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The Study on the Stationarity of Housing Price-to-Rent and Housing Price-to-Income Ratios in China

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Abstract**—**This paper aims to examine whether a bubble is present in the housing market of China. Thus, we use the housing price-to-income ratios and housing price-to-rent ratios of 35 cities from 1998 to 2010. The methods of the panel KSS unit root test with a Fourier function and the SPSM process are likewise used. The panel KSS unit root test with a Fourier function considers the problem of non-linearity and structural changes, and the SPSM process can avoid the stationary time series from dominating the result-generated bias. Through a rigorous empirical study, we determine that the housing price-to-income ratios are stationary in 34 of the 35 cities in China. Only Xining is non-stationary. The housing price-to-rent ratios are stationary in 32 of the 35 cities in China. Chengdu, Fuzhou, and Zhengzhou are non-stationary. Overall, the housing bubbles are not a serious problem in China at the time.

Keywords**—**Housing Price-to-Income Ratio, Housing Price-to-Rent Ratio, Housing Bubbles, Panel Unit-Root Test.

I. Introduction

AFTER the 2008 financial crisis, the U.S. base rate became close to zero. The U.S. Federal Reserve launched the QE (Quantitative Easing) policy (QE1: March 2009 to March 2010), which involved the large purchase of government bonds, corporate bonds, etc. The U.S. long-term bond prices were increased and the interest rates were likewise decreased. The U.S. Federal Reserve lowered mortgage rates to avoid the collapse of the U.S. housing market. Moreover, the implementation of QE3 has further supported economic recovery and enhanced employment since September 15, 2012. QE3 has created a global environment characterized by low interest rates and ample liquidity that will continue for a longer period. It has likewise increased the prices in the stock market and the real estate market. However, countries with emerging markets will face the biggest threat at the later stage of QE3. Rising interest rates and withdrawn money will hurt the economies of emerging market countries. Therefore, noting whether housing bubbles, measured through housing price-to-rent and housing price-to-income ratios, exist in China is extremely necessary.

In the real estate system of China, the Chinese government established the private residential mechanism in 1998, and the residential rate has reached 80% under vigorous promotion. The Chinese government implemented reforms and the opening-up policy after 1978. To promote the rapid development of the Chinese economy, massive credit expansion and the fiscal stimulus package of the government allowed a yearly increase in the amount of investment in real estate development. The Chinese government executed monetary policies, lowered the benchmark lending rate, and reduced lending restrictions to ease the global economic recession after the 2008 financial crisis. However, these measures likewise caused excessive money supply flows in the real estate market. The average growth rate of real estate development was 23.9% from 1998 to 2012. A housing bubble waits in the wings at the present.

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The rise in real estate price can present the illusion of prosperity in the short term. However, it also generates problems because individuals become unable afford to pay such prices to purchase houses. Moreover, the gap between the rich and poor widens. Once the housing bubble bursts, banks lose liquidity and become unable to settle funds, and the financial system stability may collapse. Several researchers (i.e., Hui & Yue [1], Xiao & Tan [2], Clark & Coggin [3], and Zaemah et al. [4]) noted a housing bubble might possibly exist. However, other researchers (i.e., Himmelberg et al. [5], Baker [6], and Mikhed & Zemčík [7]) doubted and denied the existence of a housing bubble. Given the results are mixed, investigating whether a housing bubble exists using more robust methods is necessary.

The ratios of housing price-to-rent and housing price-to-income are principally used to examine the housing bubble problem. Case and Shiller [8] indicated that investors suffered large losses through the collapse in asset prices if housing prices were not founded on the basic elements of fundamental price. On the basis of rational expectations theory, the basic value of housing price can be calculated through discounted rental incomes. The present value of housing price is shown as follows.

$$P_t = \frac{E(D_{t+1} + P_{t+1})}{1 + R_{t+1}} \tag{1}$$

where P is the housing price, D is rent, and R is the real interest rate.

This model is similar to the dividend discount model. Housing prices are similar to the stock prices. Rent is similar to cash dividend per share. The real interest rate is similar to the dividend discount rate.

Black et al. [9] used the discounted future disposable income to develop the present value model of housing prices as follows.

$$P_t = E_t \sum_{i=1}^{\infty} \left(\frac{1}{\prod_{j=1}^{i} (1 + \rho^*_{t+j})} \right) Q_{t+i} \tag{2}$$

where, P_t represents housing price in the phase of t, Q_{t+i} is the family real disposable income in the phase of t+1, ρ is real interest rate (real discount rate), and Et is the conditional expected value.

