Schreyer, 2009). Although financial no arbitrage offers more precision on bubble its empirical implication is weaker than envisioned as house is very different from other assets in terms of high cost and immobility. Furthermore, this financial no arbitrage approach is sensitive to variation in factors that are difficult to measure such as maintenance costs, risk aversion, future price growth and expected tenure (Glaeser & Gyourko, 2007). Another drawback of financial no arbitrage condition is that fundamental value for house is based on future rent flow that may be affected by house price. This makes house different from assets like stock or bond whose dividend is not influenced by asset price. Moreover, house price changes and rent growth rates have been proved correlated in econometric model by Campbell et al. (2009). This inversely causal problem may be another flaw of financial no arbitrage condition.

Third, no arbitrage between owning and renting is another ideology on which most studies of housing market concentrate. This condition initially comes from the usually-seen mismatch between house prices and rents and is further described by Hendershott and Slemrod (1982) and Poterba (1984) as some relationship between house price and rent that focuses on trade-off between owning and renting. Prior to specific formula introduced by Poterba, Henderson and Ioannides (1983) also provided thorough considerations from perspective of customers on tenure choice of housing. Based on Poterba's work, McCarthy and Peach (2004) presented a way to show expectation on house price appreciation and gived a direct answer to doubt of bubble in housing market[7]. Furthermore, according to Poterba's formula Himmelberg, Mayer and Sinai (2005) developed imputed rent for equilibrium market with which actual rent is compared to tell whether there is bubble. However, there is some contends on whether owning units and renting

[7] Contemporary study on expectation by Case and Shiller (2004) put some doubts on the way expectations are derived from Poterba's formula by McCarthy and Peach. From data of US metropolitan areas Case and Shiller found that homebuyers in areas with flat house price also have high expectation on appreciation. So expectations may be random walking and accuracy of any derivation method may be doubtful.

units are comparable. Rosen (1979) first proposed that units for owning and renting should be analyzed as two different commodities. Whereas Goodman (1988) observed that is was easier to purchase large amounts of housing by renting as least for US housing market in 1980s[8]. Similarly, opponents Glaeser and Gyourko (2007) rebut no arbitrage condition between owning and renting by stating that the two kinds of units are quite different in their attributes such as size, layout, location and neighborhood and in behaviors of owners and renters so that comparison between owning price and rental might not be conceivable. Besides Smith and Smith (2004) argued that it is difficult to gauge unobserved factors such as preference between fixed-rate mortgage and volatile rent, namely buying and renting.

What is noteworthy is that the financial no arbitrage and no arbitrage between owing and renting are quite similar as they both use rents as key factor to develop fundamental value for house prices. Glaeser and Gyourko presented a compound approach to fundamental value, under which discount rate is replaced with user cost rate in the financial no arbitrage equation for fundamental value[9]. In this way the two no arbitrage conditions are combined to present another perspective of fundamental value.

2.3.2 Models for fundamental value

Beside three no arbitrage conditions above, myriad recent studies on house prices are based on models with series of economic variables that likely have impacts on prices. Using these models

[8] Note that Goodman build up econometric model for housing upon variables such as income, characters of housing and more importantly purchaser type-owner or renter.

[9] $H(t) = \sum_{j=0}^{\infty} \frac{R(t+j)}{(1+(1-\tau)(r+p)+\delta)^{j+1}}$ where H is house price, R is rent, τ is income tax rate, r is mortgage rate, p is property tax rate and δ is depreciation rate, here homebuyers are assumed to be risk-neutral (Glaeser & Gyourko, 2007). This formula will be returned for detail later in 5.3.1 User cost formula.

researchers derive expected prices to which current house prices are compared or demonstrate drives underlying variances of house prices and determinants of house price dynamics.

One widely used method is cointegration model that is used to test whether house prices or growth of house prices share common stochastic trend with economic forces and if house prices do not deviate from fundamental economic variables there is no evidence for bubble. The methodology was first introduced by Granger and Engle (1987) and applied in testing stationary relationship between present value of stock and dividends by Campbell and Shiller (1987), Diba and Grossman (1988) and Timmermann (1995)[10].

In recent empirical study in housing market cointegration has become a standard means of detecting bubble. House prices or changes of prices are regressed on fundamental variables then hypothesis of unit root in residuals will be tested[11]: if residuals contain unit root then house prices are concluded not to reflect economic factors, that is, there is evidence for bubble in market. Studies with focus on cointegration test are distinct in terms of choice on fundamental variables and of whether using individual dataset or group data[12]. Hui and Yue (2006) conducted cointegration tests on house prices and each of fundamental variables-disposable income, local GDP and Shanghai stock price index-with data of housing markets in Beijing, Shanghai and Hong Kong. Test results confirmed existence of bubble in Hong Kong 1997 and showed strong evidence of bubble in Shanghai housing market but no sign of bubble in Beijing market for same year. Also between house prices and individual economic variables, cointegration tests were carried by

[10] Timmermann also showed that cointegration test is robust in testing stationary relationship between stock price and dividend even when return rate is time-varying.

[11] Unit root tests are needed before regression of house prices on explanatory variables to ensure time series and these variables are integrated with same order.

[12] This category principle refers to whether it is the whole set of fundamental variables or individual variable that house prices are regressed in cointegration tests.

Arshanapalli and Nelson (2008) between house price index and following variables-mortgage rates, unemployment, ratio of debt to income, housing affordability index, home stock and mean of income from top fifth and middle fifth population in US national housing market. Results showed that cointegration between house price index and major fundamental variables vanished since 2005. Based on the fact that US house bubble burst in late 2007, Arshanapalli and Nelson suggested that cointegration test may serve as early bubble detection system. Through cointegration test between house prices and whole set of fundamental variables Gallin (2006) reached contrary conclusion that level of house prices in US from 1975-2002 does not appear to have long-run stable equilibrium relationship with income or population. Particularly Gallin tried three types of test statistic to avoid small-sample bias on test result and results based on various test statistics are consistent. With more extensive set of fundamental variables-house rent, construction costs, income, population, mortgage rates and stock market wealth-Mikhed and Zemcik (2009) also showed same conclusion of no cointegration between house prices and economics factors 1996-2006. Based on Gallin's method, they added a diagnostic test on cross-section dependence introduced by Pesaran (2004) to detect correlation among sections in panel data before cointegration test. And it turned out that house price and fundamental variables are correlated among different metropolitan areas of US hence cross-sectionally augmented Dickey-Fuller test (Pesaran, 2007) is used to detect unit root in panel data. Result here is plausible as it showed that no-conintegration started alleviating since mid-2006[13], exactly the time when high house prices began declining in US. If house prices are cointegrated with independent variables

[13] See Case-Shiller index, http://us.spindices.com/indices/real-estate/sp-case-shiller-us-national-home-price-index.

then normal OLS regression is feasible with additional error correction component[14]. Dreger and Zhang (2010) pushed cointegration test forward to an error correction model given that house prices in 35 major cities in China 1998-2009 exhibit cointegration with fundamental factors-income, population, interest rates and land prices-for period before 2009. Results of the error correction model showed that house prices of the 35 housing markets were 25% higher than their equilibrium levels in 2009. However, comparison between actual house prices and predicted prices from error correction model is applicable only when house prices are cointegrated with fundamental variables. Therefore, Mikhed and Zemcik (2007) developed bubble indicator especially for situation of no-cointegration between house prices and rents with semi-annual data 1975-2006. So-called bubble indicator is defined as zero for stationary prices and one for non-stationary prices and stationary rents whereby indicator of one implies high-likelihood bubble while zero basically eliminates existence of bubble. And values between zero and one are p-values of test for stationary of price-rent ratio.

In aforementioned literature, researchers tend to identify fundamental variables from demand and supply in housing market and in this way effects of these variables on house prices are intuitively justified prior to cointegration test. Some other studies on house price start from market equilibrium (Muth & Goodman, 1989); house prices are compared with structural equilibrium to see if market deviates from equilibrium or not, namely, bubble or not.

One typical example is structural model constructed by McCarthy and Peach (2002; 2004) whereby long-run equilibrium house price is derived from reduced form of market equilibrium based on housing stock, income, user cost of ownership, investment rate and construction cost.

[14] If time series Y_t and X_t are both not stationary then regression $Y_t = \beta_0 + \beta_1 X_t$ is not applicable but error correction model $Y_t = \beta_0 + \beta_1 X_t + \beta_2 (Y_t - zX_t)$ can be used to predict Y_t if $Y_t - zX_t$ proves stationary, namely no unit root. More details will be discussed in 6.1 .

Difference between actual house prices and long-run equilibrium price and short-run gap between price and equilibrium level thus provides evidence for bubble. This structural model of US housing market presented conclusion of no bubble that is different from cointegration tests aforementioned[15]. From structural model, following scholars concentrate on price elasticity of housing supply to explain persistent high prices in housing market. In order to demonstrate extent of mispricing, Malpezzi (2001) constructed structural model of housing stock, sales, price, income and population then derived supply elasticity from reduced form of market equilibrium. The logic behind is that house prices rise because housing supply does not adjust growing demand immediately so the more inelastic housing supply is the more long-lasting and intensive mispricing will be. Since elasticity of housing supply implies persistence of mispricing and speed of bubble alleviation, higher elasticity of housing supply in US post-war than pre-war indicates that rapid growth in house prices should be less likely to happen during post-war. However, this is inconsistent with fact that there have been multiple "rocket taking off" periods since 1960s in US (Shiller, 2005)[16]. Based on elasticity of housing supply Harter-Dreiman (2003) constructed an impulse response function whereby giving measure of speed of adjustment to equilibrium: 70 percent of adjustment occurs within 5 years and 90 percent within 10 years in US housing market. This is basically consistent with performance of US house prices since peak in 2006. Unlike Malpezzi, Goodman and Thibodeau (2008) suggested that rising house prices caused by expectations on real house price appreciation in inelastic-supply market that experience unsatisfied demand cannot be evidence of speculative bubble. Thus housing markets can be diagnosed as having bubble if appreciation of real house price exceeds what can be explained by

[15] Data used by McCarthy and Peach is US national data and most cointegration models use data from various regions and some constantly low-price areas to some extent flattens national data.

[16] See "*Irrational Exuberance*" edition 2nd, p12-15.

elasticity of housing supply. Price elasticity of housing supply is derived from structural model given estimated price elasticity of demand and increase in number of housing units and supply costs. Then expected appreciation rate is computed from "no-bubble" elasticity of housing supply estimated from data of "non-bubble" 1990s. Compared with expected appreciation, actual appreciation rates show that 25 out of 84 metropolitan areas have experienced overpricing during 2000-2005 in US under bubble threshold of "30% over expected increase".

It can be seen from structural models that housing supply plays key role in evolution of house price and supply constraints have been confirmed as significant contributor to high volatility of house prices. With data of US metropolitan areas Paciorek (2013) developed a structural model with focus on housing supply based upon regulatory index, density of housing and estimate of real construction cost. Results show that supply constraints play significant role in explaining house price volatility and authority regulations add construction costs and cause delays thus reduce supply elasticity and amplify house price volatility. Besides, geographic limit on land availability also increases construction cost and subsequent house price. Hilber and Vermeulen (2009) studied regulatory constraints on building in the United Kingdom with a novel instrumental variables strategy and concluded that constraints are responsible for a substantial fraction of both the high level and volatility of house prices in that country. Using similar data to mine for the United States, Huang and Tang (2012) estimate the relationship between supply constraints, including regulation and land availability, and the sizes of cities' housing booms and busts from 2000 to 2009. Their work reflected that more constrained cities have experienced larger price run-ups and more striking declines in subsequent period.

Aside from cointegration test and structural model, some researchers focus study on variation of house prices and identify which factors and by what mechanism house prices change. Abraham and Hedershott (1994) pointed out that determinants of house price variation are divided into two groups: those responsible for growth of equilibrium price and those for deviation or adjustment to equilibrium price level. Thereinto, natural increase in equilibrium price is attributed to real income, employment, construction cost and after-tax interest rate while deviation of actual price from equilibrium level evolves from correlation with previous house prices and deviations. This typology of determinants underlying changes of house price is endorsed by Shiller (2005) who stated that bubble in housing market originates from irrational expectation that is brought by deviation or slow adjustment to equilibrium whereas growth in equilibrium price would push price up to a sustainable higher level. However, with data of 30 cities US during 1977-1992 the model explains only three-fifths of variation of house prices thus specification of model needs to be improved if there is no important variable missed. Subsequently, Capozza et al. (2002) proposed another perspective of house price dynamics that price variation is governed by serial correlation and mean reversion, namely persistence and amplitude of cycles in housing market. Thereby, fundamental variable affect house prices through determining how long and how large house price cycles evolve. Compared with Abraham and Hedershott's model, as whole fundamentals-population, income and construction cost-are stronger at explaining price variation. What's noteworthy is that serial correlation tends to play bigger role in house price dynamics than mean reversion and influence of the latter changes very little no matter with time or across different housing markets. This implies that cycles of house prices are more characterized by persistence instead of amplitude[17]. Campbell et al. (2009) pointed that the remarkable influence of serial correlation may come from reverse effects of rising house prices on fundamental variables that would further enhance serial correlation. So a

[17] One explanation is that when house price grows for period long enough, deviation from equilibrium must be quite large. So compared to mean reversion serial correlation has more impacts on price evolution.

VAR model was constructed on rent-to-price ratio, real interest rates, housing premium[18] in order to demonstrate interaction between house price and fundamentals. It is shown that housing premium is the largest source of price volatility and covariance among interest rates, housing premium and rent growth helps dampen volatility in price. Thereby, overpricing shown in VAR model is less apparent than simple regression models given same dataset.

In summary, literature on house price can be categorized into four strands. First strand concentrates on service or utility house brings to homebuyers. As immobile commodity, location is chosen as the key attribute of house that determines equilibrium price, e.g. spatial no arbitrage condition. Second strand puts emphasis on demand in housing market. For example, financial no arbitrage is based on customer's comparison between return and cost of house investment. Analogously, no arbitrage between renting and owning compares house price with rent for same-quality house. Third strand is conventional structural model where house price is determined by equilibrium of demand and supply. Last also the most recent strand is characterized by exploring direct effects of economic fundamentals on house price. Beside regression of house price on economic variables e.g. models of OLS and VAR, cointegration model skips mechanism of influence and provides diagnostic method to existence of housing bubble.

[18] Housing premium, namely excess return to housing, equals real return minus interest rate. And additional variables in the VAR model are income growth, employment growth and population growth.

3 Background and Features of China Housing Market

3.1 Brief history

Till 1979, the state was determined national economic plan and was monopoly provider of housing thus virtually no housing market existed in the first 30 years since foundation of the state 1949. Work units were in charge of allocating all housing properties to urban dwellers based on their family sizes and the rents were quite low. Following lack of investment insufficient investment on residential properties brought poor housing conditions like 4 square meters per capita in late 1970s.

In 1979 trial privatization of state-owned residential housing units began in several coastal cities and soon spread to the entire country. This trial triggered emergence of housing market and commodity housing whereas this market targeted only foreigners and employees of non-state-owned enterprises which is fairly small percentage of whole population[19].

Housing market grew slowly with limited scope until early 1990s when government issued series of housing policies and measures to accelerate development of housing market and to switch housing system from state-allocation to market-orientation. In early 1990s to privatize housing properties houses allocated by work units were allowed to be purchased by residents at price lower than market. Milestone in China housing market took place in 1998 when the state declared 23rd Decree stating that work units are not allowed to develop houses for employees. Since then all urban households have to buy or rent houses in market.

With high-speed economic development, housing system reform dramatically stimulates evolution of housing market. Over the past decade, housing investment has grown at annual rates of 20 percent. Houses have inevitably become the most important private property for urban

[19] According to China Statistics Yearbooks, by 1989 the number of registered private enterprises is 98,000 with 4.73 of nationwide workforce and it must be even less in 1979 when economic reform just started.

households (Dreger & Zhang, 2010). Meanwhile housing condition has steadily improved like size per capita increasing to 24 square meters. For the recent years real estate has become engine of economic development for example investment in real estate occupies over 10 percent in nationwide GDP in 2011[20].

3.2 Ultimate state ownership

An essential characteristic of China housing market is that ultimate ownership of urban lands belongs to the state, the representative of central government. Local governments decide what can be built in their jurisdictions by controlling land supply and overall city plan of development whereas all land transactions have to be subject to regulations of central government. After purchase, urban individuals have the right to use land for certain number of years: 70 years for residential uses, 50 years for industrial and mixed uses and 40 years for commercial uses[21]. So local governments in fact lease not sell land parcels to developers for limited years of use. Developers then build housing units and sell households who will live in, sell or rent out those units to other households[22].

3.3 Land auction

Another characteristic of China housing market is the land auction that first took place in Shenzhen in 1987. But most land parcels were not sold via public auctions or bidding in subsequent years. Instead, to encourage housing development local governments could be

[20] Source: China Statistics Yearbook 2012.

[21] Since housing privatization in 1979 the oldest residential units in China are just 33 years thus nearly no residential units have reached their expire date. What will happen with ownership of land and attached housing units when expire date is unclear at present.

[22] According to housing regulation, units can only be sold after paying back all loans on them. To restrain speculation in recent few years governments restrict second-hand units transaction by setting high tax rates for income from selling second-hand units that were purchased less than 5 years ago.

contacted by developers who were interested in certain land parcels and acquiring price could also be negotiated bilaterally. Many such deals were conducted at very low prices moreover this approach to acquiring lands may breed bribery and corruption (Cai, et al., 2009). In 2002 the state thus required that all urban land for residential and commercial use could only be transacted through public auction or bidding. Since then land price turns public and transparent.

3.4 Land supply and high land price

An issue associated with the land supply system is that land sales have become a substantial part of revenue for local governments. As seen in Figure 3, gross income from land selling is nearly 2.7 trillion Yuan in 2012 which is five times of its 2003 level 524 billion Yuan. As benchmark, budgetary income of local governments grows much more steadily and ratio of land sales to budgetary income keeps around 0.5 during recent years. As off-budget revenue land sales income is not sustainable since developers have the right to use land parcels in subsequent 70 years and land is naturally a depleted resource. Evidently land sale income is a short-term benefit for local governments and potential crisis may underline this high reliance of local budget on land sales. On the other hand, as monopoly supplier in land market local government behavior clearly has huge impacts on house price and quantity of housing units. The rarer available land parcels[23] would naturally exacerbate tense housing supply whereby unsatisfied demand might drive up house price in market. Du, Ma and An (2011) have reported Granger causality from land price to house price while house price do not have impact on land price after 2004 according to Peng and Thibodeau (2009).

