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 Rising interest rates and withdrawn money will hurt the economies of emerging market countries.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.

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 to 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.

\[ P_i = \frac{E(D_{t+1} + P_{t+1})}{1+R_{t+1}} \]

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.

\[ P_i = E \sum_{t} \left[ \frac{1}{\prod_{i=1}^{t} (1 + \rho_{t+1})} \right] Q_{t+1} \]

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where, \( P_t \) represents housing price in the phase of \( t \), \( Q_{t+1} \) is the family real disposable income in the phase of \( t+1 \), \( \rho \) is real interest rate (real discount rate), and \( E_t \) 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, Changan, 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. However, 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.

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

\[ \Delta y_t = \gamma y_{t-1} (1 - \exp(-\theta y_{t-1}^2)) + v_t, \]

where \( \gamma \) 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, \( y_t \) follows a linear unit root process; under the alternative, \( y_t \) follows a nonlinear stationary ESTAR process. One shortcoming of this framework is that the parameter \( \gamma \) is not identified under the null hypothesis. Kapetanios et al. [11] used a first-order Taylor series approximation for \( y_{t-1} \) so that \( y_{t-1} \) is approximated by its first-order Taylor series expansion about \( y_{t-1}^* \).
In this framework, the null hypothesis and the alternative hypothesis are expressed as \( \theta = 0 \) (nonstationarity) against \( \theta < 0 \) (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:

\[
\Delta y_i = \gamma_i y_{i,-1} \{1 - \exp(-\theta_i y_{i,-1})\} + v_{i,t},
\]

where \( \Delta y_i = y_i - y_{i-1} \) and the hypotheses established by the two for unit root testing based on regression (6) are as follows:

\[
H_0 : \delta_i = 0 \quad \text{for all } i \quad \text{(linear nonstationarity)}
\]

\[
H_0 : \delta_i < 0 \quad \text{for some } i \quad \text{(nonlinear stationarity)}
\]

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

\[
\Delta y_i = \xi_i + \delta_i y_{i,-1} + \sum_{j=1}^k \theta_{i,j} \Delta y_{i,-j} + v_{i,t},
\]

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:

\[
H_0 : \delta_i = 0 \quad \text{for all } i \quad \text{(linear nonstationarity)}
\]

\[
H_0 : \delta_i < 0 \quad \text{for some } i \quad \text{(nonlinear stationarity)}
\]

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.
The housing bubble measured using the housing price-to-rent ratio can be rejected. The null hypothesis of linear nonstationarity in the first 32 cities. The null hypothesis of linear nonstationarity in parentheses are smaller than the 10% significance level for the Fourier function.

Testing the Stationarity of Housing Price-to-Rent Ratios

Table II shows that the p values of the OU statistic within parentheses 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 Fourier function. 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.

REFERENCES