This study followed these two ratios to measure the degree of the housing market bubble. The housing prices, incomes, and rents of 35 major cities in China were collected, and the panel KSS unit root test with a Fourier function and the SPSM process were used in this study. Non-linearity and structural changes were considered. We hope that the empirical results can be more robust in this study.

The panel KSS unit root test with a Fourier function considers the problem of non-linear and structural changes, and the SPSM process can avoid the stationary time series from dominating the results and creating bias.

II. Data

This empirical study uses the quarterly data of the house price index, the rent index, and per capita disposable income for 35 cities in China (i.e., Beijing, Tianjin, Shijiazhuang, Taiyuan, Hohhot, Shenyang, Dalian, Changchun, Harbin, Shanghai, Nanjing, Hangzhou, Ningbo, Hefei, Fuzhou, Xiamen, Nanchang, Jinan, Qingdao, Zhengzhou, Wuhan, Changsha, Guangzhou, Shenzhen, Nanning, Haikou, Chongqing, Chengdu, Guiyang, Kunming, Xi'an, Lanzhou, Xining, Yinchuan, and Urumqi) from 1998 to 2010. Data were obtained from the CEIC China economic database.

Figs. 1 and 2 show the plot of the average housing price-to-income ratio and housing price-to-rent ratio for the 35 cities. We observed a downward trend in the housing price-to-income ratio presented in Fig. 1 from 1998 to 2010. Housing prices in China were basically supported by per capita disposable income. Perhaps housing bubbles were not a serious problem in China. However, a gradual slowdown in the trend occurred after 2009. This phenomenon is worth noting by Chinese authorities. Fig. 2 shows that the average housing price-to-rent ratio modestly changes between 0.975 and 1.075. The median is 1.02. The mean-reverting process is shown in the series. Housing price was probably not out of control in China.

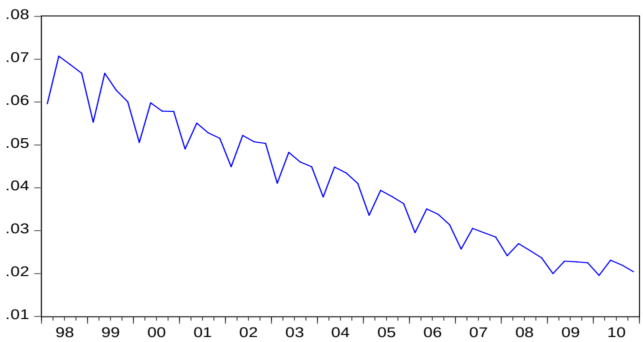

Fig. 1 Average housing price-to-income ratio for 35 cities

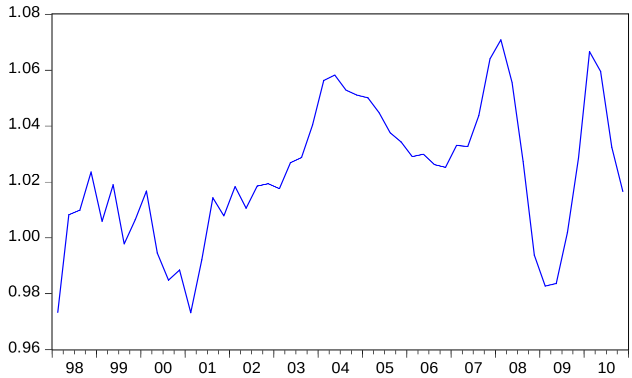

Fig. 2 Average housing price-to-rent ratio for 35 cities

III. Methodology and Empirical Results

A. Panel KSS Unit Root Test with a Fourier Function

Studies have found that numerous macroeconomic and financial time series do not only contain unit roots but also exhibit nonlinearities. Thus, conventional unit root tests such as the ADF unit root test poorly detect mean reversion in the series. Consequently, stationary tests in a nonlinear framework must be applied. Ucar and Omay [10] proposed a nonlinear panel unit root test by combining the nonlinear framework in the study by Kapetanios et al. ([11], KSS) and the panel unit root testing procedure used in the study by Im et al. [12], which has been proven useful in testing for mean reversion in time series data. Perron [13] argued that if a structural break exists, the power to reject a unit root decreases when the stationary alternative is true, and the structural break is disregarded. Structural changes present in data generation but have been disregarded sway the analysis toward accepting the null hypothesis of a unit root. Therefore, the SPSM proposed by Chortareas and Kapetanios [14], combined with the Panel KSS unit root tests with a Fourier function, were used to test for the stationarity of the housing price-to-income and housing price-to-rent ratios for a sample of 35 cities in China.

