Scaling Relationships Between Real Estate Price and Macroeconomic Indicators in Mainland China

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Abstract—In this paper, wavelet transform was used to examine the volatility of real estate market and its relationship with macro economy at different time scales. Continuous wavelet transform (CWT) is a multi-scaling approach which decomposes the variance of a time series, and in this study, it is used to uncover transient characteristics in real estate market. Through wavelet coherency analysis, we examine relationships between real estate and macro economy by measuring intensity of covariance between time series of property price and that of each indicator on a scale by scale basis. Data of China in recent decades were collected to do the research, and the wavelet technique successfully described the patterns of scaling relationship between real estate price and macroeconomic indicators in China.

Keywords- wavelet transform; scale; real estate; macro economy

I. INTRODUCTION

Estate market is a large share of the overall macro-economy. There is a relatively recent, growing recognition about the importance of the interactive nexus between and among estate markets and the macro-economy, especially in China, where the soaring housing price is recognized as playing a significant role within national overheated economy.

Concerns about the detection of lynchpin estate–macroeconomic nexus issues have increased significantly in recent years, pertaining to housing taxation, price dynamics, estate–business cycle relationship and estate market–urban structural form. Among these, Jud and Winkler (2002) conclude that real housing price appreciation is strongly influenced by the growth of population and real changes in income, construction costs and interest rates.[1] Davis and Heathcote (2001) employing the US national data, find that the correlation between residential property price and the real output is 0.53 and statistically significant.[2] In contrast, Kan et al. (2004) using city data, find that the average correlation between residential property price and the real output for about 50 major US cities is 0.1475.[3] Shen Yue and Liu Hongyu (2004) use Dummy Variable Regression Model to investigate the city level interactions of housing prices and economic fundamentals in China, and demonstrate partial explanatory power. [4] Duan Zhongdong(2007) analyses the mechanism of house prices affecting inflation and output, concluding the effects are very limited in short term, but significant in the long term.[5] Huang Zhonghua (2008) employing econometric analysis, find that the relationship between house price and macro-economy in China is stable in a long term and unbalanced in a short run.[6] Yan Jinhai (2009) analyze the impact mechanism of housing price on output and inflation by using IS-LM model and AD-AS model, and execute an empirical study by using the actual data in China.[7]

Macro-housing mechanism is a very complex one, of which the operation is affected by acting time of macro controlling policies, hysteresis of market response, reallocation of economic activities and resource and so on. Therefore, the interplay between the estate market and macro-economy performs differently among various temporal scales. In simple words, it shows much variation in short run and long term, which is demonstrated in former studies as illustrated before. However, there are still few special researches dealing with this temporal multi-scale issue. To further examine the multi-scale temporal dependence of relationships between estate market and macro-economy, the technique of wavelet analysis is introduced. This technique now has been used to analyze trends and cycles of land prices, [8] detect jump point detection for real estate investment success, [9] or unified with neural network to do forecast to the real estate price index. But no studies have made use of the detection ability of multi-scale information of wavelet transform to analyze estate-macroeconomy issue, and the main goal of this research is to further examine the relationship at different time scale.

II. METHODS

A. Wavelet transform

Wavelet analysis is a new technique for time-scale analysis and multi-resolution analysis. Compare to Fourier analysis, which implicitly assumes that the underlying processes are stationary in time, the wavelet transform is capable of exploratory analysis of non-stationary and complex data series, providing the time and frequency information simultaneously.

Continuous wavelet transform (CWT) [10] can decompose a signal into a set of finite basis functions, so it can uncover transient characteristics in the signal. CWT is better for feature extraction purposes than DWT (discrete wavelet transform).
\[ W(a,b) = \frac{1}{\sqrt{a}} \int_{-\infty}^{\infty} f(t) \psi \left( \frac{t-b}{a} \right) dt \]  

(1)

\( a \) is a scaling parameter, \( b \) is a time shift parameter, is called a mother wavelet, \( W(a,b) \) are wavelet coefficients containing frequency information, a series of which can be obtained by adjusting the scale \( a \).

In this study, we adopt a symmetric and periodic wavelet-Morlet wavelet. Morlet wavelet is a good choice for data that is varying continuously in time, since it provides a good balance between time and frequency localization, and it can also be used to study the phase synchronization between two signals.

B. Wavelet coherence

Wavelet coherence analysis can provide further information about time-scale-dependent phase shifts and correlations between two different time signals. In other words, wavelet coherence analysis, based on wavelet transforms of two different time signals, provides a quantitative way to describe the correlations between two time signals as a function of both time scale and phase shift.

