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Abstract

The causality between the real estate and stock markets of China remains a mystery in the literature. This paper investigates the non-linear causal relationship between real estate property and stock returns in China from the perspective of conditional quantiles. The results of the quantile causality test suggest a significant causal relationship between these two markets, especially in the tail quantile.

JEL code: C22; O18; R31

Keywords: Property return; Stock return; Causality; Quantile regression

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1 Introduction

The causality between real estate and stock markets is a widely studied topic in the literature. (see, Chen 2001, Kapopoulos and Siokis 2005, Ibrahim 2010, Chang, Chen, and Leung 2011, Anderson and Beracha 2012). Okunev, Wilson, and Zurbruegg (2000) show a strong unidirectional non-linear causal relationship from the stock market to the real estate market in the United States. Sim and Chang (2006) find that property prices Granger-cause stock prices in most regional housing and land markets in South Korea, whereas no reverse causation from the stock market to the real estate market is found. Aye, Balcilar, and Gupta (2013) employ a non-parametric cointegration test to identify a long-term bidirectional causal relationship between the two markets in South Africa. The conclusion on causality depends on the selected test. For instance, using a linear causality test, Okunev, Wilson, and Zurbruegg (2000) show a unidirectional relationship from the real estate market to the stock market. However, results of the non-linear causality test suggest otherwise. Aye, Balcilar, and Gupta (2013) find no long-term stable relationship between the housing and stock prices in South Africa using a linear cointegration test. However, a bidirectional causality is found when using a non-parametric cointegration test.

This paper investigates the non-linear causal relationship between real estate property and stock returns in China. To the best of our knowledge, no such study has investigated the non-linear linkage between the two markets in China. Our study contributes to the existing literature by filling this gap. Despite being the second largest economy in the world, China's housing and land markets are underdeveloped. The real estate and stock markets in the country possess unique features that deserve special attention from researchers. For instance, the average housing price is growing at roughly 14% annually and tripled from 2005 to 2009 due to the supportive government policies. Conversely, China's stock market is very volatile. The Shanghai Stock Exchange (SSE) Composite Index reached the historic high of 6,124.04 on October 16, 2007, and fell to around the

2,000 level afterwards. Moreover, as an emerging economy, China is undergoing economic reforms and policy changes that might generate a non-linear dependence between the real estate and the stock markets. Following Chuang, Kuan, and Lin (2009), we investigate the causality from the perspective of conditional quantiles. The quantile causality test has been used to evaluate the causal relationships in different quantile intervals. It enables us to identify the quantile intervals that contain the interdependence. The results of the linear Granger causality test provide no evidence to support the causal relationship between the real estate and the stock markets. However, we find the existence of a causal relationship in the lower- and upper-level quantiles when the quantile causality test is applied. The tail interdependence of the stock and real estate markets can be interpreted from the perspective of systemic risk. Baur and Schulze (2005) argue that systemic risk arises under extreme market conditions. In our case, when the return of the stock market is extremely high or low, it becomes more vulnerable to the shock of the housing market, and vice versa. Therefore, the tail quantile intervals in one market are more easily affected by another market. The rest of the paper is organized as follows. Section 2 describes the data. Section 3 presents the test results of the linear Granger causality test and the quantile causality test. Section 4 concludes the paper.

2 Data Description

The monthly average price of residential commodity buildings and the monthly Shanghai Stock Exchange Composite Index from March 1998 to December 2011 are drawn from CEIC, an economic database for emerging and developed markets.[1] The monthly average price of residential use land parcels from May 2002 to December 2011 is obtained from SouFun, a leading Chinese data company specializing in land and housing transaction data and real estate indices.[2] The return

[1] The website of the databases is http://www.ceicdata.com

[2] The website of the company is http://www.fdc.soufun.com.

series is calculated as the first difference of the log price series.

The summary statistics of the series are reported in Table 1. The means of return series are all close to zero, but the means of housing and land returns exceed those of stock returns. These results imply that the real estate market generates a higher yield than the stock market, which is consistent with the observations in China. Moreover, the return series of land price is more volatile than the other two series. Compared to the housing and stock markets, the land market is less efficient. Sales of land are more easily subject to insider trading and corruption, which results in a high volatility of land price. Note that all three return series exhibit excess kurtosis, but the return series of housing price considerably exceeds the others, indicating that the future housing returns are most likely to include several extreme values.