[23] Purchasing agricultural land might mitigate limited supply of urban residential land supply but those land parcels are basically far away from city center and with less amenity. Moreover the state has been concentrating on maintaining enough agricultural land. So land available in suburban area still has little impact in total land supply.

Beside monopoly behavior of local governments, increasing bids set by developers might be another reason underlying the high land price. Wu, Gyourko and Deng (2012) have shown in their price model that transaction price is 27.4% higher when the land is purchased by state-owned-enterprises (SOE) developer than by other non-governmental developers with other influential variables being controlled. With more abundant funding, SOEs tend to offer high enough bid to ensure of acquiring land parcels so house price is naturally higher to cover land cost if land parcel is developed by SOE. The high land transaction price caused by SOEs might be concerned with bidding rules set by local governments. According to game theory, transaction price should be lowered if auction is conducted as the second highest buyer gets the bid. However, as beneficiary of the high bidding local governments might be reluctant to change the auction rule although there is solution to high land price evolved from SOEs.

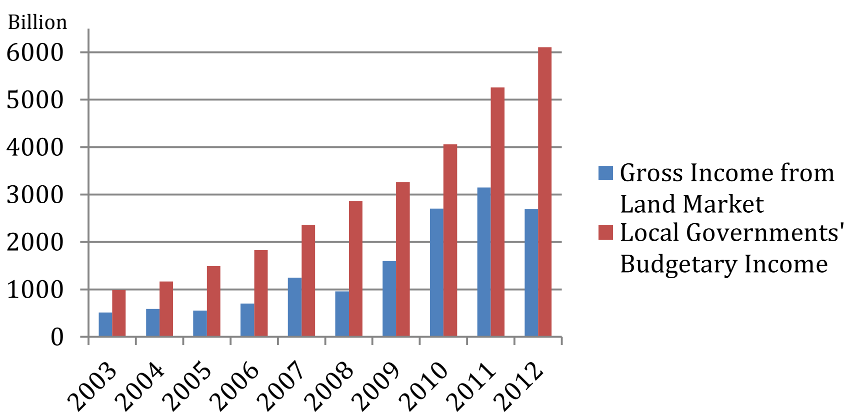


Figure 3 Gross income from land transaction vs. budgetary income of government

Source: China Statistics Yearbook 2003-2012

3.5 Rapid urbanization and migration to cities

The ongoing huge trend of urbanization has been an underpinning factor in striking development of China housing market in past 30 years. Besides smaller family size following one-child policy helps create more housing demand contemporaneously. As shown in Figure 4, urban population turns 3.7 times from 191.4 million in 1980 to 711.82 million till 2012 meanwhile percentage of urban population goes up and exceeds that of rural population in 2011 with 51.27% and 2012 with 52.6%. Increases of population in metropolises contribute to the nationwide fast urbanization, for example population in Beijing grows 52% and Shanghai 48% in last decade.

The underlying force of rapid growing urban population is undoubtedly migration that mainly consists of young graduates working in metropolitan areas. This young generation has to rent houses as house prices are out of their reach but owning a unit is more appealing because regulation system does not give much protection to tenants (Dreger & Zhang, 2010). Due to the volatility of rental and high saving rates Chinese tend to own a tenure residence rather than renting. Therefore, these immigrants into urban areas constitute a forceful demand for housing.

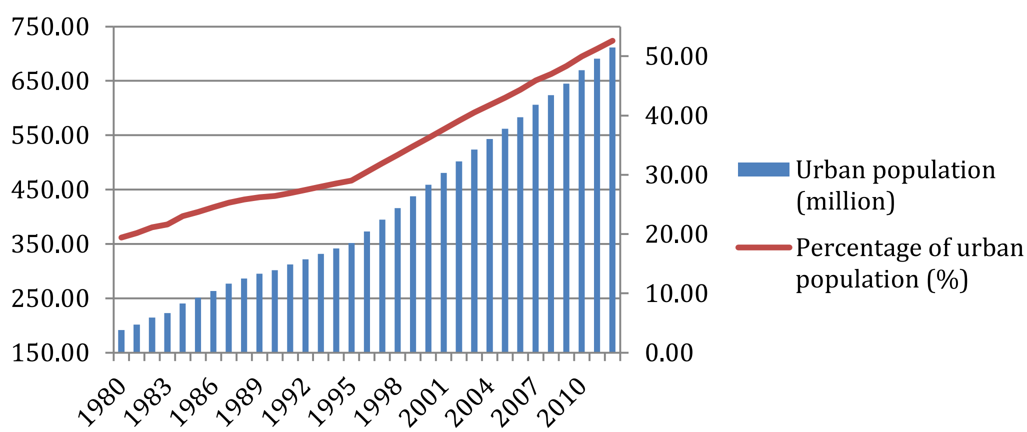


Figure 4 Urban population and percentage of urban population

Source: China Statistics Yearbook 2012

3.6 Immature social housing provision system

Unlike western countries such as Denmark, Finland or France China has not established robust social housing system for citizens with low affordability although central government has taken various measures to satisfy housing demand of low-income citizens since 2011[24]. However, one of the requirements to access to units from social housing system is that at least one member in family must have permanent non-agricultural identity[25] in the unit located city for more than five years. To some extent, current social housing system does help low-income urban residents solve housing problem but due to above policy immigrants residing in cities most of housing demand are left unsatisfied and has to pay for house without governmental assistant. Thus Chinese social housing system just covers small part of housing demand.

[24] There are mainly two kinds of social housing supply, one is economical housing that local governments provide developers preferential tax policy and free infrastructure like water and electricity. Certified low-income households can purchase these units with price lower than market. The other one is social rented housing. Low-income households can rent these units but cannot acquire ownership for the property.

[25] In China identity of citizen is classified into agricultural and non-agricultural citizens and this classification is shown on ID card as well. Basically people families rooted in rural areas belong to agricultural group while those born in urban families are registered as non-agricultural citizens. Plus non-agricultural citizens from different cities are not entitled to access to social housing services in cities other than their mother city.

4 The Data

The dataset spreads from January 2006 to October 2013 covering four glamorous cities-Beijing, Shanghai, Guangzhou and Shenzhen as shown in Figure 5 and eight variables- house price index, rent index, vacant dwelling, Shanghai stock exchange index, local GDP, disposable income per capita, average house prices and land purchase[26]. Among these selected variables, local GDP and income per capita is in quarterly frequency and other six variables are monthly data. Table 1-5 report descriptive statistics of all variables in analysis for the four markets. House price index and rent index used here focus on residential homes excluding real estate for offices or shops. Notably, all data collection does not contain indemnificatory houses that are constructed for low-income households and are prohibited from being merchandised in market. Omitting of indemnificatory houses may lead to overestimate of average house price in analysis.

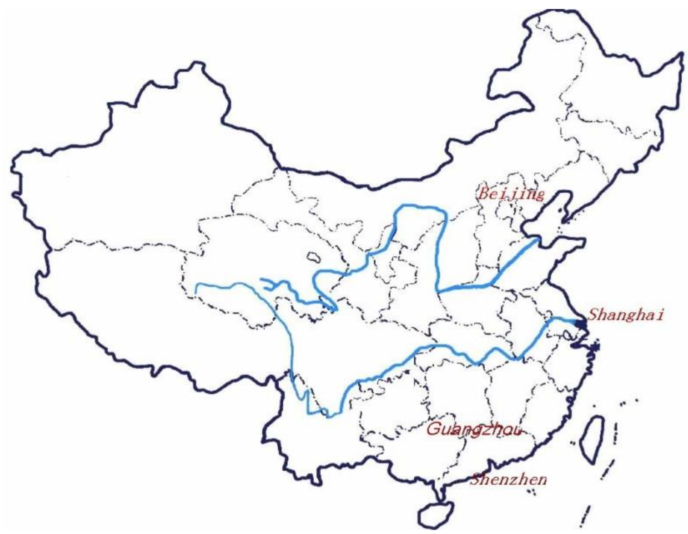


Figure 5 Four major China housing markets

[26] House price index used here is hedonic index that is computed on constant-quality houses. Main data source is CREIS and few missing data are collected from local bureaus of statistics.

Table 1 Descriptive statistics of Shanghai stock exchange index Jan 2006-Oct 2013

Source: monthly stock index series is computed from average of daily closing index[27]

Maximum	Minimum	Average	Standard Deviation
9098.54	1225.04	2778.93	1124.66

Table 2 Descriptive statistics of selected variables for Beijing

	Maximum	Minimum	Average	Standard Deviation
HP	4026	1237	2545	674
RENT	2239	992	1593	403
VAC	834.38	376.10	539.28	135.55
GDP	13766.20	1681.60	3665.81	2345.23
INCOME	10175.00	4796.00	7145.19	1620.90
rHP	31333	6817	16465	7528
LP	290.05	0.00	38.02	54.17

Here and after, HP is house price index, RENT is rent index, VAC is quantity of vacant dwelling (10,000 square meter), GDP is local gross product (billion Yuan), INCOME is disposable income per capita (Yuan), rHP is real average house price (Yuan/sqr. meter) and LP is land purchase of developers in the whole city (hundred million Yuan).

Table 3 Descriptive statistics of selected variables for Shanghai

	Maximum	Minimum	Average	Standard Deviation
HP	2707	1591	2209	297
RENT	1788	1014	1506	137
VAC	1060.94	273.97	574.42	180.30
GDP	6459.41	2541.43	4384.50	891.05
INCOME	12233.65	4834.00	7769.49	2031.67
rHP	30544	11538	19634	6606
LP	475.79	0.00	33.54	58.46

Table 4 Descriptive statistics of selected variables for Guangzhou

	Maximum	Minimum	Average	Standard Deviation

[27] Stock indexes are collected from http://vip.stock.finance.sina.com.cn/mkt and monthly stock indexes are computed from mean of daily closing indexes in respective month.

HP	2654	1091	1807	363
RENT	1874	1063	1383	254
VAC	376.88	121.31	206.82	66.34
GDP	4075.47	1304.63	2517.24	780.03
INCOME	12440.59	3109.41	7439.00	2094.17
rHP	17871	5564	11192	3231
LP	161.43	0.00	8.09	21.08

Table 5 Descriptive statistics of selected variables for Shenzhen

	Maximum	Minimum	Average	Standard Deviation
HP	3763	1240	2566	546
RENT	2367	1181	1666	313
VAC	254.23	33.21	102.30	59.00
GDP	4069.57	1346.15	2355.44	739.12
INCOME	13352.40	2874.69	7933.07	2141.48
rHP	30330	6171	16840	6993
LP	53.39	0.00	3.14	8.54

5 Ratios of House Price Dynamics

In this section, three conventional matrices are shown to sketch a picture on house price levels in each market. As the most widely used matrices, price-income ratio and price-rent ratio manifest price level in a housing market from perspective of affordability and opportunity cost respectively. On the other hand, imputed-actual rent ratio gives hints on deviation of the housing market from equilibrium by comparing actual rent with imputed equilibrium-rent.

All of four cities in discussion have experienced huge economic development and fast population growth in recent years. As shown in Table 6, aside from high urbanization and over 10 million population by 2010 each of the four cities has around 4% growth on resident population. This may support sustaining high demand for house and continuously expanding housing market in these cities.

Table 6 Urbanization, population and average population growth in four cities 2010

Source: China Real Estate Index System

	Beijing	Shanghai	Guangzhou	Shenzhen
Urbanisation %	85.96	88.86	89.82	100.00
Population million	19.62	23.03	12.70	10.37
Average population growth %	4.21 %	4.14 %	6.71 %	3.78 %

5.1 Price-income ratio

5.1.1 ADF test on stationarity of price-income Ratio

As one of international matrices on housing market, price-income ratio exhibits affordability of households on housing purchase. There are several specifications on formula of this ratio. The standard formula found in housing literature is: [28]

[28] Price-income ratio is obtained by dividing OFHEO price index by index of mean per capita income (Himmelberg, et al., 2005).

$$\text{price-income ratio}=\frac{\text{average total price of housing unit}}{\text{average household income}}$$

And due to availability of data source, Wu et al. (2012) re-write the formula as[29]

$$\text{price-income ratio}=\frac{\text{average housing price per sq.m}}{\text{average per capita income}}\times\text{housing size per person}$$

The former formula used by US OFHEO is based on unit of household while the latter one spreads base to per capita. However Wu et al. use yearly data that would make variations of price-income ratio unseen. Thus quarterly data is used here to show more variations in time series of price-income ratio.

The formula applied in computation is

$$\text{price-income ratio}=\frac{\text{average housing price per sq.m}}{\text{disposable income per capita}}\times\text{ average housing size}$$

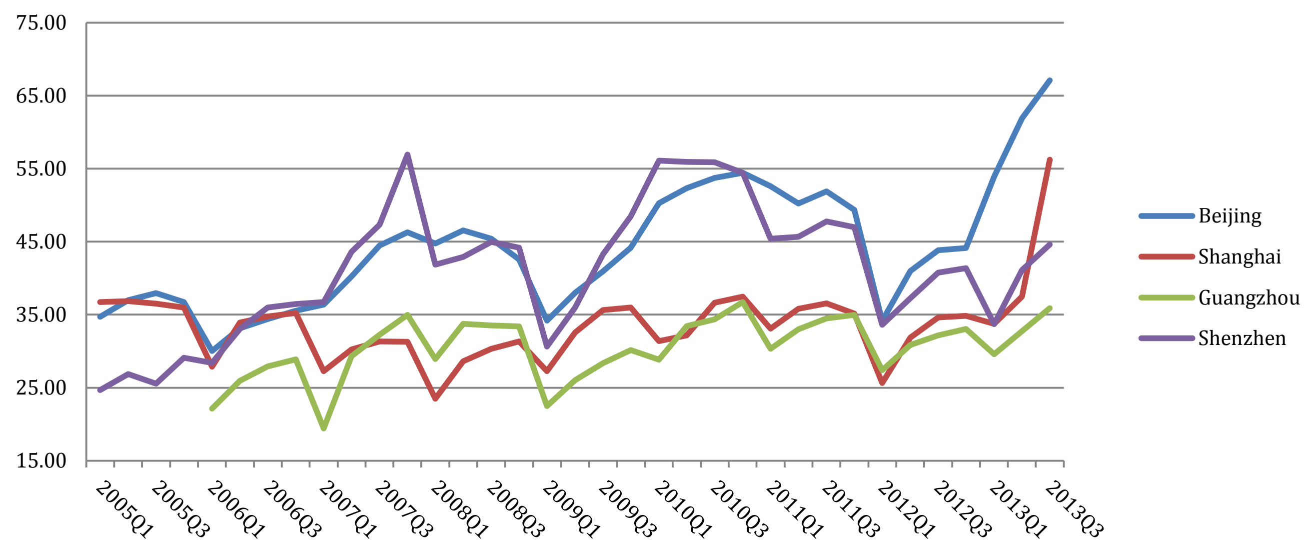
There are three reasons why formula above is chosen. First, as aforementioned due to data availability average household income is hardly traced in current statistical sources so the ratio can only be gauged on individual unit instead of household. Second, Wu et al. (2012) assume housing size per person to be $30m^2$ but in reality house buyers normally purchase a house unit which is averagely $90m^2$.[30] Third, with yearly disposable income and price for a housing unit the ratio derived has an implication as how many times price of house is higher than a person's yearly income. Thus apart from loans this ratio implies how many years one is able to pay for a house unit.

[29] See Wu, Gyourko and Deng (2012) p539.

[30] Since 2006 Chinese government requires that no less than 70% of newly-built houses be larger than $90m^2$. And average housing size per person is $30m^2$ (Wu, et al., 2012) in China with average household size of 3 persons.

Initial data are monthly constant-quality house prices and quarterly disposable per capita income.[31] Monthly house prices are first converted to average quarterly data, divided by disposable per capita income and multiplied by average housing size $90m^2$.

As shown in Figure 6, price-income ratios in four markets have experienced severe fluctuations in recent years. Overall the ratio kept rising except the two remarkable sharp drops in 2009Q1 and 2012Q1 among four markets. It can be seen that Shanghai and Guangzhou maintained lower level of price-income ratio than Beijing and Shenzhen while Table 7 also indicates that Beijing and Shenzhen have higher mean values than the other two cities. Consistent with line-look in Figure 6, standard deviations of Beijing and Shanghai are larger than those of the other two markets implying that changes in house price are more dynamic than in disposable income in Beijing and Shenzhen.



Source: Calculated from data of China Real Estate Index System, Beijing Municipal Bureau of Statistics and Shanghai Bureau of Statistics

Figure 6 Price-income ratio 2005Q1-2012Q4[32]

[31] Average constant quality house price (Yuan/m^2) is from CREIS and disposable income is reported both by CREIS and local Bureau of Statistics websites.

As aforementioned, computation of this ratio implies by how many years one can pay for an average-size house unit given income constant and excluding mortgage payment. Since in China average work period in lifetime is 35 years house price in these four cities has left disposable income far behind especially in Beijing and Shenzhen[33] whereas in Figure 6 price-income ratios of Shanghai and Guangzhou show occasional jumps over benchmark value 35.

A critique on the measure of price-income ratio is that it is better to use ratio of mortgage payments to income than ratio of price to income (Smith & Smith, 2006) since mortgage is closer to actual payment of home buyers (McCarthy & Peach, 2004). Admittedly, ratio of mortgage to income is more accurate as it takes mortgage interest rates into account but it is difficult to measure monthly pay on mortgage because interest rate varies across different mortgage-periods and percentages of out-of-pocket costs.[34] Using house price instead of mortgage payment will underestimate price-income ratio as numerator becomes smaller without mortgage interests. On the other hand, neglecting increase rate of disposable income[35] will overestimate price-income ratio. Other sources of measure error results from the fact that not all residents in housing market need to buy house: payment on a house is always supported by both spouses while most middle-age people do not have demand of house. Notably, due to over 10% cyclical

[32] Data for Guangzhou starts from 2006 Q1 as house prices in 2005 for Guangzhou are missing.

[33] Retirement age for women is 50-55 years old and 60 years old for men currently in China.

[34] Interest rate is usually lower when payment period is longer and home buyers may get some bonus if their down payment reaches specific percentage of whole house value or if they pay back loan earlier than contracted.