In line with Kapetanios et al. [11], the KSS unit root test is based on detecting the presence of nonstationarity against a nonlinear but globally stationary ESTAR process. The model is given by

$$\Delta \tilde{y}_t = \gamma \tilde{y}_{t-1}\{1-\exp(-\theta \tilde{y}_{t-1}^2)\} + v_t, \quad (3)$$

where $\tilde{y}_t$ is the data series of interest (income gap), v_t is an independent identically distributed error with zero mean and constant variance, and $\theta \geq 0$ is the transition parameter of the ESTAR model that governs the speed of transition. Under the null hypothesis, $\tilde{y}_t$ follows a linear unit root process; under the alternative, $\tilde{y}_t$ follows a nonlinear stationary ESTAR process. One shortcoming of this framework is that the parameter γ is not identified under the null hypothesis. Kapetanios et al. [11] used a first-order Taylor series approximation for {

$1-\exp(-\theta\tilde{x}_{t-1}^2)$ } under the null hypothesis $\theta=0$ and then approximated (3) by using the following auxiliary regression:

$$\Delta\tilde{y}_t = \xi + \delta\tilde{y}_{t-1}^3 + \sum_{i=1}^{k}\theta_i\Delta\tilde{y}_{t-i} + v_t \quad t = 1,2,....,T \tag{4}$$

In this framework, the null hypothesis and the alternative hypothesis are expressed as $\delta = 0$ (nonstationarity) against $\delta < 0$ (nonlinear ESTAR stationarity). Ucar and Omay [10] expanded a nonlinear panel data unit root test based on regression (3). The regression is expressed as follows:

$$\Delta\tilde{y}_{i,t} = \gamma_i\tilde{y}_{i,t-1}\{1-\exp(-\theta_i\tilde{y}_{i,t-1}^2)\} + v_{i,t} \tag{5}$$

Ucar and Omay [10] also applied first-order Taylor series approximation to the panel ESTAR model around $\theta_i = 0$ for all *i*, and obtained the following auxiliary regression:

$$\Delta\tilde{y}_{i,t} = \xi_i + \delta\tilde{y}_{i,t-1}^3 + \sum_{j=1}^{k}\theta_{i,j}\Delta\tilde{y}_{i,t-j} + v_{i,t}, \tag{6}$$

where $\delta_i = \theta_i\gamma_i$ and the hypotheses established by the two for unit root testing based on regression (6) are as follows:

$$H_0 : \delta_i = 0 \text{ for all i (linear nonstationarity)}$$
$$H_0 : \delta_i < 0 \text{ for some i (nonlinear stationarity)} \tag{7}$$

The system of the KSS equations with a Fourier function that we estimate here is

$$\Delta\tilde{y}_{i,t} = \xi_i + \delta_i\tilde{y}_{i,t-1}^3 + \sum_{j=1}^{k1}\theta_{i,j}\Delta\tilde{y}_{i,t-j} + a_{i,1}\sin(\frac{2\pi kt}{T}) + b_{i,1}\cos(\frac{2\pi kt}{T}) + \varepsilon_{i,t}, \tag{8}$$

where $t = 1,2,....,T$, k represents the frequency selected for the approximation, $[a_i, b_j]'$ measures the amplitude and the displacement of the frequency component, and the rationale for selecting $[\sin(2\pi kt/T), \cos(2\pi kt/T)]$ is that a Fourier expression can approximate absolutely integrable functions to any desired degree of accuracy. At least one frequency component must also be present if a structural break exists. Enders and Lee [15] suggested that the frequencies in (6) should be obtained via the minimization of the sum of squared residuals. However, their Monte Carlo experiments suggest that no more than one or two frequencies should be used because of the loss of power associated with a larger number of frequencies. Gallant [16], Becker et al. [17], Enders and Lee [15], and Pascalau [18] demonstrated that a Fourier approximation can often capture the behavior of an unknown function even if the function itself is not periodic. Considering that no a priori knowledge exists on the shape of the breaks in the data, we first perform a grid search to find the best frequency.