[Insert Table 1 about here]

3 Empirical Analysis

3.1 Linear Granger Causality Test

When a variable x does not Granger-cause another variable y, it suggests that

$$\mathbb{E}(y_t|(\mathcal{Y},\mathcal{X})_{t-1}) = \mathbb{E}(y_t|\mathcal{Y}_{t-1}), \quad \text{a.s.}, \tag{3.1}$$

where $(\mathcal{Y},\mathcal{X})_{t-1}$ denotes the information set generated by y_i and x_i at time $t-1$. To conduct the Granger causality test for our study, we estimate the following models:

$$rhp_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i rhp_{t-i} + \sum_{i=1}^{q} \beta_i rsp_{t-i} + \varepsilon_{rhp,t}, \tag{3.2}$$

$$rsp_t = \phi_0 + \sum_{i=1}^{p} \phi_i rsp_{t-i} + \sum_{i=1}^{q} \varphi_i rhp_{t-i} + \epsilon_{rsp,t}, \tag{3.3}$$

where rhp_t and rsp_t are the housing and stock returns at time t respectively, and $\varepsilon_{rhp,t}$ and $\epsilon_{rsp,t}$ are i.i.d random disturbances.

We test the null hypothesis that $\beta_i = 0$ for $i = 1, 2, \cdots, q$ in the above regression model (3.2). Rejecting the null hypothesis implies that the lagged values of rsp_t affect rhp_t, and a causal relationship exists from rsp_t to rhp_t. Table 2 shows the results of the linear Granger causality test in mean.[3] No causal relationship is found between the housing and stock returns based on the linear Granger causality test.

[Insert Table 2 about here]

Analogously, we can test for the causal relationship between land and stock returns based on the following bivariate autoregressive models.

$$rlp_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i rlp_{t-i} + \sum_{i=1}^{q} \beta_i rsp_{t-i} + \varepsilon_{rlp,t}, \tag{3.4}$$

$$rsp_t = \phi_0 + \sum_{i=1}^{p} \phi_i rsp_{t-i} + \sum_{i=1}^{q} \varphi_i rlp_{t-i} + \epsilon_{rsp,t}, \tag{3.5}$$

where rlp_t and rsp_t are the land and stock returns at time t, respectively, and $\varepsilon_{rlp,t}$ and $\epsilon_{rsp,t}$ are i.i.d random disturbances. The empirical results are reported in Table 3. No linear causal relationship between land and stock returns is found.

[Insert Table 3 about here]

3.2 Quantile Causality Test

Consider the following Granger non-causality test in quantiles:

$$Q_{y_t}(\tau|(\mathcal{Y}, \mathcal{X})_{t-1}) = Q_{y_t}(\tau|\mathcal{Y}_{t-1}), \quad \forall \tau \in [a, b] \quad \text{a.s.}, \tag{3.6}$$

[3] Before performing the Granger causality test, we select the desired lag order q based on Akaike Information Criterion (AIC). In our model, the selected lag order q is two.

where $Q_{y_t}(\tau|\mathcal{F})$ denotes the τ-th quantile of the distribution. If (3.6) holds, then x_t does not Granger-cause y_t over the quantile interval $[a, b]$. One can perform the Granger non-causality test in quantiles using the quantile regression method in Koenker and Bassett (1978). To test for the nonlinear causal relationship from the housing returns to stock returns, we consider the following conditional quantile function model:

$$Q_{rsp_t}(z|\mathcal{X}_{t-1}) = a(\tau) + \sum_{j=1}^{q} \alpha_j(\tau) rsp_{t-j} + \sum_{j=1}^{q} \beta_j(\tau) rhp_{t-j}. \tag{3.7}$$