[35] As the largest part of housing demand young people in China usually have steady up-going salary by job-hopping or promotion. A survey on graduate monthly income in 2012 shows that monthly salary for graduates with bachelor degree increases 10.3% averagely nationwide. Results of this survey are reported by MyCOS and can be found here http://edu.people.com.cn/n/2013/0609/c244541-21805887.html (in Chinese). While the high rise rate may not sustain for more than 3-5 years as frequent changes of workplace tend to happen in first few years after graduation as stated in report.

increase[36] in hedonic house price four markets in discussion imputed price-income ratios here are very likely to be lower than their actual levels. Thus conclusions inferred from ratio calculated by house price and disposable income may still hold because underestimated ratios here are already high enough to deduce possible overvaluation in the four house markets.

Table 7 Descriptive statistics of price-income ratio in four markets

	maximum	minimum	mean	standard deviation
Beijing	67.11	25.54	43.97	9.14
Shanghai	56.22	23.47	33.24	5.50
Guangzhou	36.73	19.44	30.77	3.97
Shenzhen	56.94	28.38	42.18	7.88

ADF tests are presented in Table 8 to illustrate whether price-income is stationary in the four markets (Dickey & Fuller, 1979). Since t-values are significantly larger than critical values[37] at all significance levels price-income ratios of housing markets in four cities are non-stationary according to result of ADF test, that is, long-term movement of this ratio for these major markets are unpredictable and stochastic.

Table 8 ADF test result for price-income ratio

	Sample size	Lag order[38]	t value	Results
Beijing	35	1	-0.9705	N
Shanghai	35	4	-0.3954	N
Guangzhou	31	7	-0.6503	N
Shenzhen	35	2	-2.3863	N

[36] According to data from CREIS, from 2006 to 2012 average cyclical monthly increases in Hedonic house price are 13.73% for Beijing, 6.51% for Shanghai, 11.07% for Guangzhou and 14.16% for Shenzhen. Mean of these four cities is 11.37%.

[37] The critical values for ADF test are -2.57 (10%), -2.86 (5%) and -3.43 (1%) with intercept only (Cheung & Lai, 1995).

[38] The number of lags is determined by AIC/BIC (see Appendix 1) and statistical method is referred to Stock and Watson (2007, p549-533).

Y means rejection of null hypothesis of unit root namely the time series is stationary while N means that the time series is non-stationary.

ADF test on first difference of price-income ratio is also conducted. Under 5% significance level, four markets all show stationarity on first difference of price-income ratio. [39] This indicates that increase rates of price-income ratio in these markets fluctuate around a particular constant and may be predicted under appropriate estimation. Therefore, ratio of increase rates of house price and that of disposable income shows a stable and predictable trend, implying growth of house price is at some simultaneous pace with increase of disposable income in the four markets.

Admittedly, it is abrupt to say that there exists mispricing in house market where price-income ratio is stochastic. Vice versa, stationary price-income ratio does not guarantee that there is no bubble in the housing market. Although price-income ratio is inadequate to grip bubble unstable trend in this matric indeed provides reasons to suspect overvaluation in housing market (Himmelberg, et al., 2005). Therefore, it is convincible to cast doubt of bubble on housing markets in these glamorous cities. What is noteworthy here is that as the numbers of observations for all markets in question are not large as seen in Table 8 result of ADF test may incline to favor null hypothesis of non-stationarity. Suspect of overvaluation in the four markets thus needs to be further assessed from other perspectives.

5.1.2 Comparative analysis between China and US on price-income ratio

Another perspective to see whether there is overheating in China housing market may originate from comparing current situation of China market with that of US market during the well-known housing bubble in 2007. To make price-income ratio in the two countries comparable, price-income ratios among markets in discussion are all converted into index with 2006Q1 level equal

[39] The lag order in ADF tests for first-difference of price-rent ratio are set as two periods lag due to small sample size, t-values are respectively -3.8388, -3.8786, -5.0511 and -4.7519 (-2.86, 5%).

to 100[40]. As seen in Figure 7 and Figure 8, US national price-income ratio and four glamorous states are chosen to compare with four cities of China. Also remarkable troughs and summits and respective trend lines are marked in both figures.[41] It is apparent that fluctuations of price-income ratio of China are more frequent and severe than those in US markets and steady ascending is hardly observed in China's markets. Coincidently or not, three-year cycle is manifested in the four markets of China though it is not obvious for Shanghai housing market. In the end of time series 2013Q3 price-income ratio for both Beijing and Shanghai reached their peaks.

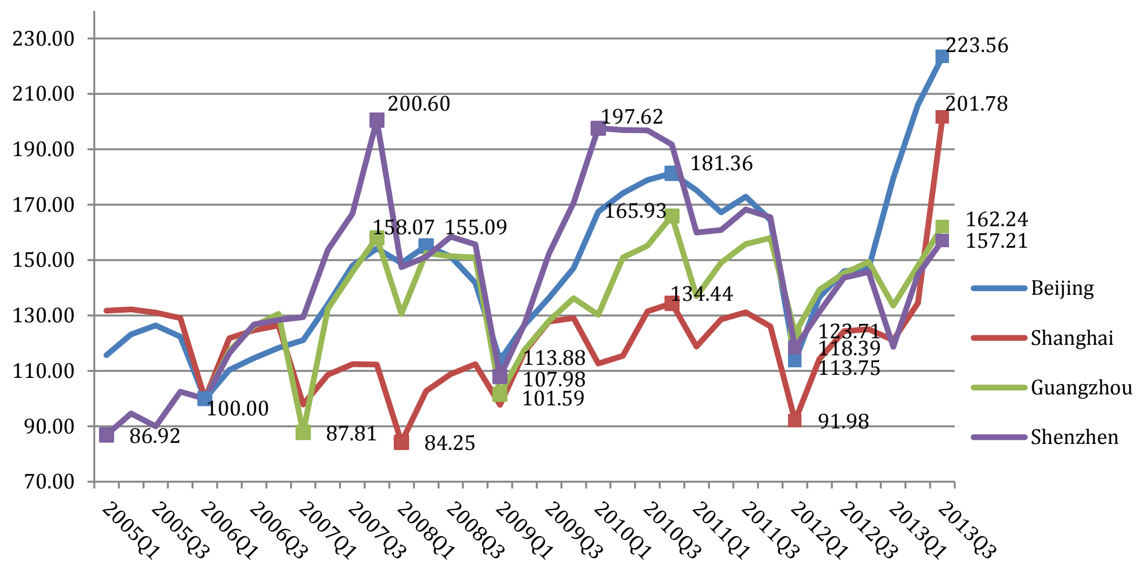


Figure 7 Price-income ratio index for China 2005Q1-2013Q3 (2006Q1=100)[42]

---

[40] There are two reasons to convert price-income ratio into indexes: one is the absolute ratio values is not comparable between two countries and what is more of interest is their respective increases compared to previous time, the other is that US income used here is not disposable income as for China so ratio for US might be underestimated.

[41] Price-income ratios for main fluctuations for China's four markets are labeled while the lowest and highest ratios during formation of housing bubble are labeled for US markets. Trend lines for in Figure 8 are linear.

[42] Data for Guangzhou in 2005 is missing. These indexes are derived from dividing price-income ratios by ratio in 2006Q4 and multiplying 100.

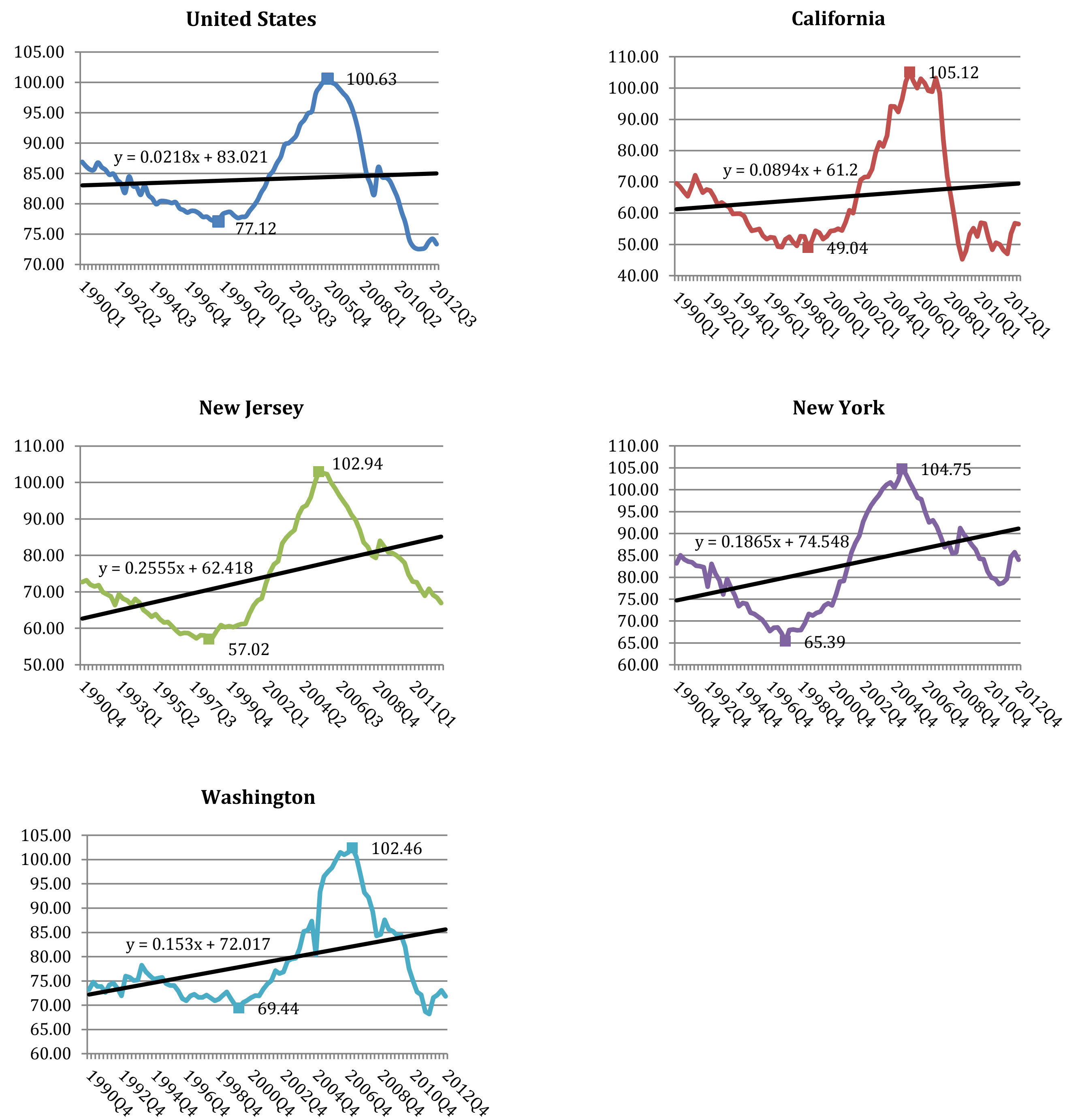


Figure 8 Price-income ratio index for US 1990Q1-2012Q4 (2006Q1=100)[43]

[43] Data for New Jersey, New York and Washington in first three quarters 1990 is missing. This ratio is computed from dividing average house price by per capita income for respective regions. Data sources is as followed: Per capita income is from http://bber.unm.edu/econ/us-pci.htm, national average house price is from

There are two viewpoints regarding comparison between housing markets in current China and bubble-phase US. One is to compare remarkable rises of price-income ratio for China's four markets with those for US markets in their bubble phase. As shown in first three rows Table 9 and first row Table 10, all of historical increases in China's four cities exceed percentage change of US national market in bubble. Furthermore, most recent growths of price-income ratio in Beijing and Shanghai (96.54% and 119.37%) are far higher than those in popular states New Jersey, New York and Washington and even close to increase in admittedly fever state California. Whereas, recent rises of price-income ratio in Guangzhou and Shenzhen are smaller than lowest level among four glamour US states. Comparisons above indicate that recent house prices in Beijing and Shanghai are indeed experiencing overheating relative to income since rises of price-income ratio in the two markets leave far behind rise in any US regional or national housing market. Contrarily, house prices in Guangzhou and Shenzhen do not exceed income as much as the extent by which US house price outstripped income in bubble phase. So overpricing is not so evident in Guangzhou and Shenzhen as in the other two cities.

The other viewpoint of comparison between current Chinese housing market and US bubble is to show deviation of price-income ratio from trend. In Table 9 and Table 10 deviations of price-income ratio from trend are presented for China and US housing markets. Similar with results inferred from rise of price-income ratio, most recent deviations from trend in Beijing and Shanghai are significant compared with US bubble-phase levels especially deviation in Shanghai is almost as large as that in California, the conventionally hot market. Price-income ratios in

---

http://www.lincolninst.edu/subcenters/land-values/rent-price-ratio.asp, California average house price is from http://www.car.org/marketdata/data/housingdata/and average house prices of the other three states are from http://www.zillow.com/local-info.

recent Guangzhou and Shenzhen, on the other hand, do not obviously depart from their trend lines and the ratio in Shenzhen even falls below trend in late few months.

Aside amplitude of deviation, persistence of deviation of housing affordability from trend may also provide evidence of housing bubble (Holstein, et al., 2013)[44]. Since price-income ratio to large extent reflects housing affordability, the ratio's exceeding trend implies deterioration of housing affordability. As seen in Figure 8, price-income ratios in US markets all stayed well above trends for several quarters prior to collapse of housing bubble. It is therefore reasonable to examine persistence of deviation of price-income ratio in China markets. Except in Shenzhen, price-income ratios in other three cities have all been above trends for around three months recently. As the ratio's departure from trend in Guangzhou is quite small, consistently with inferences above house prices in Beijing and Shanghai have been experiencing overheating relative to income level.

Table 9 Notable ascents of price-income ratio[45]

	Beijing	Shanghai	Guangzhou	Shenzhen
2005Q1-2008Q2	55.09 %	-	80.01 %	130.79 %
2009Q4-2010Q4	59.26 %	59.57 %	63.33 %	83.02 %
2012Q1-2013Q3	96.54 %	119.37 %	31.15 %	32.79 %
Deviation from trend 2013Q3	21.15 %	54.51 %	6.57 %	-8.20 %

Table 10 Performance of price-income ratio US during bubble[46]

	US	California	New Jersey	New York	Washington
Percentage change from pre-	30.48 %	114.36 %	80.54 %	60.20 %	47.56 %

[44] Holstein et al. suggested that a housing bubble probably exists when monthly housing affordability index value falls below trend for at least three months.

[45] Since ratio trend for Shanghai is relatively stable only two great cycles are shown here from 2008Q1 to 2010Q4. Deviation from trend line is computed from percentage change of ratios in 2013Q3 from linear trend lines that are not shown here.

[46] Deviation from trend line during bubble in computed from percentage change of summit in bubble from trend line.

bubble levels					
Deviation from trend in bubble	19.20 %	57.28 %	32.84 %	22.44 %	26.31 %

5.2 Price-rent ratio

5.2.1 ADF test on stationarity of price-rent Ratio

Analogous with price-income ratio, price-rent ratio is another conventional measure of house price dynamics that reflects comparison between purchase price and rent of houses with constant quality such as usable size, location, transport convenience, interior conformation and suchlike. Alternatively, price-rent ratio can be termed as its reciprocal rent-to-price ratio that compares house price with rent that homeowner would pay for house unit similar to his home (McCarthy & Peach, 2004). Although there are contends against direct comparison between owner-occupied and rental units in terms of location, building density and demand formation[47] (Glaeser & Gyourko, 2007) such differences are not conspicuous in the given four markets as the occupied and rental units are often commingled in same neighborhood and contain comparable house components (Wu, et al., 2012). Price-rent ratio is thus more applicable for China housing market than other countries.

Price-rent ratio can be used to test existence of bubble in housing market because increasing house price either comes from exuberent economic fundamentals or irrational bubble. And if fundamentals are the reason pushing up house price then there should be corresponding increases in rent (Baker, 2006). So house price should not outpace rent too much in market without mispricing and price-rent ratio either cannot deviate from constant level for long time. Another reason why price-rent ratio is appealing when testing bubble, as suggested by Himmelberg, Mayer and Sin (2005), is that house market may contain overvaluation when price-

[47] Some scholars have rebut so-called differences between owning and renting units by stating that it is possible for households to buy or rent similar properties nowadays (Smith & Smith, 2006).

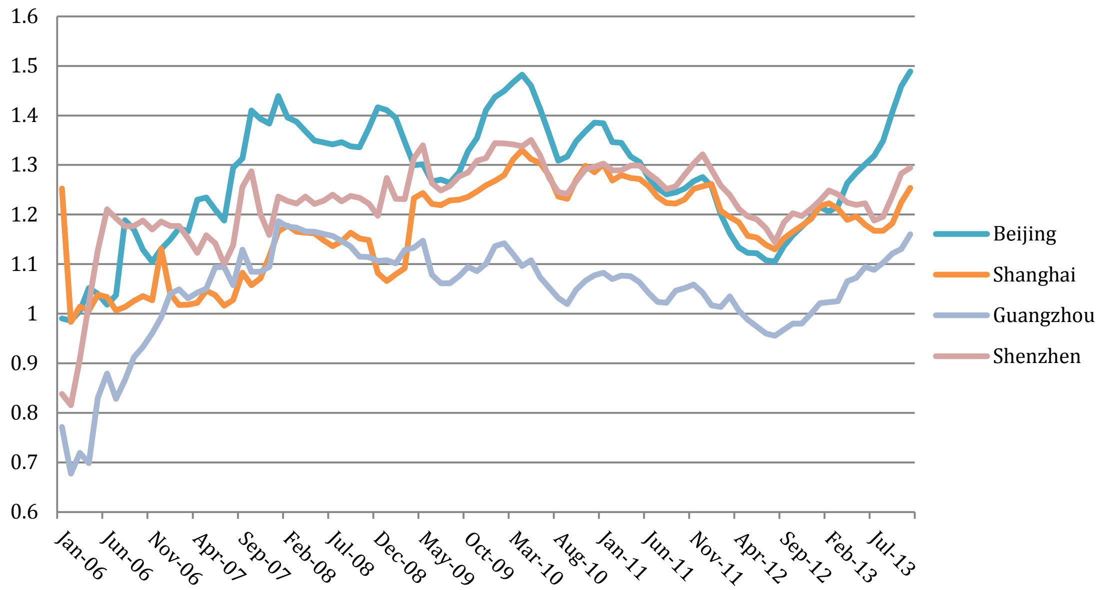
rent ratio remains high for prolonged period. But conclusive role of price-rent ratio on verifying bubble in house market has to be held here as one matrix alone is not sufficient to support claim of market bubble.