B. SPSM Process

The SPSM proposed by Chortareas and Kapetanios [14] is based on the following steps:

1) The panel KSS test with a Fourier function is first performed on all real output gaps in the panel. If the unit-root null cannot be rejected, the procedure is stopped, and all series in the panel are considered nonstationary. If the null is rejected, Step 2 is conducted.
2) The series with the minimum KSS statistic is removed because it is identified as stationary.
3) Step 1 is repeated for the remaining series, or the procedure is stopped if all series are removed from the panel.
4) The result is a separation of the whole panel into a set of mean-reverting series and a set of nonstationary series.

IV. Empirical Results

The KSS Fourier unit root test considers the problem of non-linearity and structural changes, and the SPSM can prevent the stationary time series from dominating the result-generated bias. Through a rigorous empirical study, we summarize the empirical results as follows.

A. Testing the Stationarity of Housing Price-to-Income Ratio

Table I shows that the p values of the OU statistic within parentheses are smaller than the 10% significance level for the first 34 cities. Thus, the null hypothesis of linear nonstationarity in the housing price-to-income ratio can be rejected. The null hypothesis of linear nonstationarity cannot be rejected in the last city of Xining. Thus, a housing bubble exists in this city. Based on the preceding findings, housing prices in China are supported by per capita disposable income for almost all cities. The housing bubble measured using the housing price-to-income ratio is not a serious problem in China.

TABLE I
PANEL KSS UNIT ROOT TEST WITH FOURIER FUNCTION WITH TREND

Sequence	OU statistic	Min. KSS	Fourier(k)	Series
1	-1.8488(0.0000)	-3.0364	5	Hohhot
2	-1.7983(0.0000)	-2.8324	5	Shenzhen
3	-1.7571(0.0000)	-2.2938	5	Shenyang
4	-1.6564(0.0000	-2.2423	5	Wuhan
5	-1.6502(0.0002)	-2.1021	5	Taiyuan
6	-1.6441(0.0004)	-2.0752	5	Ningbo
7	-1.6480(0.0002)	-1.9034	5	Nanchang
8	-1.6301(0.0004)	-1.838	5	Hefei
9	-1.6279(0.0002)	-1.8347	5	Beijing
10	-1.5876(0.0002)	-1.8211	5	Qingdao
11	-1.5782(0.0002)	-1.777	5	Shijiazhuang
12	-1.5258(0.0006)	-1.7312	5	Haikou
13	-1.5270(0.0006)	-1.721	5	Xi'an
14	-1.5293(0.0006)	-1.6615	5	Nanning
15	-1.5351(0.0004)	-1.5825	5	Chengdu
16	-1.5456(0.0002)	-1.5789	5	Xiamen
17	-1.5298(0.0000)	-1.3991	5	Hangzhou
18	-1.5587(0.0002)	-1.3615	5	Yinchuan
19	-1.4868(0.0006)	-1.3531	5	Shanghai
20	-1.5266(0.0002)	-1.3339	5	Zhengzhou
21	-1.4716(0.0002)	-1.1673	5	Dalian
22	-1.4019(0.0008)	-1.1418	5	Fuzhou
23	-1.3245(0.0026)	-1.1131	5	Kunming
24	-1.3697(0.0016)	-1.0733	5	Nanjing
25	-1.4350(0.0014)	-1.0659	5	Guangzhou
26	-1.4964(0.0040)	-1.0101	5	Changchun
27	-1.5940(0.0032)	-1.0067	5	Harbin
28	-1.4557(0.0046)	-0.8996	5	Changsha
29	-1.5516(0.0094)	-0.859	5	Chongqing
30	-1.7455 (0.0068)	-0.846	5	Tianjin
31	-1.7978(0.0108)	-0.7761	5	Jinan
32	-1.4830(0.0280)	-0.7625	5	Guiyang
33	-1.8313(0.0128)	-0.6489	5	Lanzhou
34	-1.8821(0.0212)	-0.467	5	Urumqi
35	**0.1335(0.5724)**	**-0.231**	**5**	**Xining**

Notes: Entry in parenthesis stands for the p-value that was computed by means of Bootstrap simulations using 5000 replications. The maximum lag is set to be 8. Fourier (k) is chosen by minimum sum square of residual for Fourier function.