The null hypothesis of non-causality in quantiles is

$$H_0 : \beta(\tau) = 0, \quad \forall \tau \in [a, b],$$

where $\beta(\tau) = [\beta_1(\tau), \beta_2(\tau), \cdots, \beta_q(\tau)]'$. A Wald test is performed. Koenker and Machado (1999) and Chuang, Kuan, and Lin (2009) show that the sampling distribution of the Wald test statistic follows the sum of squares of p independent Bessel processes:

$$\sup_{\tau \in \mathcal{T}} \mathcal{W}_T(\tau) \rightsquigarrow \left\| \frac{\mathbf{B}_q(\tau)}{\sqrt{\tau(1-\tau)}} \right\|^2. \tag{3.8}$$

where $\mathcal{W}_T(\tau)$ denotes the Wald test statistic for the quantile $\tau \in [a, b]$ and $\mathbf{B}_q(\tau)$ is a vector of p independent Brownian bridges, $\mathbf{B}_p(\tau) = [\tau(1-\tau)]^{1/2} \mathcal{N}(0, I_p)$. Empirically, we can calculate the sup-Wald test statistic by

$$\sup \mathcal{W}_T = \sup_{i=1,2,\cdots,n} \mathcal{W}_T(\tau_i).$$

The critical values of the sup-Wald test can be simulated with the standard Brownian motion using a Gaussian random walk with 3000 i.i.d. $N(0, 1)$ innovations. Critical values of the test can be found in De Long (1981) and Andrews (1993).

To empirically perform the quantile causality test, we first select a lag order q^* for each quantile interval. We consider eight quantile intervals: [0.05, 0.95], [0.05, 0.5], [0.5,0.95], [0.05, 0.2], [0.2, 0.4], [0.4, 0.6], [0.6, 0.8], and [0.8, 0.95]. For example, if the null of $\beta_q(\tau) = 0$ for $\tau \in [0.05, 0.2]$ is not rejected under the lag-q model, but the null $\beta_{q-1}(\tau) = 0$ for $\tau \in [0.05, 0.2]$ is rejected for the lag-$(q-1)$ model, we infer that rhp_{t-q} does not Granger-cause rsp_t in quantiles but rhp_{t-q+1} does.[4] In this case, we set the desired lag order as $q* = q-1$ for the quantile interval [0.05, 0.2]. We conduct the sup-Wald test to evaluate the joint significance of all coefficients of lagged housing returns for eight quantile intervals. For example, if the desired lag order is $q*$, then the null hypothesis is $H_0 : \beta_1(\tau) = \beta_2(\tau) = ... = \beta_q * (\tau) = 0$ for $\tau \in [0.05, 0.2]$. From the sup-Wald statistic, we can conclude whether the housing returns cause the stock returns over the specific quantile interval. The simulated critical values of the sup-Wald test statistic allow us to check whether the housing returns cause the stock returns over the specific quantile interval. For the quantile interval [0.05, 0.2], housing returns significantly affect stock returns. For all other intervals, test statistics are not significant. Table 4 summarizes the desired lag order and the testing results for joint significance.

[Insert Table 4 about here]

The above results indicate that the housing return affects the stock return only when the latter is in the quantile interval [0.05, 0.2]. The following model is estimated when we investigate the causal relationship from the stock returns to the housing returns:

$$Q_{rhp_t}(z|\mathcal{X}_{t-1}) = b(\tau) + \sum_{j=1}^{q} \phi_j(\tau) rhp_{t-j} + \sum_{j=1}^{q} \varphi_j(\tau) rsp_{t-j}. \tag{3.9}$$

The selected lag orders and the sup-Wald test statistics are reported in Table 4. The statistics overwhelmingly reject the null of non-causality at the 5% level in the top quantile interval [0.8, 0.95], suggesting that the stock return can impact on the housing return only when the latter is high. To investigate the causal relationship between land and stock markets, we estimate the following model:

$$Q_{rsp_t}(z|\mathcal{X}_{t-1}) = \alpha(\tau) + \sum_{j=1}^{q} \alpha_j(\tau) rsp_{t-j} + \sum_{j=1}^{q} \beta_j(\tau) rlp_{t-j}, \tag{3.10}$$

[4] If no value is significant in that interval at all, lag-1 order will be selected.

$$Q_{rlp_t}(z|\mathcal{X}_{t-1}) = b(\tau) + \sum_{j=1}^{q} \phi_j(\tau) rlp_{t-j} + \sum_{j=1}^{q} \varphi_j(\tau) rsp_{t-j}. \tag{3.11}$$