Price-rent ratio is computed from

$$\text{price-rent ratio}=\frac{\text{residence price index}}{\text{rent index}}$$

Detailed micro data on two indices above are reported by China Real Estate Index System (CREIS) for four markets.[48] Figure 9 shows movements of price-rent ratio in four cities where price-rent ratio displays frequent fluctuation on monthly base. Price-rent ratio maintained upward trend in four markets until early 2008 when three out four cities came to their peaks. Following remarkable summits in April 2010 price-rent ratios of four markets dropped down to troughs contemporaneously in mid-2012. Among the four markets, price-rent ratio for Guangzhou has been at lower level than the other three that have been tied on ratio level for most of time. Compared to level at very start, recent price-rent is much higher except Shanghai market implying that house price has grown more quickly than rents. This mismatch may reflect that rent is more insensitive to market than house price or that house price has been going far from level of efficient market. In Table 11 price-rent ratios for Beijing and Shenzhen have higher mean values and Beijing also possesses most volatile house price relative to rent (variation 12.2%) among the four markets.

[48] The indices are obtained, according to CREIS, through weight calculation of data collected under classification of different districts, interior structures, distances to city center, sizes and price levels.



Source: Calculated from data of China Real Estate Index System

Figure 9 Price-rent ratio 2006 Jan-2013 Nov

Table 11 Descriptive statistics of price-rent ratio

	Maximum	Minimum	Mean	Standard Deviation
Beijing	1.489	0.986	1.274	0.122
Shanghai	1.330	0.983	1.169	0.093
Guangzhou	1.186	0.677	1.045	0.100
Shenzhen	1.351	0.815	1.225	0.091

Although it is not applicable in China housing market that owner-occupied units and rental units are very different in physical characteristics, location and neighborhood owners and renters are indeed heterogeneous in terms of unobserved factors. As emphasized by Glaeser and Gyourko (2007), because of aversion to risk of non-shelter and rent volatility and benefits of customization owners are willing to pay about 40% higher than landlords for same property.[49] Suppose that home buyers in the four house markets are also appealed to aforementioned advantages of owning then residence price index should be naturally higher than rent index by

[49] Higher maintenance fee and capital costs, risk aversion, fear of future price growth and allowance for customization all cause owner-occupiers to be willing to be pay more than landlords (Glaeser & Gyourko, 2007).

some percentages smaller than 40% as landlords in China do not need to pay higher maintenance fee and house payment is not deductible from income tax either. Therefore, the natural price-rent ratio for efficient market without mispricing is somewhere between 1 and 1.4. As seen in Figure 9, only Beijing out of four markets displays price-rent ratio above 1.4 while the ratio in other three markets stays below 1.4 for most of time in recent years. This implies that price-rent ratio may be deviating from its natural level in house markets of Beijing, Shanghai and Shenzhen. More importantly, rapidly growing price-rent ratio during second half year 2013 in four markets indicates that house price is rising much faster than rent, which is cited by Leamer (2002) as evidence of bubble in house market. Also Krainer and Wei (2004) suggest that bubble occurs when price of asset deviates largely and prolonged from its fundamental value. Therefore, the wandering of price-rent ratio away from implicit natural level together with faster growing of house price relative to rent support claim of bubble in the four housing markets.

If no arbitrage condition between owning and renting holds then households should be indifferent between owner-occupying and renting after taking into account costs of occupying house and risk premium in equilibrium market. House price is thus supposed to be stable relative to rent when there is no overvaluation in market, implying that price-rent ratio cannot be in secular monotonous trend or in frequent severe fluctuations. ADF test on price-rent ratio in four markets is conducted again to see whether price-rent series is stationary or stochastic. As presented in Table 12, housing markets in Guangzhou and Shenzhen manifest stationary price-rent ratio while those for Beijing and Shanghai are going stochastic. This indicates that there is overpricing in housing markets of Beijing and Shanghai compared with rent payment. On the other hand probability of bubble in Guangzhou and Shenzhen cannot be eliminated since renting markets in the two cities possibly contain overheating and if rent is overpriced stationarity of house price relative to rent cannot justify anything of existence of bubble in market.

Table 12 ADF test result for price-rent ratio

	Sample size	Lag order[50]	t value	Results[51]
Beijing	95	2	-2.2700	N
Shanghai	95	1	-2.0358	N
Guangzhou	95	1	-4.1203	Y
Shenzhen	95	2	-3.8306	Y

Y means rejection of null hypothesis of non-stationarity namely the time series is stationary while N means that the time series is non-stationary.

5.2.2 Comparative analysis between China and US on price-rent ratio

Analogous to price-income ratio, comparison between housing markets of current China and bubble-phase US is conducted for price-rent ratio from two perspectives: increase of ratio itself and deviation from trend. To make ratios of China and US comparable, again they are converted to indexes[52]. As seen in Figure 10, most recent increases of price-rent ratio in four markets are labeled and calculated in Table 13 and Figure 11 shows evolution of price-rent ratio for US and corresponding trend line.

Comparing recent rises of price-rent ratio 2012 Aug-2013 Nov in China's four markets with that of US market during bubble phase in Table 13 it can be seen that only market in Beijing has been experiencing greater increase in this ratio than US market in bubble. On the other hand, none of the four markets in China has price-rent ratio with deviation from trend that is higher or close to percentage change from trend of the ratio for US during its bubble. Therefore, through comparing with performance of price-rent ratio of bubble-US little evidence is of bubble found in Chinese

---

[50] Lag order is determined by AIC and BIC (see Appendix 1). Detailed values of information criteria are negative while according to Jouni Kuha (2004) the lag order with most negative value is chosen in estimated model.

[51] For price-rent series in Beijing house market, null hypothesis can only be rejected under 10% significance level. And critical statistics are referred to footnote 37.

[52] Here base value of price-rent ratio index for China's four markets is 2006 Jan Beijing as both residence price index and rent index are based on value of Beijing 2005 Dec.

four markets. However, renting market is admittedly closely related to housing market within any region especially for metropolitan areas of China where owner-occupied and rental units are always commingled in one building or neighborhood. So rents are very likely to go up with house prices, leading to a seemingly steady price-rent ratio. Probability of bubble in markets, therefore, cannot be eliminated here.

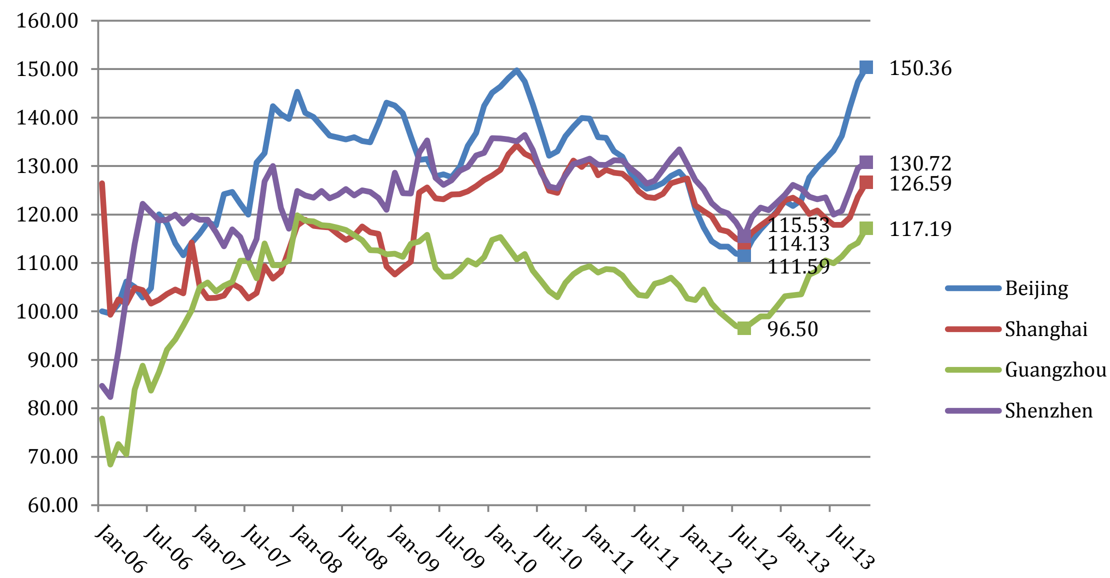


Figure 10 Price-rent ratio for China four cities 2006 Jan-2013 Nov (2006 Jan Beijing=100)

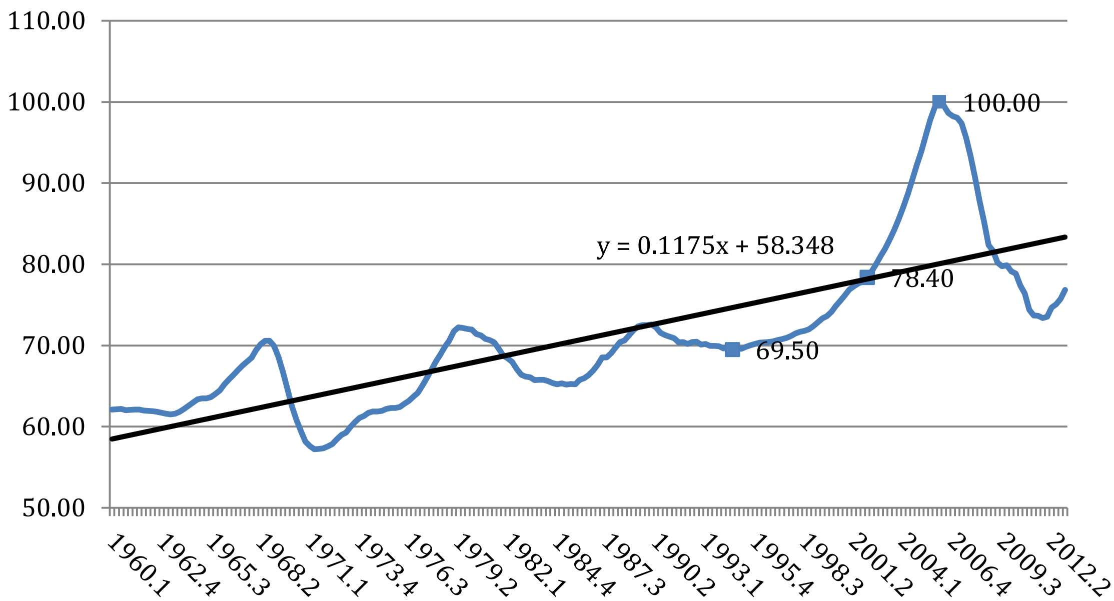


Figure 11 US price-rent ratio 1960Q1-2013Q1 (2006Q1=100)[53]

Table 13 Comparison on price-rent ratio between China and US

	US-bubble	Beijing	Shanghai	Guangzhou	Shenzhen
Recent increase	27.55 %	34.74 %	10.92 %	21.44 %	13.15 %
Deviation from trend	24.87 %	12.34 %	-1.27 %	6.20 %	-0.06 %

5.3 Imputed-actual rent ratio

5.3.1 User cost formula

Akin to price-rent ratio, imputed-actual rent ratio presents comparison between actual rents and simulated rents imputed from actual house prices with assumption of no overheating in market. This ratio is based on a widely used formula introduced by Hendershott and Slemrod (1982) and Poterba (1984). This user cost formula explores trade-off between owning and renting by giving costs and benefits of one-year ownership as seen below. The right hand R_t is annual rent costs while at left hand P_t is house price, τ is income tax rate, λ is percentage of loan of whole value, r is

[53] Data source is http://www.lincolninst.edu/subcenters/land-values/rent-price-ratio.asp and initial data is rent-price ratio and has been taken reciprocal here.

mortgage interest rate, p is local property tax rate, m is maintenance, δ is depreciation, β is required risk premium to compensate home buyers for illiquid and last term $E(P_{t+1} - P_t)$ is expected appreciation. Rearranging this formula, one-year payment for a house as seen in right hand is mortgage interest, property tax, maintenance, depreciation and risk premium. Meanwhile these payments have to subtract income tax deductibility of mortgage interests and of property tax and expected appreciation of house value. As whole, left hand side represents net annual cost for ownership that should not exceed annual cost of renting R_t in equilibrium market (Himmelberg, et al., 2005). Denote expected appreciation rate as π^e then user cost[54] of per unit of house value UC is $(1\text{-}\tau)(r+p) + m+\delta+\beta\text{-}\pi^e$.

$$R_t = P_t[(1\text{-}\tau)(\lambda r+p) + m+\delta+\beta] - E(P_{t+1} - P_t)$$

$$R_t = P_t[(\lambda r+p) + m+\delta+\beta] - P_t\tau(\lambda r+p) - E(P_{t+1} - P_t)$$

$$R_t = P_t[(1\text{-}\tau)(\lambda r+p) + m+\delta+\beta\text{-}\pi^e]$$

$$\Leftrightarrow R_t/P_t = UC$$

This user cost formula has been different versions when used by scholars in previous research. Glaeser and Gyourko (2007) assumed risk neutrality by setting risk premium β as zero in formula when trying to derive house price in equilibrium market. While Sinai and Gyourko (2004) gave different user cost formulas for home occupiers and landlords as homebuyers would be able to deduct maintenance and depreciation from their income tax if they are treated as landlords. Thus the term $(1\text{-}\tau)$ should be added in front of sum of maintenance and depreciation $m+\delta$ when house is bought for leasing. Poterba and Sinai (2008) suggested a more complicated version of this formula by introducing deduction of non-loaned part of house price from income tax and

[54] The user cost is originally defined by Jorgenson (1963) who suggests user cost is sum of after-tax opportunity cost, after-tax property taxes and repair and depreciation minus expected capital gain.

benefit of default of homebuyers. Other scholars such as Wu et al. (2012) and McCarthy and Peach (2004) applied classical user cost formula suggested by Poterba (1984) that is termed as $R_t = P_t[(1\text{-}\tau)(r\text{+}p) + \delta] - E(\pi_t)$[55]. The formula stated above basically follows the one used by Wu et al. since they have applied detailed data of China housing market into this formula. The only modification from the one used by Wu et al. is percentage of loan of whole value λ is added in front of mortgage interest rate r because practically few households in China purchase their homes totally by mortgage[56]. So mortgage interest rate should multiply the loan percentage λ in user cost formula.

What is noteworthy is the difference between user cost UC and price-rent ratio that seem quite relevant. It can be seen that user cost of per unit of house value UC equals R_t/P_t the inverse of aforementioned price-rent ratio. These two measurements are similar in format but the logic underlying them is quite different. Price-rent ratio as a measurement on overpricing relies on the presumption that if economic fundamentals such as GDP, income or population have driven house price to some higher levels rental should be correspondingly going up given that there is no speculative bubble in market. User cost, on the other hand, is based on no arbitrage condition for equilibrium in housing market namely households are indifferent between owning and renting.

Notably, as proposed by Glaeser and Gyourko (2007) the user cost formula might oversee unobserved costs and benefits of ownership-time and efforts homeowners put in maintenance, avoidance of volatile rentals or the ability to customize housing unit. Here these unobserved

[55] McCarthy and Peach merge maintenance and depreciation into one notation δ and drop risk premium β while the version used by Wu et al. is $UC=P_t[(1\text{-}\tau)(r\text{+}p) + m\text{+}\delta\text{+}\beta] - \pi^e$.

[56] According to rule of major banks in China (China Construction Bank, Agricultural Bank of China and Bank of China) the rate of loan to value of house is around 70% with upper bound at 80%.

merits and demerits of ownership are assumed to offset each other equally in the user cost formula.

5.3.2 Analysis on imputed-actual rent ratio

To assess overpricing in housing market, Himmelberg, Mayer and Sinai (2005) calculated imputed-actual rent ratio by dividing imputed rent with actual rent where imputed rent equals house price times user cost discussed in formula above. Since situation in China housing market is quite different from that in US market Wu, Gyourko and Deng (2012) adjusted user cost formula to current housing market in China. Owner-occupied house is not tax advantaged in China thus the term $(1\text{-}\tau)$ falls from the equation. Similarly, property tax regime has not actually applied to housing market in Beijing, Guangzhou and Shenzhen. Property tax policy in Shanghai seems not significantly influential for ownership cost there[57]. Therefore, property tax rate p in formula is roughly zero. As shown in Table 14, standard 5-year mortgage interest rates issued by People's Bank of China are used as interest rates r in formula since that is closer to reality than other deposit rates[58]. As stated in footnote 56, ratio of loan to whole value λ is estimated to be 70% that is applicable to most homebuyers in China. Regarding maintenance m, depreciation rate δ and risk premium β estimates by Wu et al. are followed: $m+\delta$ is 2.5% and β is 2%[59]. Expected

[57] Till August 2013, only in Shanghai of the four markets households need to pay property tax that is 0.4% or 0.6% for 70% of excessive size over 60 m^2/person. And this property tax only applies to second house of a family that is not for residence purpose (Ye, 2013). Plus residents in Shanghai are not responsible for property tax as regime issued by authority. Thus property tax rate in user cost formula can be roughly zero due to limited influences of property tax.

[58] Wu et al. (2012) use five-year deposit rate as proxy of mortgage interest rate in calculating user cost while Himmelberg et al. (2005) use actual mortgage rate in their analysis. Here mortgage interest rate of more than 5 years is more accurate as difference between deposit rate and mortgage rate can be as high as 1%, e.g. 5.6% for deposit and 6.66% for mortgage in 2008.

[59] These estimates on maintenance, depreciation and risk premium are consistent with those set by Himmelberg et al. (2005) and Poterba and Sinai (2008).

appreciation rate π^e is approximated by nominal appreciation rates minus inflation rates (Himmelberg, et al., 2005) and the former equals mean of actual price appreciation in corresponding periods of last two years[60] (Xu & Ge, 2011). And R_t and P_t are annual rent and average house price respectively[61]. To summarize, user cost of house value is modified to be $UC=[\lambda r + m+\delta+\beta-\pi^e]$ that matches features of Chinese housing market. Then house price is multiplied by user cost of house value UC to get imputed rent that shows the level at which rent should be if households are indifferent between owning and renting. As equation below, imputed-actual rent ratio is derived by dividing imputed rent by actual rent.

$$\text{Imputed-actual rent ratio} = P_t \times UC / R_t$$

Table 14 Mortgage interest rates and yearly average inflation rates[62]

Source: See footnote 62

	Mortgage interest rates	Inflation rates
2006	6.12%	2.81%
2007	6.84%	4.80%
2008	6.66 %	1.26 %
2009	5.94 %	1.70 %
2010	5.05 %	4.57 %
2011	6.40 %	4.06 %
2012	7.05 %	2.41 %
2013	6.55 %	2.36 %

Series of imputed-actual rent ratio are plotted in Figure 12 at monthly frequency. If no arbitrage between owning and renting condition holds and if user cost catches major factors that may

[60] This approximation by Xu and Ge is based on their econometric result by consulting representative homebuyers and major housing agents about their expectations. Their result shows that actual appreciation in corresponding periods of last two years have strongest explanatory power on expectation in present period.