To measure wavelet coherency, following Torrence and Webster (1998) we define it as \[ R_{xy}(a,b) = \frac{\langle W_x(a,b) \rangle^2}{\langle W_x(a,b) \rangle^2 + \langle W_y(a,b) \rangle^2} \]  

(2)

\( \langle \rangle \) indicates smoothing in both time and frequency, \( W_x(a,b) \) is the wavelet transform of series \( x(t) \), \( W_y(a,b) \) is the wavelet transform of \( y(t) \), and \( W_{xy}(a,b) \) is the cross-wavelet transform. Wavelet coherence ranges from 0 to 1, with a value of 1 indicating maximum coherency. It gives a measure of the dependency and synchrony between the two time series as a function of both scale (period) and time. Wavelet phase measures the phase difference between the complex wavelet transforms and indicates whether two time series tend to oscillate simultaneously, rising and falling together with the same period.

III. DATA

For this study, we employ the national monthly data of China. The sampling period is over 20 years from Jan. 1991 to Mar. 2011. The real estate price index (REPI), CPI, macroeconomic prosperity index, and land transactions price index are selected as variables.

The real estate price index indicates the variation of estate price, when computing with the land transaction price index; we transfer the monthly data to quarterly data.

CPI is a reflection to inflation of macro-economy, and contains the price level variation of consumer goods.

Macroeconomic prosperity index mainly tells the general developing situation of macro-economy, and we employed coincident index, referring to the right time of computing period.

Land transactions price index is also be introduced to this research, which is different from former studies. In China, the land resource is public and national assets, and the land resource flow is not fully dependent on market, but instead, mostly controlled by the government. The land supply and land use are included in government policies and plans, and even the price is highly influenced by the act of government. Land resource plays a vital role in macro-economy and is closely relevant with real estate market, so it is reasonable to enclose it in our study. Only quarterly data from 1998 to 2010 are obtained for this variable.

All the variables, if belongs to the type growing rate, are adjusted to base the same period of last year as benchmark. All the time series, are examined for their histograms, and do the simple “percentile” transformation if not normally distributed. All the data come from CEInet Statistics Database.

IV. STUDY AREA

In recent years, the 1st tier cities of China encounter the fastest increase of estate price, almost tenfold higher than 10 years ago. Now the level of housing price far surpasses the affording ability of average family. Along with this, China shares with many developing countries the same intractable problems–namely, a shortage of housing supply and housing inequality in the urban sector. The soaring housing price is recognized as playing a significant role within national overheated economy.

Since 2004, China's housing policy has entered into an adjustment period. The central government tries to take macro measures to regulate the urban housing market, with the purpose of enhancing long-term housing development and cooling down the overheated economy. These policies have become increasingly stricter, and the effects change with period.

V. RESULTS AND ANALYSIS

The values are coherency coefficient ranges from 0 to 1. In the chart of Morlet squared wavelet coherence, the 5% significance level against red noise is shown as a thick contour, and the cone of influence (COI) where edge effects might distort the picture is shown with lighter shade. The relative phase relationship is shown as arrows. The direction of the arrows in the coherence spectrum indicates the phase between the two series involved: horizontal right is 0° and corresponds to an in-phase situation, horizontal left is 180° and corresponds to an anti-phase situation, and both vertical up (90°) and vertical down (270°) correspond to an out-of-phase situation.

A. REPI and CPI

Inspecting the wavelet coherency between REPI and CPI, three scales of variation are revealed: < 1 year (12 months); 2-5 years; > 5 years (60 months). For the shortest time scale, the coherency is basically insignificant in less than 3 months (a quarter), but the co-vary relationship begins to show with the lengthening of time, and two wavelet coherency centers are observed at the scale of 4-12 months. This indicates that the reaction or effecting time of land estate market to macro inflation or versus may be at least longer than a quarter. For the medium time scale, the mutual controlling power of these two indices becomes much more evident. During the years...
before 1998, there is a high common power center in 32-month scale, where the estate market and macro inflation shows anti-phase relationship. This nexus turns to in-phase situation when comes to the significant area around the year 2000 at 16-month scale, and again turns back to anti-phase situation in the high coherency area after 2007 at a scale ranging from 2 to 5 years. This phenomenon can be seen as a reflection of interactive mechanism between the two virtual economic subjects. They are always trying to keep the balance and adjusting when it is broken, so we can see the relationship in imbalance areas alternates between the anti-phase and the in-phase. And this can only be detected in the long run. As for the scale above 5 years, the coherency is relatively lower, but it may be stronger in an even longer scale, but our study can only be limited here because of the time length of data. Additionally, a common significant coherency time period can be found in nearly all scales-namely, around the year 2007. We guess it owns to large-area building process of public housing which exerts effects on housing price and increasing inflation rate in recent years.