B. Testing the Stationarity of Housing Price-to-Rent Ratios

Table II shows that the p values of the OU statistic within parentheses are smaller than the 10% significance level for the first 32 cities. The null hypothesis of linear nonstationarity in the housing price-to-rent ratio can be rejected. The null hypothesis of linear nonstationarity cannot be rejected in the last three cities of Chengdu, Fuzhou, and Zhengzhou. Thus, a housing bubble exists in these cities. Based on the preceding findings, housing prices in China are supported by rent for most of cities. The housing bubble measured using the housing price-to-rent ratio is likewise not a serious problem in China.

TABLE II
PANEL KSS UNIT ROOT TEST WITH FOURIER FUNCTION WITHOUT TREND

Sequence	OU statistic	Min. KSS	Fourier(k)	Series
1	-4.2599(0.0000)	-8.4229	1	Beijing
2	-4.1375(0.0000)	-7.9181	1	Shenzhen
3	-4.0229(0.0000)	-6.4281	1	Changsha
4	-3.9478(0.0000)	-6.4151	2	Shijiazhuang
5	-3.8682(0.0000)	-6.2343	2	Wuhan
6	-3.7893(0.0000)	-5.6553	1	Xiamen
7	-3.7249(0.0000)	-5.6481	1	Guiyang
8	-3.6563(0.0000)	-5.6355	1	Xi'an
9	-3.583(0.0000)	-5.602	4	Nanning
10	-3.5053(0.0000)	-5.2867	3	Hangzhou
11	-3.434(0.0000)	-5.2558	5	Harbin
12	-3.3581(0.0000)	-4.4951	5	Taiyuan
13	-3.3087(0.0000)	-4.3697	1	Shenyang
14	-3.2605(0.0000)	-4.2448	5	Nanchang
15	-3.2136(0.0000)	-4.2339	1	Dalian
16	-3.1626(0.0000)	-4.2164	1	Xining
17	-3.1071(0.0000)	-4.1953	5	Maryland
18	-3.0467(0.0000)	-4.1173	5	Ningbo
19	-2.9837(0.0000)	-4.1106	2	Hohhot
20	-2.9133(0.0000)	-4.0672	5	Chongqing
21	-2.8363(0.0000)	-3.8915	4	Canton
22	-2.761(0.0000)	-3.7705	1	Changchun
23	-2.6833(0.0000)	-3.5758	1	Yinchuan
24	-2.6089(0.0000)	-3.2319	2	Tianjin
25	-2.5523(0.0000)	-3.2271	1	Seaport
26	-2.4848(0.0002)	-3.1852	2	Hefei
27	-2.407(0.001)	-2.9362	1	Kunming
28	-2.3409(0.006)	-2.6888	2	Nanjing
29	-2.2912(0.0138)	-2.671	5	Qingdao
30	-2.2278(0.021)	-2.6428	2	Shanghai
31	-2.1449(0.0344)	-2.5339	2	Urumqi
32	-2.0476(0.0862)	-2.4825	1	Jinan
33	**-1.9026(0.1608)**	**-2.0507**	**1**	**Chengdu**
34	**-1.8286(0.2174)**	**-1.8378**	**1**	**Fuzhou**
35	**-1.8193(0.1976)**	**-1.8193**	**5**	**Zhengzhou**

Notes: Entry in parenthesis stands for the p-value that was computed by means of Bootstrap simulations using 5000 replications. The maximum lag is set to be 8. Fourier (k) is chosen by minimum sum square of residual for Fourier function.

V. CONCLUSION

Previous panel-based unit root tests are joint tests of a unit root for all members of a panel and are incapable of determining the combination of I(0) and I(1) series in a panel setting, whereas the SPSM proposed by Chortareas and Kapetanios [14] classifies an entire panel into a group of stationary members and a group of nonstationary members. Thus, these tests clearly identify the number of series and the specific series in the panel that comprises stationary processes. This study applies the SPSM combined with the Panel KSS unit root tests with a Fourier function to test for the stationarity of the housing price-to-income and the housing price-to-rent ratios for a sample of 35 cities in China from 1998 to 2010.

Our empirical study proves that housing prices in China are supported by per capita disposable income and rent, respectively, for almost all 35 cities in China. The housing bubble is not a serious problem in China.

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