[61] Annual rents are annualized monthly average rents for each market and average house prices are estimated by 90 m^2-size apartment prices as what is done for price-income ratio.

[62] Mortgage interest rates are those for loans longer than five years and inflation rate for 2013 is average from January to June 2013. The former data come from www.YinHang123.net and inflation rates are from http://www.inflation.eu/inflation-rates/china/historic-inflation/cpi-inflation-china.aspx.

affect housing tenure choice, this ratio should be somewhere close to one instead of staying above 2 in all of the four markets during most of recent years. The most eye-catching point would be ratio for Shenzhen in June 2008 that is as low as 1.07, namely imputed rent is very close to actual rent. This is because expectation for appreciation reaches its record level 7.77% in mid-2008 thus user cost touches an extreme trough due to negative correlation with expectation[63]. One striking turn is at January 2010 when all four cities experienced huge increase of imputed rent relative to actual rent, implying that annual user cost of ownership started going far away from actual rents since then.[64] On the other hand, Table 15 shows that means of imputed-actual rent ratios in four cities are all higher than 3 and standard deviations are notably high from 74% to 108%, implying that imputed rents in the four markets have all maintained at high levels relative to actual rents and fluctuated with severe extents.

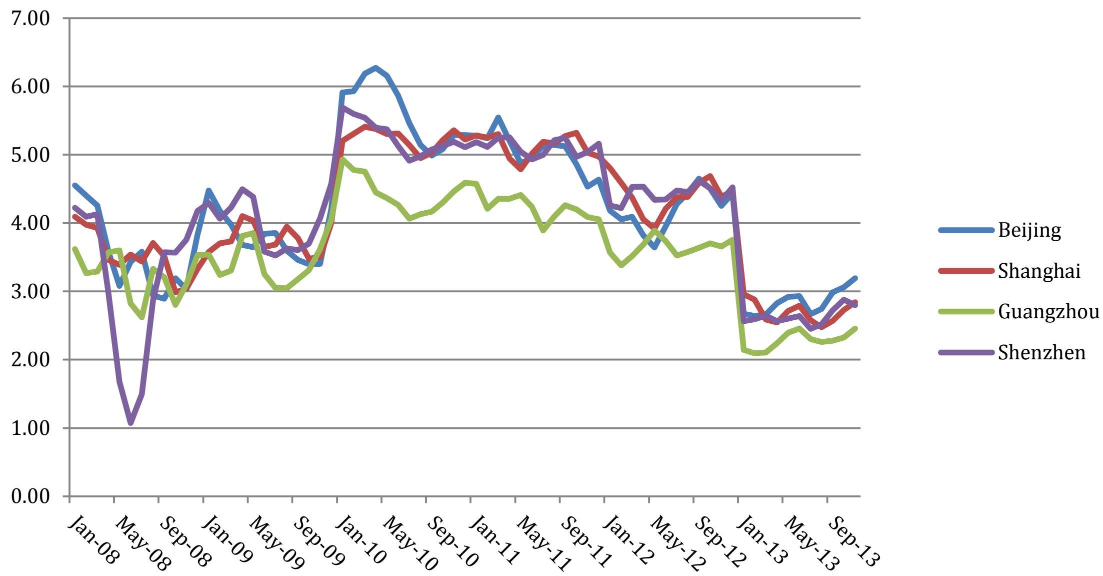
A rough compare between China and US on imputed-actual rent ratio can be conducted here. Himmelberg et al. calculated imputed-actual rent ratio for 12 US metropolises 1980-2005 and showed that before 2000 the ratio in most of object regions lingered around 1 except few jumps over 1.5 (that returned to 1 very quickly) whereas since 2000 ratios in most cities all revealed up-trend.[65] Since US housing bubble has proven to burst in mid-2007 and striking increase started in late 90s (Shiller, 2005, p. 13), obvious rise of imputed-actual rent ratio over 1 foreshadows overpricing in housing market. Therefore, high imputed-actual rent ratios in Figure

[63] House price level reached summit in October 2007 and central government started to increase interest rates for 12 times since then. Constrain policies affected expectation of homebuyers in Shenzhen as speculative demand for housing occupies 70%. Furthermore, around 70% potential homebuyers believed house prices would slow down up-trend in 2008 according to survey http://house.sina.com.cn/ljbg/2008-06-27/1443259859.html (in Chinese).

[64] Another important reason is that there is remarkable increase of inflation rate in 2010 as seen in Table 14 and this inflation has greater impacts on house prices than rents.

[65] See Himmelberg, Mayer and Sinai (2005), p17 Figure 2.

12 ranging from 2.09 to 6.27 (except very though of Shenzhen 1.07 in mid-2008) provide evidence of bubble in four markets. Moreover, as stated by Himmelberg et al. (2005) housing market is efficient when trade-off between owning and renting maintains in equilibrium namely households cannot improve utility by moving from renting to buying or the other way around. From that perspective, neither the relatively high deviations in Table 15 nor frequent fluctuations in Figure 12 supports that imputed-actual rent ratio-the base of housing tenure choice-stays in equilibrium. Therefore, overheating of house prices in the four cities cannot be denied at least when looking at behaviors of imputed-actual rent ratios in these markets[66].



Source: Calculated from data of China Real Estate Index System, mortgage interest rate from China's bank system[67]

Figure 12 Imputed-actual rent ratio 2008 Jan-2013 Nov

Table 15 Descriptive statistics of imputed-actual rent ratio

	Maximum	Minimum	Mean	Standard

[66] Tests of stationarity are not conducted here as for price-income ratio or price-rent ratio because the number of observations 65 is small and results are very likely to be biased to rejection of null hypothesis of non-stationarity. Furthermore, the trough value in June 2008 for Shenzhen market would make result for Shenzhen market unreliable.

[67] Website source is www.YinHang124.net.

				deviation
Beijing	6.27	2.64	4.20	0.998
Shanghai	5.41	2.47	4.15	0.920
Guangzhou	4.93	2.09	3.56	0.740
Shenzhen	5.69	1.07	4.12	1.080

5.3.3 Expected appreciation

As key part of user cost, expected appreciation is estimated with actual appreciations in corresponding period of last two years when deriving imputed-actual rent ratio above. Although expected appreciation is accepted to be backward-looking by many scholars[68], the inverse effects of expectation on house prices dynamics have been proved in some papers. Wu et al. (2012) showed that even modest underperformance relative to expectations is likely to be associated with sharp declines in house prices in main China housing markets; vice versa, little over performance relative to expectation could lead to more overpricing in future. Hattapoglu and Hoxha (2013), with data of Houston metropolitan area, concluded that house prices appear to be unstable when people's appreciation expectations are based on past three-year appreciation and prices tend to be stable when expectations are six-year or ten-year backward looking[69]. Himmelberg et al. (2005) proposed that house price bubble occurs when homeowners have unreasonably high expectations, leading them to pay "too much" to purchase a house today. So some scholars test bubble in housing market by focusing on expectation of appreciation that is derived from user cost formula. Wu et al. (2012) derived expectations in China housing market to uncover effects of appreciation on prices. Also with user cost formula, McCarthy and Peach (2004)

---

[68] Households' expectations on appreciation of house prices are naturally backward looking because only information about past prices and fundamental values is sure. And empirical results also show reasonability of backward looking, see (Xu & Ge, 2011) and (Hattapoglu & Hoxha, 2013).

[69] Appreciation expectation is based on both fundamental values and past price appreciations which are named as rational expectation and adaptive expectation respectively and only the latter, adaptive expectations may lead to bubble in housing market (Hattapoglu & Hoxha, 2013).

directly calculated expectation of future appreciation to reach conclusion of bubble by comparing expectation with average inflation[70].

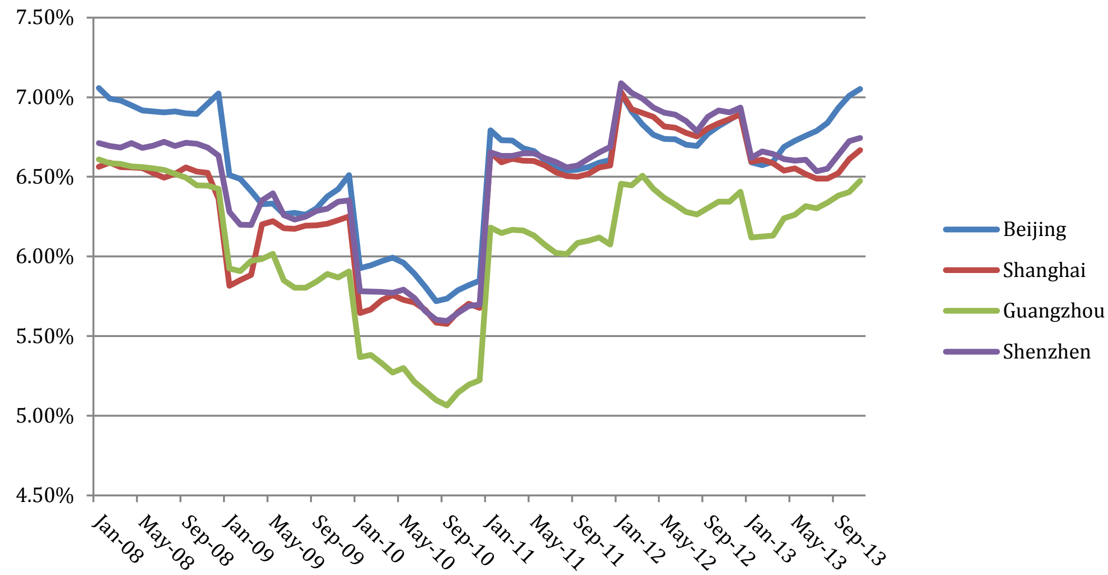
Following method of McCarthy and Peach, estimated expectations in four markets are calculated as shown in Figure 13 and Table 16. Based on equation $\pi^e = (\lambda r + m + \delta + \beta) - R_t/P_t$, appreciation expectations are estimated with average house prices, annual rents, mortgage interest rates from Table 14, maintenance, depreciation and risk premium[71]. Notably, estimated expectations plotted in Figure 13 are expectations of house value in next year though data is in monthly frequency and the estimates of expected appreciation are nominal appreciation rates excluding inflations.

For calculated from user cost formula estimates of expectation in Figure 13 reflect by how much households should expect house prices to go up if costs and benefits are in balance given house prices and rents. So expectations displayed here are rational expectations based on no arbitrage condition between owning and renting. Correlated with each other, estimated expectations among the four markets all maintain at high levels with lower bound 5% while Guangzhou contains the lowest expectation among four markets and so is the mean expectation of Guangzhou. The low estimates of expectation in Guangzhou market are consistent with low mean values of price-income ratio, price-rent ratio and imputed-actual rent ratio in Guangzhou as shown in Table 7, Table 11 and Table 15. This consistency among different matrices also happens on Beijing market that displays high values in tables above. This indicates that it is very likely to reach same result of existence of bubble whichever way one uses- price-income ratio, price-rent ratio, impute-actual rent ratio or expectation examine.

---

[70] By inserting proper parameters in user cost formula $R_t = P_t\left[(1-\tau)(r+p)+m+\delta+\beta-\pi^e\right]$, appreciation expectation π^e is derived (McCarthy & Peach, 2004).

[71] As aforementioned, maintenance rate m and depreciation δ are totally 2.5% and risk premium β is 2% while percentage of loan in total house value λ is approximated as 70%.



Source: Calculated from data of China Real Estate Index System, mortgage interest rate from China's bank system

Figure 13 Expected appreciation from user cost formula 2008 Jan-2013 Nov

Table 16 Descriptive statistics of expected appreciations

	Maximum	Minimum	Mean	Standard deviation
Beijing	7.06%	5.72%	6.57%	0.38%
Shanghai	7.03%	5.58%	6.38%	0.40%
Guangzhou	6.61%	5.06%	6.07%	0.44%
Shenzhen	7.09%	5.59%	6.48%	0.40%

According to McCarthy and Peach (2004), overheating may exist in housing market if nominal appreciation of house prices largely outrun composite purchase index. Thus the fact that calculated expectations leave far beyond inflation rates as seen in Table 14 indicates probability of bubble in the four markets.

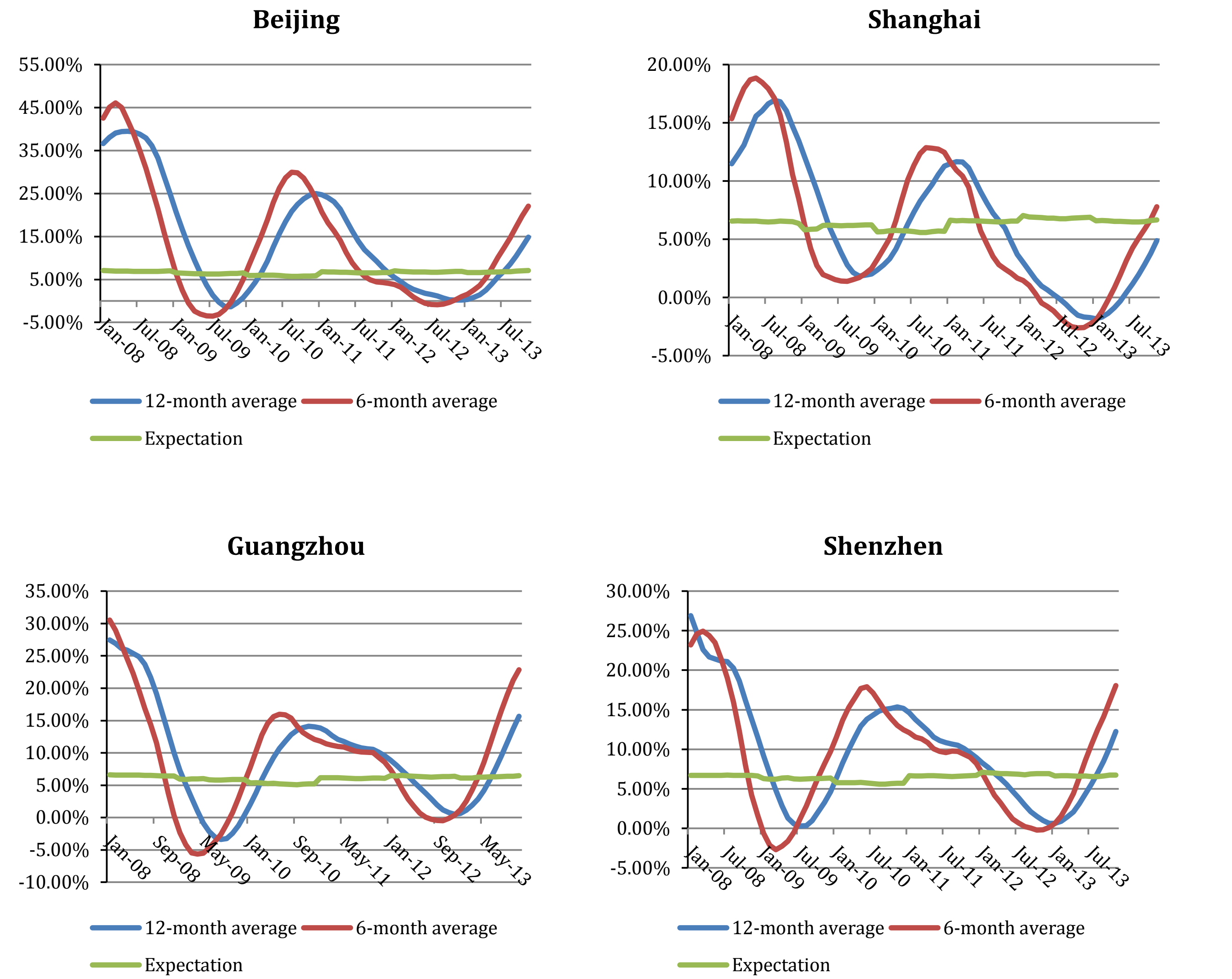
However, homebuyers' expectations are formed by not only rational compare between cost and return of owning but previous appreciations. So expectations are affected by both rational measure of costs and benefits of house purchase and adaptive response to past actual appreciations (Hattapoglu & Hoxha, 2013; Shiller, 2005). Unfortunately real expectations of households in the four markets can hardly be shown in any way due to data limitation and heterogeneity across homebuyers. Whereas it is of interest to show another source of expectation formation-past actual appreciations as seen in Figure 14 where 12-month and 6-month average percentage changes together with estimated expectations are presented. Compared with rational estimates of expectation, 12-month and 6-month moving averages of house appreciation are much wavier. Since both rational expectations and actual appreciations have impacts on real expectations it can be boldly inferred that actual appreciations and calculated expectations have same large influence on real expectations. As shown in Figure 15 beside short-term of expected appreciation around zero in Guangzhou, homebuyers in four markets believe appreciation in house value for the past four years. Due to data unavailability, compare between current China's housing market and bubble-phase US market on expectation is carried between current China and admitted no-bubble-period US[72] 1991-2001. Expected appreciations in 90s US displayed steady down-going in those ten years[73] while expected appreciation stayed positive in recent years and even displayed notable ascents in recent months. This contrariety, to some extent, provides counter-evidence of no bubble in China housing market.

Furthermore, inverse effects of expectation on house price are always referred to in feedback loop theory of increasing house prices that result in bubble. Strong belief of appreciation leads to rising demands for house and given certain housing supply large part of growing demands would be left unsatisfied, which makes house prices further climb up. On the other hand, high appreciation expectation will positively affect regional economic production as proposed by

[72] Many previous studies proposed that there is no evidence of bubble in US housing market during 90s (Smith & Smith, 2006; Glaeser, et al., 2008). Furthermore, in other papers US house prices in 90s are regarded as criteria with which prices are compared to test bubble.

[73] See Chart 9 in McCarthy and Peach, 2004.

Miller et al. (2011)[74]. The subsequent better performance of local economy undoubtedly puts more pressure on increase of house prices as more households will move to productive area.