The results are reported in Table 5. Only a one-way dependence is observed between land and stock returns. We find no evidence for the existence of a significant causal relationship from the land returns to the stock returns. As the land market is a market for developers, it might not affect the household decision in the stock market. Thus, land returns will not significantly affect stock returns. The sup-Wald test statistics of tail quantile intervals are significant for the effects of stock returns on land returns, which implies that stock returns affect land returns only when the latter are extremely high or extremely low. [5]

[Insert Table 5 about here]

4 Conclusion

The interaction between the real estate market and the stock market in China is an important research topic yet to be fully addressed. This paper investigates the non-linear causal relationship between the stock and real estate markets in China. It is the first study to test for nonlinear interdependence of the real estate and stock markets in China. Our results of the quantile causality test suggest a significant causal relationship between these two markets, especially in the tail quantile. The existence of a significant tail interdependence implies that investors are unable to hedge the risk across the real estate and stock markets when they are extremely volatile. It also suggests that policymakers should be cautious of increasing systemic risk when extreme returns are observed in these two markets.

[5] To check the robustness of our results, we delete the observations from the abnormal year 2006, the year when the stock market was at a historic high. The results are quite similar.

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Table 1: Summary statistics for return series

	rhp	rlp	rsp
mean	0.0058	0.0056	0.0035
st. deviation	0.050	0.36	0.084
skewness	2.20	0.10	-0.27
kurtosis	10.95	3.70	4.53
minimum	-0.12	-1.08	-0.28
maximum	0.26	1.08	0.28

Notes: rhp, rlp and rsp represent the housing returns, land returns and stock returns, respectively.

Table 2: Linear Granger causality test: housing and stock returns

Null Hypothesis	p-value	Linear causality
rsp $\nRightarrow$ rhp	0.302	No causality
rhp $\nRightarrow$ rsp	0.588	No causality

Notes: rhp and rsp represent the housing returns and stock returns, respectively. The symbol $\nRightarrow$ denotes the direction of Granger causality.

Table 3: Linear Granger causality test: land and stock returns

Null Hypothesis	p-value	Linear causality
rsp $\nRightarrow$ rlp	0.157	No causality
rlp $\nRightarrow$ rsp	0.302	No causality

Notes: rlp and rsp represent the housing returns and stock returns, respectively. The symbol $\nRightarrow$ denotes the direction of Granger causality.

Table 4: Quantile causality test: housing and stock returns

Quantile interval	rhp $\nRightarrow$ rsp		rsp $\nRightarrow$ rhp	
	(1)	(2)	(1)	(2)
$[0.05, 0.2]$	1	10.99***	1	3.75
$[0.2, 0.4]$	1	4.67	1	0.71
$[0.4, 0.6]$	6	9.71	1	1.18
$[0.6, 0.8]$	6	12.63	1	2.86
$[0.8, 0.95]$	1	4.38	3	21.50***
$[0.05, 0.95]$	1	10.99**	1	5.59
$[0.05, 0.5]$	1	10.99**	1	3.72
$[0.5, 0.95]$	6	13.48	3	21.50***

Notes: rhp and rsp represent the housing returns and stock returns, respectively. Each interval in the square brackets is the quantile interval on which the null hypothesis holds. (1) represents the desired lag order, and (2) refers to the sup-Wald test statistics. ***, ** and * denote significance at 1%, 5% and 10% level, respectively.

Table 5: Quantile causality test: land and stock returns

Quantile interval	rlp $\nRightarrow$ rsp		rsp $\nRightarrow$ rlp	
	(1)	(2)	(1)	(2)
$[0.05, 0.2]$	9	17.43	4	16.87**
$[0.2, 0.4]$	1	0.89	1	0.26
$[0.4, 0.6]$	1	1.77	1	1.39
$[0.6, 0.8]$	1	1.25	1	1.63
$[0.8, 0.95]$	1	1.43	2	13.20**
$[0.05, 0.95]$	1	1.74	1	5.35
$[0.05, 0.5]$	1	1.74	1	3.87
$[0.5, 0.95]$	1	1.73	2	12.48**

Notes: rlp and rsp represent the housing returns and s-tock returns, respectively. Each interval in the square brackets is the quantile interval on which the null hypothesis holds. (1) represents the desired lag order, and (2) refers to the sup-Wald test statistics. ***, ** and * denote significance at 1%, 5% and 10% level, respectively.