Figure 1. Morlet squared wavelet coherence between REPI and CPI

B. REPI and macroeconomic prosperity index

Figure 2 shows the pattern of wavelet coherency between the REPI and macroeconomic prosperity index. It has similarity with that of REPI and CPI: for one, insignificance or low significance at short time scale less than a year and more evident significance at longer scale 2-5 years. However, the main difference appears at the medium scale, since the wavelet coherency areas all show the in-phase situation, which reflects the effect that land market development and whole macro-economy development are mutually reinforcing and promoting each other. The former can stimulate the latter, and the latter can provide a favorable environment. The relatively lower significance between 1997 and 1999 may be influenced by the Asia-Pacific financial crisis. But that between 2000 and 2004 are hardly to find a profound reason, as the real estate market and whole macro-economy are both in swift development in reality. A possible explanation may be that there exists time lag between these two development process, and with tiny fluctuations along the period, they do not show completely synchronized developing tendency. Additionally, in the long run, the prosperity of macro-economy cannot be over-relied on the real estate industry, which will make our economy less competitive.

Figure 2. Morlet squared wavelet coherence between REPI and macroeconomic prosperity index

C. REPI and land transactions price index

In this session, we use the quarterly data because of the data limitation of land transactions price index. From Figure 3 we can see that the patterns of wavelet coherency between REPI and land transactions price index are much simpler than that between REPI and the other two factors. For the less than 2-year scale, only small scattered red area signifying high coherency are shown. For the 2 to 5 year scale, the wavelet coherency is significant throughout the whole studied time phase, and with in-phase relationship. As explained in former parts, the land resource is public and national assets in China. Under this system, the land price and real estate price are high relevant. There is a reasonable explanation to the insignificance of short time scale: the housing price has tiny variations, i.e. price fluctuations in short time period of 1-2 years, but the growing trend of land transaction price is more stable and pure. However, the estate price will also show a general trend of linear development in long terms, and it co-varies with land price changing trend,
so the wavelet coherency turns to be significant. It can also be observed that the significant scale become larger with time, indicating that the land price has more powerful controlling ability over the real estate market, at both shorter and longer time scales.

VI. CONCLUSIONS AND DISCUSSIONS

A. Conclusions

The wavelet coherency detection of multi-scale relationship between REPI and CPI shows their interplay is evident at scale of 2-5 years, and the situation alternate between the in-phase and the anti-phase, reflecting their interactive mechanism of keeping balance.

The results of multi-scale relationship analysis between REPI and macroeconomic prosperity index also give the similar conclusion that the significant coherency mainly exists at the scale of 2-5 years. But they all show in-phase situation.

The land transactions price index, as analyzed, is more directly and strongly connected with estate price. And their wavelet coherency is significant throughout the whole studied time phase.

In conclusion, the relationship between estate market and macro-economy varies among different time scales and changes over different time phase.

B. Discussions

In the study, the wavelet transform analysis confirms that there is a temporal scale-dependent relationship between REPI and macro-economy indices. This is helpful to our understanding of short and long term effects of public policies on both economy and housing, and further provides information and reference in the process of policy-making.

The WTC charts in these study shows the results of relationship not as evident as those in physical geography series. It is easy to be understood if we take into consideration the flaw of our statistic progress and interference of human elements. The pure natural phenomena are invariably performing more regularity. Moreover, the interplaying mechanism of real estate and macro-economy is a very complex one, thus the results of simple detection cannot be that clearly and evidently presented.

In the first two charts, we can detect a sign at the bottom of the chart that the relationship between corresponding indices may be stronger in an even longer scale. But accurate results are incapable of computing owning to the limited length of time series that can be obtained. The estate market has experienced enormous changes since the founding of P.R.China, and the statistical work in the real estate field started relatively later. So it is difficult to access data of a long time period more than 20 years. But the longer scale relationship and variation detection deserve special research attention.

REFERENCES


Figure 3. Morlet squared wavelet coherence between REPI and land transactions price index