Source: calculated from monthly increase of residence index (CREIS) from same month last year

Figure 14 12-month and 6-month average actual expectations Jan08-Nov13

[74] Miller et al. used home sales as proxy of anticipated house values and regressed gross metropolitan production (GMP) per capita on home sales. Their results indicated that home sales positively granger cause GMP.

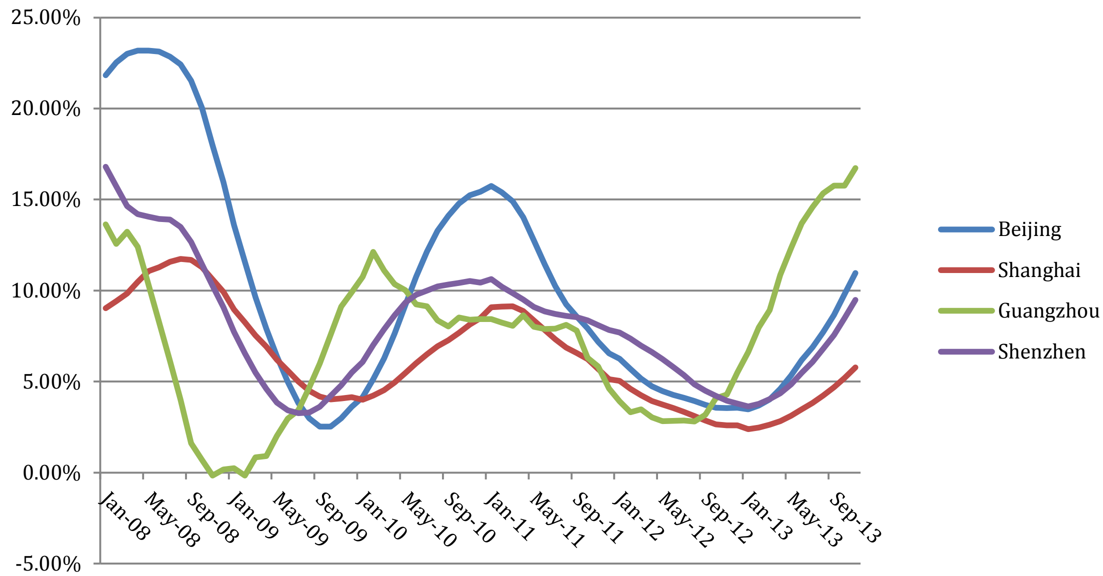
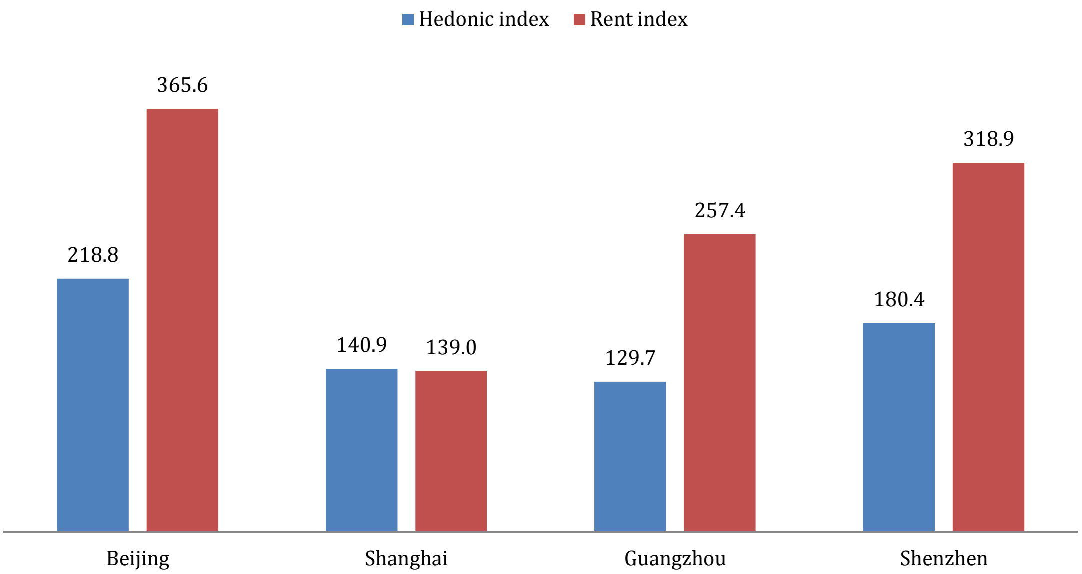


Figure 15 Mean of 12-month average actual appreciation and calculated expected appreciation

One restriction about analysis based on expectations is that expectations calculated from user cost formula might overestimate expectation rates for following two reasons. One is that owning is much preferred than renting in China as variation of rents is larger than that of house prices as seen in Figure 16. Due to more risk of renting and lack of social housing system, households in China tend to make tenure choice between buying and renting. Thus annual user cost of owning for Chinese households should be smaller than $\lambda r + m + \delta + \beta$ as owning brings extra utilities to homeowners. The other reason for overestimation is that mortgage interest rates are often lower than those in Table 14 because homebuyers can receive discounts on interest rate when down payment exceeds certain percentage of total value[75].

[75] Discount for mortgage interest rate ranges from 0.9 to 0.95 of standard rates in Table 14 and some banks like Agricultural Bank of China and Bank of China provide discount 0.85 of standard rates to homebuyers that buy house for first time.



Source: calculated from data of China Real Estate Index System

Figure 16 Comparison of standard deviations of Hedonic index and rent index

To summarize, there are three aspects of expected appreciation that support existence of bubble. First, estimates of expected appreciation from user cost formula are obviously higher than inflations in corresponding years. Second, compared with expected appreciations derived also from user cost formula for US market during 1991-2001 when there was no bubble, expected appreciation of Chinese housing markets displays strong ascending trend that is contrary to steady down-going in no-bubble US market. Third, positive effects of growing expectation on housing demand, through regional production or not, will push up house prices. Therefore, based on performance of expected appreciation in recent Chinese market with high possibility overpricing is present in the four housing markets.

6 Verify Bubble in Housing Market

After presenting evidence of from analysis of conventional matrices this section will further verify bubble through cointegration model that is originated from Stiglitz's definition of bubble and has been widely used in previous literature of housing bubble. In this section, selected variables and interactions among them are first introduced. Then statistical methods of ADF/CADF and panel cointegration test are demonstrated in detail. The last two parts will show results of tests above and present analysis based on those results.

6.1 Correlation matrix of selected variables

As mentioned in section The Data, there are totally eight variables selected in this paper and excluding house price index and average house price the other six economic variables will be used in following tests on bubble in Chinese major housing markets. Here reasons of choosing these variables are briefly explained. First, as an important variable rent always accompanies house price in previous studies of housing bubble and high house prices relative to rent indicate overpricing in market so rent index is included in following model. Second, vacant dwelling is chosen because it is estimate of excessive supply over demand and vacant dwelling also reflects inelasticity of supply[76] given incumbent demand in housing market. Third, as stock market provides alternative for investors and smart money always flows between stock market and housing market in China Shanghai stock exchange index needs to be taken into account to compare housing market with national stock market[77]. Fourth, local GDP and income are two indicators of housing demand that represent housing affordability and economic performance

[76] Paciorek (2013) suggested that inelasticity of housing supply is significant in explaining house price volatility among variables like construction cost, regulatory index and density of housing etc..

[77] Shiller (2005) proposed that normal market volatilities always flares up in both stock market and housing market so if trend of house price obviously departs from that of stock index then boom of house price may not be a normal one, see *Irrational Exuberance* p17.

respectively. Last but not least, due to data availability construction cost is hardly collected so land purchase is used as a proxy of construction cost[78].

Table 17-20 report correlation coefficients[79] among selected variables of the four cities. It can be seen from matrices below that house price index and average house price both display significantly positive correlation with rent index (0.84-0.96). This is quite consistent with positive mutual influence between house price and rent- one always tangles with the other. Also the positive correlation between house price index and stock exchange index (0.04-0.10) conforms to the logic that investors always switch to other asset market when house price is thought to be too high to exploit investment opportunity. Whereas the small values of coefficient may suggest that speculative investment is not large part of aggregate housing demand.

According to theoretical hypothesis, correlation between house price and variables like local GDP and disposable income should be strongly positive while that between house price and vacant dwelling should be negative as vacant dwelling reflects excessive housing supply. However, correlations between house price and vacant dwelling in the four cities are all notably positive ranging from 0.26 to 0.77. Hui and Yue (2006) presented same correlation matrix for Beijing and Shanghai with monthly data 2001-2003 and correlation between house price and vacant dwelling was then strongly negative for Shanghai. So counter-theory results shown in correlation matrices provide circumstantial evidence that there exist bubbles in the four housing markets especially Shenzhen.

[78] A survey conducted in 2008-2010 shows that land purchase is the largest part of construction cost, 54%-55%, the second largest source of cost is value-added tax 10%-15% and the rest includes construction material 20% and infrastructure facilities. Links to survey results are http://sjz.house.qq.com/a/20120213/000016.htm and http://house.people.com.cn/n/2013/1203/c164220-23724142-3.html (in Chinese).

[79] The mathematical formula for computing correlation coefficient is $r = \frac{\mathrm{Cov}(X,Y)}{\sqrt{\mathrm{Var}(X)}\sqrt{\mathrm{Var}(Y)}} = \frac{n\sum XY - \sum X \sum Y}{\sqrt{n(\sum X^2)-(\sum X)^2}\sqrt{n(\sum Y^2)-(\sum Y)^2}}$.

Table 17 Correlation matrix for Beijing 2006-2013

	HP	RENT	VAC	STOCK	rHP	LP	GDP*	INCOME*
HP	1	0.94	0.37	0.07	0.96	0.26	0.73	0.92
RENT		1	0.58	-0.05	0.95	0.20	0.69	0.96
VAC			1	-0.36	0.47	0.05	0.56	0.75
STOCK				1	0.01	0.05	-0.23	-0.16
rHP					1	0.26	0.57	0.69
LP						1	0.42	0.91
GDP							1	0.28
INCOME								1

Here and after, "*" means the last two columns are correlation coefficients from quarterly data while entries in other columns are from monthly data. HP is house price index, VAC is quantity of vacant dwelling, STOCK is Shanghai stock exchange index, rHP is real house price, LP is land purchase, GDP is four cities' local gross product and INCOME is disposable income per capita.

Table 18 Correlation matrix for Shanghai 2006-2013

	HP	RENT	VAC	STOCK	rHP	LP	GDP*	INCOME*
HP	1	0.84	0.47	0.04	0.94	0.25	0.55	0.82
RENT		1	0.58	0.05	0.82	0.15	0.53	0.79
VAC			1	-0.34	0.60	-0.02	0.45	0.75
STOCK				1	-0.07	-0.01	-0.01	-0.10
rHP					1	0.24	0.55	0.85
LP						1	0.19	0.02
GDP							1	0.40
INCOME								1

Table 19 Correlation matrix for Guangzhou 2006-2013

	HP	RENT	VAC	STOCK	rHP	LP¤	GDP*	INCOME*
HP	1	0.90	0.26	0.10	0.98	0.14	0.94	0.78
RENT		1	0.54	-0.11	0.92	0.11	0.94	0.78
VAC			1	-0.40	0.27	-0.01	0.49	0.45
STOCK				1	0.08	0.06	-0.20	-0.08
rHP					1	0.14	0.94	0.77
LP						1	0.30	-0.06
GDP							1	0.70
INCOME								1

"¤" means for housing market in Guangzhou and Shenzhen entries in the column are correlations between land purchase and any other variables from Jan2008 to Oct2013 since land purchase for the two markets 2006-2007 is missing.

Table 20 Correlation matrix for Shenzhen 2006-2013

	HP	RENT	VAC	STOCK	rHP	LP¤	GDP*	INCOME*
HP	1	0.96	0.77	0.07	0.95	0.10	0.89	0.82
RENT		1	0.84	0.02	0.96	0.07	0.90	0.83
VAC			1	-0.15	0.75	-0.02	0.85	0.76
STOCK				1	0.06	-0.01	-0.24	-0.13
rHP					1	0.13	0.87	0.80
LP						1	0.11	-0.14
GDP							1	0.69
INCOME								1

6.2 Methodology

Although some abnormalities are found in correlation matrix they are not enough to justify existence of bubble. Here cointegration test is chosen to justify bubble in housing market because it is originated from the most widely applied definition of bubble that bubble emerges when house price deviates from economic fundamentals. On the other hand, cointegration test has been applied in previous literature on housing market and results of those implemented tests conform well to bubble that had happened in housing markets of US and Hong Kong (Gallin, 2006; Hui & Yue, 2006; Arshanapalli & Nelson, 2008; Mikhed & Zemcik, 2009). The last also the most important reason for using cointegration test especially panel cointegration test is that the small sample of the four markets (monthly 2006-2013) might lead bias[80] in conventional ADF unit root test and possible strong correlation between house prices in these markets will make panel cointegration test more valid than ADF test.

Conventional cointegration test is based on unit root test, namely Augmented Dickey-Fuller test (ADF). ADF test is based on equation below where Y_t is time series and t is time trend that is

[80] Small sample size always make it more possible that ADF test shows rejection on null hypothesis of unit root, in other word, conclusion of no-cointegration may result from small sample size not from actuality.

optional in this regression. Null hypothesis is that $\delta = 0$ and alternative is that $\delta < 0$ that implies Y_t is a stationary trend without unit root.

$$\Delta Y_t = \beta_0 + \alpha t + \delta Y_{t-1} + \gamma_1 \Delta Y_{t-1} + \gamma_2 \Delta Y_{t-2} + \cdots + \gamma_p \Delta Y_{t-p} + u_t$$

Definition of cointegration is stated as following: suppose both X_t and Y_t are integrated of order one[81], if for some coefficient θ, $Y_t - \theta X_t$ is integrated of order zero, then X_t and Y_t are said to be cointegrated (Stock & Watson, 2007).

To conduct cointegration test, the first thing is to test of which order each variable is integrated. Then if they are integrated of the same order, regression above will be proceeded to get t statistic for coefficient δ. Only when t statistic of δ is smaller than corresponding critical value the two time series are cointegrated.

Method of cointegration followed in this paper is, however, different from the conventional method. As aforementioned, variables like house price and rent in this panel data are very likely to be correlated across different sections and small sample size may lead to bias of test result. So following Mikhed and Zemcik (2007, 2009) cointegration test applied here is oriented to panel data and robust to small sample size.

The first part of cointegration test in this paper is cross-sectional dependence test (CD test) introduced by Pesaran (2004). Objective of CD test is to see whether there is significant dependence across sections in panel data and if there is cross-sectional dependence the second part of testing the integrated order of individual variables will take cross-sectional dependence into account, namely, cross-sectional ADF test (CADF test) which was proposed by Pesaran (2007). But if cross-sectional correlation is not significant ADF test will still be used. After ADF (CADF) test, variables integrated of same order will enter into cointegration test. The second

[81] If time series Y_t contains unit root and first difference of Y_t (ΔY_t) does not contain unit root, namely stationary then Y_t is said to be integrated of order one.

part of test is panel cointegration test presented by Pedroni (1999) and also used by Maddala and Wu (1999) and Gallin (2006). See Appendix 2-4 for details of derivation of test statistics and corresponding critical values.

6.3 Cointegration test

6.3.1 Cross-sectional dependence tests

Cross-sectional dependence test is conducted on following variables: house price index, rent index, vacant dwelling, quarterly average house price, local GDP and disposable income. Notably, real house price is used here to compare with local GDP and disposable income both of which are in unit of Yuan so it is converted from monthly data to quarterly in order to align with frequency of local GDP and disposable income. And stock exchange index is not cross-sectional data so CD test is not applicable for stock index.

For each variable, CD test is conducted as demonstrated in Appendix 2 and results of tests are shown in Table 21. As CD statistic is asymptotically normally distributed under 5% significance level null hypothesis of no cross-sectional dependence is rejected for all tested variables as shown statistics are all absolutely larger than 1.645. Especially, most variables other than income display strong dependence across sections as test statistics of them are significant even under 1% level with critical value 2.326. The most possible reason underlying this strong dependence is that the four markets are under influence of common governmental policies and uniform financial system two of which have impacts on housing supply and demand respectively. Moreover, the four economic entities cooperate in so many aspects that GDP of the four areas are highly correlated. Because of dependence in GDP and income workforce flow across the four areas, as a result house prices and rents display positive correlations meanwhile. It can be seen from Table 21 that dependence in rent is larger than that in house price which is because renting market is impacted by economic factors more than owning market since transaction of rental units is more unconstrained and frequent than that of owning units.

Table 21 Results of CD tests

	HP	RENT	VAC	qHP	GDP	INC
CD statistic	5.698	7.294	8.189	2.859	6.309	2.164
Result	Y	Y	Y	Y	Y	Y

Y means there is cross-sectional dependence and N means there is no significant correlation among sections.

6.3.2 Cross-sectional ADF tests

Because of strong dependences of selected variables across the four markets cross-sectional ADF test will be used to see if variables above are integrated of the same order. While as stock exchange index is not panel data ADF test is applied to stock index. Result of ADF test on stock index is that t-value for series of stock index is -2.834 that is small enough to reject null hypothesis of unit root under significance level 10% (-2.57) but not under 5% (-2.86) and 1% (-3.43) while t-value for first difference of stock index is -3.539 that is small enough to reject unit root under all significance levels[82]. Since series of stock index is not stationary but first difference of it is stationary it can said that series of stock index is integrated of order one, denoted as I(1).

On the other hand, results of CADF tests in Table 22 show that series of selected variables are all in process I(1) as group t-values of their first differences is small enough to reject unit root whereas group t-values of initial series are much larger than corresponding critical values[83]. What is noteworthy is that for the first four variables group t-value is computed from regression formula with both intercept and time trend and critical values is at 5% significance level while for the last three quarterly variables regression formula is without intercept or time trend and group t-values are compared with critical values at 10% significance level. For number of observation of

[82] Critical values used here are for regression formula with only intercept.

[83] Critical values are referred to in Appendix 3 CADF test.

the three variables-average house price, local GDP and income-is quite small (31*4) result of CADF test is very like to be non-stationarity whereas this may only result from small sample size instead of stochastic process really contained in dataset of these variables. Therefore, significance levels for test statistics are all loosened to 10%. And dropping time trend is because group t-values become larger than all critical values for both initial data and their first differences so of which order series of variables are will not be available. Thus without any harm, time trend for qHP, local GDP and INC is eliminated in CADF tests[84]. In a summary, all variables of interest are shown to contain process I(1) which implies that cointegration test is allowed to conduct between house price or house price index and any mix of other economic variables.

Table 22 Results of CADF tests

	STO¤	HP	RENT	VAC	qHP*	GDP*	INC*
Group t-value	-2.834	-2.378	-2.092	-2.321	-1.252	-0.468	-0.955
Result	N	N	N	N	N	N	N
Group t-value diff(1)	-3.539	-4.464	-5.426	-5.217	-3.057	-2.594	-2.392
Result	Y	Y	Y	Y	Y	Y	Y

Y means that null hypothesis of unit root is rejected, that is, tested series is stationary while N means that the series is non-stationary. "¤" means that test statistic for stock index is conventional ADF t-value not group t-value. "*" means group t-value is smaller than the critical value under 10% significance level while those without mark "*" means group t-value is smaller than critical values under 5% or even 1%.

6.3.3 Cointegration tests

In this section panel data cointegration test is conducted to check whether house price shares common stochastic trend with other economic fundamentals of interest in the model. As aforementioned, local GDP and disposable income are quarterly data and units of the two variables are both Yuan instead of index. So real house price, after having been converted to

[84] Variables qHP, local GDP and income later will enter cointegration test so dropping time trend for all of them in CADF test does not leave big influence in now or later results since what CADF tells is just whether variables are integrated of same order.

quarterly data, is used in the cointegration test with local GDP and income[85]. Since the other variables, house price index, rent index, vacant dwelling and stock index, are all monthly data panel cointegration test in this paper consists of two parts: one is between monthly data house price index and rent index, vacant dwelling and stock index; the other is between quarterly data average house price and local GDP and disposable income.

Results of the two-part test are shown in Table 23. In both parts intercept and time trend are included in regression formula and because the number of regressor is three and two in each part critical intervals are different in table below. According to Pedroni (1999) the test statistic is asymptotically normal distributed so with null hypothesis of cointegration if computed statistic is outside critical interval hypothesis is rejected, in other word, divergence of movements in regressand and set of regressors is so significant that they are not cointegrated. Since results of panel cointegration test show that house price (index) is not cointegrated with combination of non-stationary fundamentals.

Table 23 Results of panel cointegration test

	Test statisitc	Critical interval	Result
HP~RENT, VAC and STO	-6.264	(-3.727, -2.631)	N
qHP~GDP and INC	-7.276	(-3.427, -2.317)	N

N means null hypothesis of unit root in panel dataset cannot be rejected, that is, house price (index) is not cointegrated with right-hand variables while Y means the other way around. Computation of test statistic and critical intervals referred to are in Appendix 4.

Apart from economic variables in cointegration test, construction cost is such an important fundamental that cannot be ignored when talking about housing bubble. As mentioned in section

[85] All of house price, local GDP and disposable income are in nominal values. Boldly it is assumed there is no harm to use nominal data because including inflation will not make big difference on result of cointegration test.

6.1, due to data availability land purchase is used as proxy of construction cost[86]. The reason why land purchase is not included in tests above is that data of land purchase dates from January 2008 and including land purchase implies sample time spread will have to shrink 24 months which is very likely to lead to bias of test result. Another more important reason of excluding land purchase is that house price is obviously divergent from land purchase in both graphic and statistical perspective so overheating of house price is apparent just from view of land purchase. Seen in Figure 17 remarkable ascents are seldom observed in land purchase as in house price especially for markets in Guangzhou and Shenzhen where land purchases are as small as zero in disconnected 24 months and 46 months respectively. Explanation for depression in land market of Guangzhou and Shenzhen is that after rapid urban development in early 2000s land available for residential use becomes scarce in recent years[87]. The lack of available land further drives up house prices as both developers and homebuyers, namely supply and demand sides, realize that house supply cannot adjust to demand even if housing demand keeps constant in the two markets. And house price tends to react more quickly to market disparity than do land price, regardless of land policies (Du, et al., 2011) house price thus has left far behind land purchase in Guangzhou and Shenzhen as seen in Figure 17. Therefore, since there is no simultaneous upward trend shown in land purchase along with ascent in house price the latter cannot be cointegrated

[86] The appropriateness of putting land purchase is based on the fact that land purchase has been the biggest part of house cost and house price in China these years as explained in footnote 78. And construction cost is always peroxided by other measures like construction employment or building worker salary whatever that catches the most part of construction cost.

[87] Notably, data for land purchase here is subject to residential use excluding land parcels for offices and shops and due to protection of cultivated land available land gets rare.

with land purchase[88], that is, land purchase is not able to justify high house prices in Guangzhou and Shenzhen.

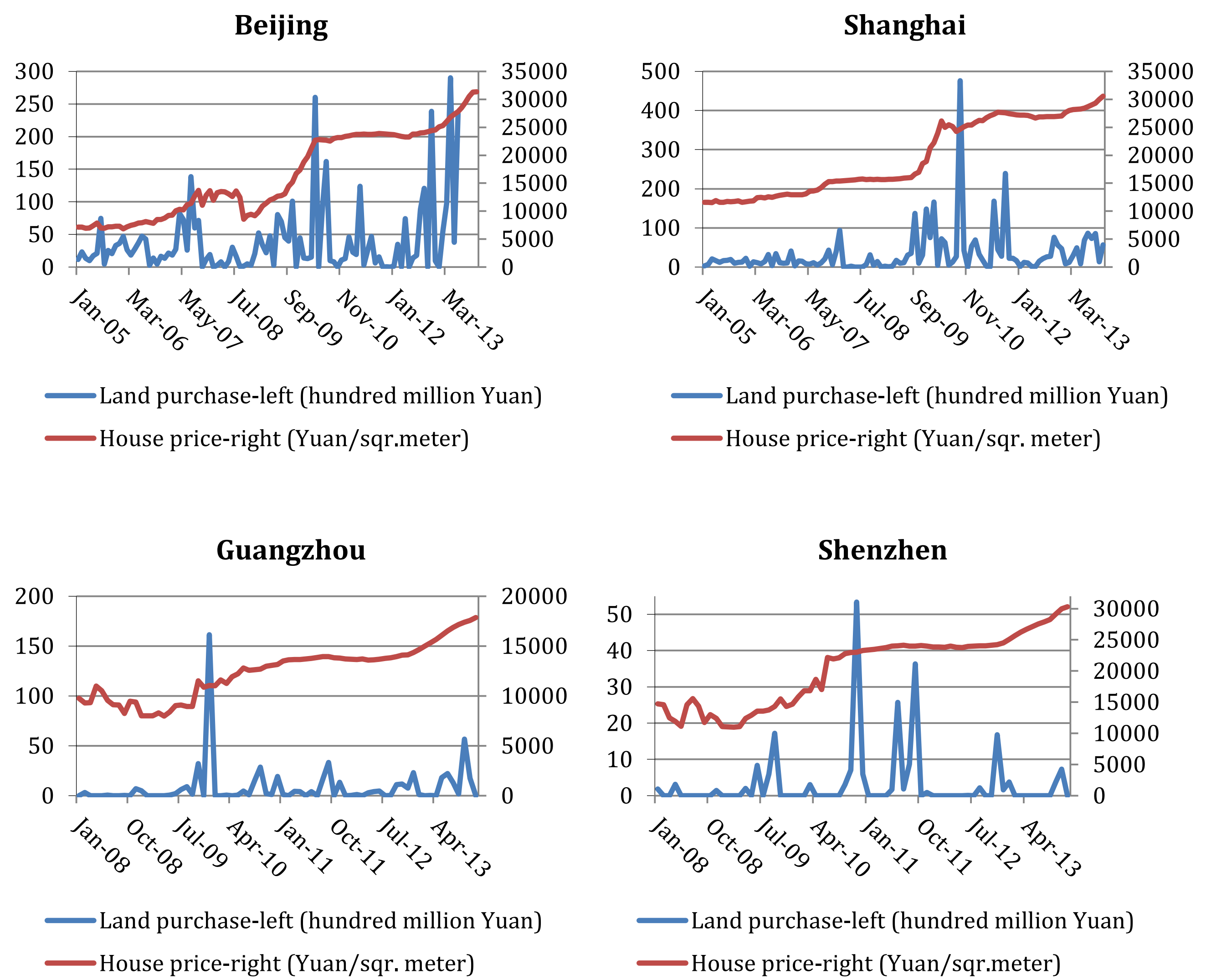


Figure 17 House price vs. land purchase in four cities Jan05-Nov13[89]

[88] Because of too many values of zero in land purchase, ADF in R program cut those zero values which shorten the sample size and lessen reliability of the test so ADF test is not applicable here.

[89] Collection of data for land purchase in Guangzhou and Shenzhen started from 2008 so data prior to that is missing for the two markets.

Regarding Beijing and Shanghai, as discrepancy between house price and land purchase is not so large as in Guangzhou and Shenzhen conventional ADF test is used here to show stationarity of series of the two variables in each city. Notably, for there are not so many zero values in land purchase of Guangzhou ADF test is applied to this market but Shenzhen is excluded since 36 months of zero land purchase make ADF test risky. Results of ADF tests in Table 24-26 show that time series of real house price in all three markets are not stationary for initial value while first differences of it are stationary, which is consistent with result of CADF test on house price index. On the other hand, time series of land purchase displays a stationary process in all subject markets. According to Mikhed and Zemcik (2007), when left-hand variable is non-stationary and right-hand variable is stationary there is clearly a bubble in this case[90]. Thus beside factual evidence from graphs above, ADF tests here provide statistical evidence of bubble in markets of Beijing, Shanghai and Guangzhou. Conclusion of bubble from ADF test in the three markets makes it convincing that there is overpricing relative to land purchase in Shenzhen since in Figure 17 divergences between house price and land purchase in other three markets are much flatter than that in Shenzhen.

Table 24 ADF test for real house price and land purchase Beijing Jan05-Nov13

	Sample size	Lag order	t value	Results
rHP	107	3	-0.838	N
diff(rHP)	106	2	-4.589	Y
LP	107	2	-3.979	Y

[90] Mikhed and Zemcik suggested a strategy of determining whether there is bubble and applied it into bubble test in housing market. In statement of this strategy, left-hand and right-hand variables were first referred as house price and cash flow of owning respectively.

Here and after, Y means that series tested is stationary and N means non-stationary. Critical values used are consistent with former ADF tests in this paper: -2.57 (10%), -2.86 (5%) and -3.43 (1%) and significance level is set as 5%.

Table 25 ADF test for real house price and land purchase Shanghai Jan05-Nov13

	Sample size	Lag order	t value	Results
rHP	107	4	-0.507	N
diff(rHP)	106	3	-4.112	Y
LP	107	2	-3.835	Y

Table 26 ADF test for real house price and land purchase Guangzhou Jan08-Nov13

	Sample size	Lag order	t value	Results
rHP	71	2	-0.087	N
diff(rHP)	70	4	-3.276	Y
LP	71	2	-4.266	Y

6.4 Preliminary Analysis

In this section, cointegration model is constructed on panel dataset of house price and other economic fundamentals in four housing markets. A series of tests have conducted and results show that there is bubble in Chinese major housing markets. This result is basically consistent with those implied from analysis of three conventional ratios and same with results of previous empirical studies on Chinese housing markets (Hui & Yue, 2006; Dreger & Zhang, 2010; Wu, et al., 2012) though approaches used here and previous are not exactly same[91].

In this model there are four steps to reach final result. First, correlation matrix is presented to demonstrate relation between house price and selected fundamentals and reasons why they are included into model. Nearly all those variables have significant correlations with house price and abnormalities shown in correlation coefficients also foreshadow existence of bubble. Second, as point check cross-sectional dependence test (CD) is done to determine if subsequent unit root test should be conventional ADF test or panel ADF test. Results of CD test give strong sectional

[91] Methods conclusions of these scholars are stated in section Literature Review.

correlations for variables of interest thus cross-sectional ADF test (CADF) is chosen then. Third, as another check point CADF test determines if selected variables are integrated of same order with house price, that is, if they can enter final cointegration test. Results of CADF test show that variables are consistently integrated of order one[92], which indicates that they can smoothly enter panel cointegration test. Finally, panel data cointegration test is conducted for two groups of panel dataset due to different data frequencies. Final results of this cointegration model show that house price is not cointegrated with economic fundamentals. Additionally, excluded variable land purchase is shown not to share any common trend with house price from both appearances of graph and ADF statistics. As a whole, cointegration model above exposes evidence of bubble in Chinese major housing markets.

The main restriction of this model is that because of data availability, final panel cointegration test has to be segmented into two groups. Cointegration test between house price and entire set of fundamentals may diminish likelihood of unit root in panel data of residuals thus the possibility that house price is cointegrated with whole set of fundamentals is left as black alley in this maze. Whereas large deviations of test statistic of panel cointegration test from critical interval leave little room for this possibility because according to Mikhed and Zemcik (2007) test statistic can be indicator of bubble then the farther test statistic is from critical interval the bigger housing bubble is. So such remarkable bubble can hardly disappear just because variables are combined together in cointegration test. Another restriction is that there might be bubble in economic fundamentals used in this model e.g. local GDP or rent which will make these variable unqualified as fundamentals. However, this caveat does not need much attention as result has shown that house price deviates from these fundamentals, in other word, if there is bubble in any

[92] Usually first difference or logarithm of non-stationary data will become stationary series in unit root test.

fundamental the result will not change and it furthermore implies that bubble in housing market is larger than that in some other fundamental.

7 Conclusion

Discussion of this paper starts from various strands of bubble definition among which definition featured by deviation from economic fundamentals is chosen as start point of subsequent analysis. To answer the question whether there is bubble in Chinese major housing markets this paper presents four main perspectives of testing bubble in housing market. The first three perspectives are three conventional matrices: price-income ratio, price-rent ratio and imputed-actual rent ratio. The last perspective is based on panel data cointegration test that detects housing bubble statistically.

Analysis on price-income ratio includes ADF test and comparison with price-income ratio of US housing market during its bubble phase. Results of the former ADF test shows that the ratio in all of the four major markets is unpredictable and comparison with US market further confirms high house price relative to income by showing that recent increases of price-income ratio in Chinese four markets are larger than US national level and deviations from trend are also comparatively striking in markets of Beijing and Shanghai. Analogously, ADF test and comparison between China and US are preceded on price-rent ratio. Slightly different from findings of price-income ratio, ADF test shows that only Beijing and Shanghai contain non-stationary price-rent ratio, on the other hand, only recent increase of the ratio in Beijing exceeds that of US national market in its bubble phase. Notably, any conclusion of no bubble from stationary price-rent ratio in Guangzhou and Shenzhen is conserved here because there is no big difference between rental units and owner-occupied units in China and rent always crawlingly pegs on house price. This interaction leads to seeming stationary price-rent ratio that conceals possibility that both rent and house price are too high.

Analysis on imputed-actual rent ratio is based on the renowned user cost formula from which imputed rent of equilibrium market is derived. Comparison between China and US shows that absolute values of imputed-actual rent ratio in Chinese major markets have all exceeded those striking levels of US durin its bubble-shaping period. Also from user cost formula expected appreciation rate is computed for the four markets. It is found that expected appreciation has been higher than inflation rate with large margin in China for recent years and roughly compared with expected appreciation of US in no bubble period expectation in Chinese housing market maintains at high levels with frequent fluctuations whereas expectation in no-bubble US market experienced steady descent.

Beside three ratios above, a panel cointegration model is constructed to answer whether there is bubble from statistical viewpoint. This cointegration model consists of a series of tests and in final panel cointegration test null hypothesis of no cointegration between house price and other economic fundamentals, namely no bubble, is rejected. To complement set of economic fundamentals, additional test between house price and land purchase is conducted and conclusion reached is also that house price largely deviates from land purchase.

In a summary, according to results of cointegration model together of all findings of the three ratios the answer to research question of this paper is that there is bubble in Chinese major housing markets. Some questions might emerge right after this conclusion, such as how large the bubble is and whether or when it will burst in the future. Since time spread of dataset is as short as 8 years and any break on the short sample period for longitudinal compare would lead to invalid result. Thus unfortunately, issue of bubble size is beyond discussion scale in this paper. Regarding explosion of bubble, a bold suppose here is that housing bubble in Chinese market will not crash down in near future. Two reasons underlying this suppose are inelastic demand and exuberant aggregate economy: unlike speculative behavior in US bubble housing demand in China are mostly constituted of owner-occupying demand instead of investment demand so house price can hardly crash down when homebuyers are not sensitive to changes of price and exuberance may lead to overheating in some industries of an economy like bubbles in boiling water. Therefore, the housing bubble justified in this paper will not explode in near future.

Appendix 1 AIC and BIC

Akaike information criteria and Bayesian information criteria are usually used to choose the most proper number of lags for auto-regression:

1. Regress first AR(1) $\Delta y_{it} = \mu_i + \alpha_i y_{i,t-1} + \sum_{j=1}^{p_i} \lambda_{ij} \Delta y_{i,t-j} + \varepsilon_{it}$ where p_i=1 and save sum of squared residual (SSR) from this regression.
2. Compute value of AIC and BIC from

$$AIC = log(SSR/T) + (p + 1) * 2/T$$

$$BIC = log(SSR/T) + (P + 1) * log(T)/T$$

   where T is the number of observation.
3. Repeat steps 1 and 2 for p=2, 3, 4, …, 10 then compare ten values of AIC and BIC and choose the p that corresponds the smallest value of AIC and BIC as the number of lags. What is noteworthy is that if result of AIC and BIC are different always choose result of AIC since AIC always refers to more lags than BIC. In order to include as much previous information as possible, more lags are better than less.

Appendix 2 CD test

Cross-sectional dependence test (CD test):

1. Run regression below and save estimated residuals for later use

$$\Delta y_{it} = \mu_i + \omega_i t + \alpha_i y_{i,t-1} + \sum_{j=1}^{p_i} \lambda_{ij} \Delta y_{i,t-j} + \varepsilon_{it}$$

   where p_i is lag order that is determined by AIC/BIC introduced above and t is time trend.

2. With estimated residuals, test statistic CD can then be computed with following equation

$$CD = \sqrt{\frac{2T}{N(N-1)}} \left(\sum_{i=1}^{N-1} \sum_{j=i+1}^{N} Corr(\hat{\varepsilon}_i, \hat{\varepsilon}_j) \right)$$

   where T is number of observations for each variable and each section, N is the number of sections and $\hat{\varepsilon}_i$ is saved estimated residuals for regression of variable in section i.

3. Compare computed CD statistic with following critical values, reject null hypothesis of null cross-sectional dependence if CD is absolutely larger than critical values: 1.282 (10%), 1.645 (5%) and 2.326 (1%).

Appendix 3 CADF test

Cross-sectional Augmented Dickey-Fuller test (CADF test):

1. Run regression below and save t statistic for coefficient for later use

$$\Delta y_{it} = \mu_i + \omega_i t + \alpha_i y_{i,t-1} + \sum_{j=1}^{p_i} \lambda_{ij} \Delta y_{i,t-j} + \upsilon_i \bar{y}_{t-1} + \sum_{j=0}^{p_i} \varpi_{ij}\, \Delta \bar{y}_{i,t-j} + \epsilon_{it}$$

   where p_i is lag order, t is time trend and $\bar{y}_{t-1}$ is average of variable y across sections at the same time t.

2. Group t statistic for CADF test is

$$\bar{t} = \frac{1}{N}\sum_{i=1}^{N} \tilde{t}_i(N,T)$$

   where T is number of observations for each variable and each section and N is the number of sections.

3. Compare $\bar{t}$ with following critical values, reject null hypothesis of unit root if $\bar{t}$ is smaller than critical values (T=100, N=10, with intercept and trend): -3.41 (10%), -3.72 (5%) and -4.35 (1%) and (T=30, N=10, without intercept or trend): -2.29 (10%), -2.66 (5%), -3.40 (1%).

Appendix 4 Panel data cointegration test

Panel data cointegration test:

1. Estimate panel data regression below and collect the residuals $\hat{e}_{i,t}$ for later use

$$y_{i,t} = \alpha_i + \delta_i t + \beta_{1i} x_{1i,t} + \beta_{2i} x_{2i,t} + \cdots + \beta_{Mi} x_{Mi,t} + e_{i,t}$$

where T refers to the number of observations over time, N refers to the number of individual members in panel dataset, and M refers to the number of regression variables excluding intercept and time trend.

2. Compute group t statistic below.

$$N^{-1/2}\tilde{Z}_{t_{N,T}} \equiv N^{-1/2}\sum_{i=1}^{N}\left(\hat{\sigma}_i^2\sum_{t=1}^{T}\hat{e}_{i,t-1}^2\right)^{-1/2}\sum_{t=1}^{T}\left(\hat{e}_{i,t-1}\Delta\hat{e}_{i,t} - \hat{\lambda}_i\right)$$

where $\hat{e}_{i,t} = \hat{\gamma}_i\hat{e}_{i,t-1} + \hat{\mu}_{i,t}$, $\hat{s}_i^2 \equiv \frac{1}{T}\sum_{t=1}^{T}\hat{\mu}_{i,t}^2$, $\hat{\lambda}_i = \frac{1}{T}\sum_{s=1}^{k_i}\left(1 - \frac{s}{k_i+1}\right)\sum_{t=s+1}^{T}\hat{\mu}_{i,t}\,\hat{\mu}_{i,t-s}$ and $\hat{\sigma}_i^2 = \hat{s}_i^2 + 2\hat{\lambda}_i$.

3. See whether group t statistic falls into critical interval, if it locates outside the interval then null hypothesis of cointegration can be rejected, that is, $y_{i,t}$ is not cointegrated with $x_{1i,t}, \ldots, x_{Mi,t}$.

   M=2: mean is -2.872 and variance is 0.555

   M=3: mean is -3.179 and variance is 0.548

References

Abraham, J. M. & Hedershott, P. H., 1994. Bubbles In Metropolitan Housing Markets. *NBER,* June.Issue 4774.

Alonso, W., 1964. *Location and Land Use.* Cambridge: Harvard University.

Arshanapalli, B. & Nelson, W., 2008. A Cointegration Test To Verify The Housing Bubble. *The International Journal of Business and Finance Research,* 2(2).

Baker, D., 2002. The Run-up in Home Prices: A Bubble. *Challenge,* 45(6), pp. 93-119.

Baker, D., 2006. The Menance of An Unchecked Housing Bubble. *Economists' Voice,* March.3(4).

Behzad, D. T. & Grossman, H. I., 1988. Explosive Rational Bubbles in Stock Prices?. *American Economic Association,* 78(3), pp. 520-530.

Beijing Municipal Bureau of Statistics, n.d. [Online]
Available at: http://www.bjstats.gov.cn/esite/

Bureau of Business&Economic Research, ei pvm [Online]
Available at: http://bber.unm.edu/

Cai, H., Henderson, J. V. & Zhang, Q., 2009. China's Land Market Auctions: Evidence of Corruption. *NBER Working Paper Series,* June.

California Association of Realtors, ei pvm [Online]
Available at: http://www.car.org/marketdata/data/housingdata/

Campbell, S. D., Davis, M. A., Gallin, J. & Martin, R. F., 2009. What moves housing markets: A variance decomposition of the rent–price ratio. *Journal of Urban Economics,* June, 66(2), pp. 90-102.

Capmbell, J. & Shiller, R., 1987. Cointegration and Tests of Present Value Models. *Journal of Political Economy,* Osa/vuosikerta 95, pp. 1062-1088.

Capozza, D. R., Hendershott, P. H., Mack, C. & Mayer, C. J., 2002. Determinants of Real House Price Dynamics. *NBER Working Paper,* Issue 9262.

Case, K. E. & Shiller, R. J., 1987. Prices of Single Family Homes Since 1970: New Indexes for Four Cities. *Cowles Foundation Discussion Paper No. 851.*

Case, K. E. & Shiller, R. J., 1989. The Efficiency of the Market for Single-Family Homes. *The American Economic Review,* March, 79(1), pp. 125-137.

Case, K. E. & Shiller, R. J., 1990. Forecasting Prices and Excess Returns in the Housing Market. *The American Real Estate and Urban Economics Association Journal,* 18(3).

Case, K. E. & Shiller, R. J., 2003. Is There a Bubble in the Housing Market?.

Chanos, J. S., 2010. *Global Business.* [Online]
Available at: http://www.nytimes.com/2010/01/08/business/global/08chanos.html?_r=0

Cheung, Y.-W. & Lai, K. S., 1995. Lag Order and Critical Values of the Augmented Dickey-Fuller Test. *Journal of Business & Economic Statistics,* July, 13(3), pp. 277-280.

China Real Estate Index System CREIS, ei pvm [Online]
Available at: http://fdc.soufun.com/creisdata/

Cohen, J. P., Coughlin, C. C. & Lopez, D. A., 2012. The Boom and Bust of U.S. Housing Prices from Various Geographic Perspectives. *Federal Reserve Bank of St. Louis Review,* September, 94(5), pp. 341-367.

Dickey, D. A. & Fuller, W. A., 1979. Distribution of the Estimators for Autoregressive Time Series With a Unit Root. *Journal of the American Statistical Association,* June, 74(366), pp. 427-431.

Dreger, C. & Zhang, Y., 2010. Is There a Bubble in the Chinese Housing Market?. *DIW Discussion Papers,* November.Issue 1081.

Du, H., Ma, Y. & An, Y., 2011. The impact of land policy on the relation between housing and land prices: Evidence from China. *The Quarterly Review of Economics and Finance,* Osa/vuosikerta 51, pp. 19-27.

Eatwell, J., Milgate, M. & Newman, P. toim., 1987. Bubbles. Teoksessa: *The New Palgrave A Dictionary of Economics.* s.l.:s.n., p. 281.

Engle, R. F. & Granger, C., 1987. Co-Integration and Error Correction: Representation, Estimation, and Testing. *Econometrica,* 55(2), pp. 251-276.

Flood, R. P. & Hodrick, R. J., 1990. On Testing for Speculative Bubbles. *Journal of Economic Perspectives,* 4(2), pp. 85-101.

Gallin, J., 2006. The Long-Run Relationship between House Prices and Income: Evidence from Local Housing Markets. *Real Estate Economics,* 3(34), pp. 417-438.

Garber, P. M., 1990. Famous First Bubbles. *Journal of Economic Perspectives,* 4(2), pp. 35-54.

Garber, P. M., 2000. Teoksessa: *Famous First Bubbles The Fundamentals of Early Manias.* Cambridge: The MIT Press, pp. 3-4.

Glaeser, E. L. & Gyourko, J., 2007. Arbitrage in Housing Markets. *NBER,* December.Osa/vuosikerta Working Paper 13704.

Glaeser, E. L., Gyourko, J. & Saiz, A., 2008. Housing supply and housing bubbles. *Journal of Urban Economics,* July, Issue 64, pp. 198-217.

Goodman, . A. C., 1988. An Econometric Model of Housing Price, Permanent Income, Tenure Choice, and Housing Demand. *Journal of Urban Economics,* Osa/vuosikerta 23, pp. 327-353.

Goodman, A. C. & Thibodeau, T. G., 2008. Where are the speculative bubbles in US housing markets?. *Journal of Housing Economics,* 17(2), pp. 117-137.

Guangzhou Bureau of Statistics, ei pvm [Online]
Available at: http://www.gzstats.gov.cn/tjsj/

Harter-Dreiman, M., 2004. Drawing inferences about housing supply elasticity from house price responses to income shocks. *Journal of Urban Economics,* 55(2), p. 316–337.

Hattapoglu, M. & Hoxha, I., 2013. The Dependency of Rent-to-Price Ratio on Appreciation Expectations: An Empirical Approach. *The Journal of Real Estate Finance and Economics,* April.

Hendershott, P. H. & Slemrod, J., 1982. Taxes and The User Cost of Capital for Owner-occupied Housing. *NBER,* July.Issue 929.

Henderson, D., 2012. *Did the Dot.Com Boom Boost GDP Much?.* [Online]
Available at: http://econlog.econlib.org/archives/2012/09/did_the_dotcom.html

Henderson, J. & Ioannides, Y., 1983. A Model of Housing Tenure Choice. *The American Economic Review,* March, 7(1), pp. 98-113.

Hilber, C. A. & Vermeulen, W., 2009. *Supply Constraints and House Price Dynamics: Panel Data Evidence from England,* s.l.: London School of Economics.

Himmelberg, C., Mayer, C. & Sinai, T., 2005. Assessing High House Prices: Bubbles, Fundamentals and Misperceptions. *Journal of Economic Perspectives,* Fall, Volume 19, pp. 69-72.

Holstein, A. D., O'Roark, B. & Lu, M., 2013. Determinants of The Home Price-Income Relationship: 1990-2011. *Global Journal of Business Research,* 7(3).

Hua Xia Times, ei pvm [Online]
Available at: http://sjz.house.qq.com/a/20120213/000016_1.htm

Huang, H. & Tang, Y., 2012. Residential land use regulation and the US housing price cycle between 2000 and 2009. *Journal of Urban Economics,* 71(1), pp. 93-99.

Hui, E. C. & Yue, S., 2006. Housing Price Bubbles in Hong Kong, Beijing and Shanghai: A Comparative Study. *Journal of Real Estate Finance and Economics,* 12, 33(4), pp. 299-327.

Jorgenson, D. W., 1963. Capital Theory and Investment Behavior. *American Economic Review,* May, 53(2), pp. 247-259.

Kindleberger, C., 1987. Bubbles. Teoksessa: J. Eatwell, M. Milgate & P. Newman, toim. *The New Palgrave: A Dictionary of Economics.* New York: Stockton Press, p. 281.

Kindleberger, C. P., 1989. Teoksessa: *Manias, Panics, and Crashes A History of Financial Crises.* 2nd toim. s.l.:Macmillan, pp. 93-96.

Krainer, J. & Chishen, W., 2004. House Prices and Fundamental Value. *FRBSF Economic Letter,* Osa/vuosikerta 2004-27.

Kuha, J., 2004. AIC and BIC : Comparisons of Assumptions and Performance. *Sociological Methods & Research,* November, 33(2), pp. 188-229.

Leamer, E. E., 2002. Bubble Trouble? Your Home Has a P/E Ratio Too. *UCLA Anderson Forecast.*

Lei, V., Noussair, C. N. & Plott, C. R., 2001. Nonspeculative Bubbles In Experimental Asset Markets: Lack of Common Knowledge of Rationality vs. Actual Irrationality. *Econometrica,* 69(4), pp. 831-859.

Lincoln Institute of Land Policy, ei pvm [Online]
Available at: http://www.lincolninst.edu/subcenters/land-values/rent-price-ratio.asp

Maddala, G. & Wu, S., 1999. A Comparative Study of Unit Root Tests with Panel Data and A New Simple Test. *Oxford Bulletin of Economics And Statistics,* Issue 0305-9049.

Malpezzi, S., 2001. The Long-Run Price Elasticity of Supply of New Residential Construction in the United States and the United Kingdom. *Journal of Housing Economics,* 10(3), pp. 278-306.

McCarthy, J. & Peach, R. W., 2002. Monetary PolicyTransmission to Residential Investment. *Federal Reserve Bank of New York Economic Policy Review,* 8(1).

McCarthy, J. & Peach, R. W., 2004. Are Home Prices the Next Bubble?. *Economic Policy Review,* December, 10(3), pp. 1-17.

Mikhed, V. & Zemcik, P., 2007. Testing for Bubbles in Housing Markets: A Panel Data Approach. *Journal of Real Estate Finance and Economics,* 38(4), pp. 366-386.

Mikhed, V. & Zemcik, P., 2009. Do house prices reflect fundamentals? Aggregate and panel data evidence. *Journal of Housing Economics,* 18(2), pp. 140-149.

Miller, N. G., Peng, L. & Sklarz, M. A., 2011. The Economic Impact of Anticipated House Price Changes - Evidence from Home Sales. *Real Estate Economics,* 39(2), pp. 345-378.

Muth, R. F., 1969. *Cities and Housing : The Spatial Pattern of Urban Residential Land Use.* s.l.:University of Chicago Press.

Muth, R. F. & Goodman, A. C., 1989. Market equilibrium and adjustment to it. Teoksessa: *The Economics of Housing Market.* Philadelphia: s.n., pp. 19-23.

Newspaper, N., 2013. *iFeng.* [Online]
[Haettu 8 August 2013].

Paciorek, A., 2013. Supply constraints and housing market dynamics. *Journal of Urban Economics,* 77(3), pp. 11-26.

Pedroni, P., 1999. Critical Values For Cointegration Tests in Heterogeneous Panels With Multiple Regressors. *Oxford Bulletin of Economics and Statistics,* Issue 0305-9049.

Peng, L. & Thibodeau, T. G., ei pvm Government Interference and the Efficiency of the Land Market in China.

People's Daily, ei pvm [Online]
Available at: http://house.people.com.cn/n/2013/1203/c164220-23724142-3.html

Pesaran, M. H., 2004. General Diagnostic Tests for Cross Section Dependence in Panels. *IZA Discussion Paper,* Issue 1240.

Pesaran, M. H., 2007. A Simple Panel Unit Root Test In The Presence of Cross-Section Depedence. *Journal of Applied Econometrics,* 22(2), pp. 265-312.

Poterba, J., 1984. Tax Subsidies to Owner-occupied Housing: An Asset Market. *Quarterly Journal of Economics,* November, 94(4), pp. 729-752.

Poterba, J. & Sinai, T., 2008. Tax Expenditures for Owner-occupied Housing: Deductions for Property Taxes and Mortgage Interest and The Exclusion of Imputed Rental Income. *American Economic Review,* 96(2), pp. 84-89.

Roback, J., 1982. Wages, Rents, and the Quality of Life. *The Journal of Political Economy,* December, 90(6), pp. 1257-1278.

Rosen, S., 1979. Wage-based Indexes of Urban Quality of Life. Teoksessa: *Current Issues in Urban Economics.* s.l.:The Johns Hopkins University Press, pp. 74-104.

Rosser Jr., B. J., 1991. Speculative Bubbles and Crashes. Teoksessa: *From Catastrophe to Chaos: A General Theory of Economic Discontinuities.* Norwell Massachusetts US: Kluwer Academic Publishers, pp. 57-71.

Rosser, J., 2000. Teoksessa: *From Catastrophe to Chaos: a General Theory of Economic Discontinuities.* 2nd toim. s.l.:Kluwer Academic, p. 107.

Schreyer, P., 2009. User costs and bubbles in land markets. *Journal of Housing Economics,* 18(3), pp. 267-272.

Shanghai Bureau of Statistics, ei pvm [Online]
Available at: http://www.stats-sh.gov.cn/

Shenzhen Bureau of Statistics, ei pvm [Online]
Available at: http://www.sztj.gov.cn/

Shiller, R. J., 2005. *Irrational Exuberance.* 2nd toim. New Jersey: Princeton University Press.

Siegel, J. J., 2003. What Is an Asset Price Bubble? An Operational Definition. *European Financial Management,* 9(1), pp. 11-24.

Sina Finance, ei pvm [Online]
Available at: http://money.finance.sina.com.cn/mkt/

Sinai, T. & Gyourko, J., 2004. The (un)Changing Geographical Distribution of Housing Tax Benefits: 1980 to 2000. *NBER,* Issue 10322.

Smith, M. H. & Smith, G., 2006. Bubble, Bubble, Where's the Housing Bubble?. March.

Smith, M. H., Smith, G. & Thompson, C., 2005. When is a Housing Bubble Not a Housing Bubble?.

Stiglitz, J. E., 1990. Symposium on Bubbles. *The Journal of Economic Perspectives,* 4(2), pp. 13-18.

Stock, J. H. & Watson, M. W., 2007. *Introduction to Econometrics.* 2nd toim. s.l.:Pearson Education, Inc..

Timmermann, A., 1995. Cointegration Tests of Present Value Models With A Time-varying Discount Factor. *Journal of Applied Econometrics,* 10(1), pp. 17-31.

US Bureau of Economic Analysis, ei pvm [Online]
Available at: http://www.bea.gov/index.htm

Wu, J., Gyourko, J. & Deng, Y., 2012. Evaluating conditions in major Chinese housing markets. *Regional Science and Urban Economics,* July, 42(3), pp. 531-543.

Xu, J. & Ge, Y., 2011. The Function Mechanism of Expected Housing Price to Rent Price Ratio: an Empirical Research Based on 35 Large and Medium Cities. *Economic Survey,* March, Osa/vuosikerta 4, pp. 51-55.

Ye, T., 2013. *iFeng.* [Online]
Available at:
http://gz.ifeng.com/loushiredian/fengyankanshi/detail_2013_08/08/1083104_0.shtml

Zillow housing information, ei pvm [Online]
Available at: http://www.zillow.com/