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Research Article

Causality Tests and Their Applications to China's Stock and Housing Markets

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The link between the stock market and the housing market is well known to be sensitive. At present, the possibility of a connection between them remains intriguing. Therefore, China works as a case study for the research inquiry into the causal relationship between the stock market and the housing market. Using the monthly data from January 2000 to January 2021 and employing the cross-correlation function approach to perform empirical analysis, the results indicate that the bidirectional causal relationship between the stock market and the housing market has been recognized as one of the most interesting findings, which constitutes a significant departure from previous research. Moreover, the other interesting result is that, from the housing market to the stock market, a causality-in-mean and a causality-in-variance are discovered. Only a tiny number of previous studies have addressed this achievement in the context of China. Meanwhile, this article's findings have both theoretical and practical implications for China's proposition.

1. Introduction

It is common knowledge that China's stock market and housing market are two of its most important markets. Their unpredictable pricing has a significant impact on China's economic growth. As a result of this background, a significant number of academic researchers have focused their attention on investigating the connection between the housing market and the stock market. Despite this, academics have not yet arrived at a decision about the connection between the two of them due to their different samples and approaches. Using the autoregressive distributed lag cointegration technique, Gounopoulos et al. [1] claimed that there was a positive association between the volatilities of the stock market and the housing market. Meanwhile, Abuzayed et al. [2] came up much later and confirmed this viewpoint as well. However, employing the quasi-maximum-likelihood approach to estimate unknown parameters of the cDCC-GJR-GARCH model, a number of academics, such as Lou [3] and Deng et al. [4], were of the opinion that the volatilities of the stock market and the housing market did not have a positive link with one another. The fact that the conclusion of divergence might vary by such a large amount completely demonstrated that the rule of correlation between the volatilities of two markets had not been consistently identified.

When taking into consideration the current state of China's economy, the Chinese government places a high premium on the fact that the stock market experiences significant swings and that housing prices continue to climb. In response, a wide range of regulatory interventions have been implemented in an effort to combat this issue. For example, the government has put limits on who can buy houses and how they can pay for them. This is an attempt to lower the level of demand in the housing market. In the meantime, the government has also made improvements to the system that is designed to prohibit and regulate speculative trading on the stock market to lower the level of risk associated with trading on the stock market, but the problem of housing prices that are too high has not been properly addressed or solved. In addition to this, the stock market is subject to wild swings in volatility on occasion. Even more alarming is the fact that the consequences of the policy are far less than we expected. China's degree of financial development is considered to be at the lower end of the spectrum when compared to that of developed countries. Investors have a limited number of options when it comes to markets and items that provide large earnings. As a result, the majority of investors opt to put their money into either the stock market or the housing market. To phrase this another way, it is worthwhile to conduct an investigation into the connection that exists between the stock market and the housing market. To be more explicit, on the one hand, it is beneficial for investors to forecast the trajectory of economic development and to rationally organize their asset portfolio in accordance with the data that correspond to this trajectory. On the other hand, it gives the Chinese government a clear point of reference for figuring out what the rule means based on the state of the economy at the time. In fact, analyzing both the housing market and the stock market is important for controlling financial risks and preventing too many market bubbles from forming. Both the healthy growth and consistent growth of the stock market and the housing market are supported by the importance of both of these factors.

In line with the findings of Hafner and Herwartz [5], the cross-correlation function approach is employed to analyze the causal link between China's housing market and the stock market. In fact, several researchers, such as Alaganar and Bhar [6], Nakajima and Hamori [7], and Toyoshima and Hamori [8], have employed the cross-correlation function approach to undertake studies on the commodities market, the stock market, and the business cycle. Meanwhile, with regard to the study that Hafner and Herwartz [9] have conducted, the Granger causality test is used to examine the causality-in-mean. In addition, in reference to the work of Chang and McAleer [10], the causality-in-mean or the causality-in-variance is examined using the cross-correlation function approach. In comparison with the work of Hong [11], the cross-correlation function approach has the significant advantage of being easy to not only investigate the causality direction but also validate the appropriate lag length and lead length. This is the most obvious advantage of the cross-correlation function approach. Moreover, the cross-correlation function technique enables both flexible specification of the innovation process and independence from normality, as can be shown by examining the work of Dakhlaoui and Aloui [12]. In view of the discoveries presented above, this study uses the monthly data from January 2000 to January 2021 and employs the cross-correlation function approach to investigate the connection between China's stock market and the housing market. The empirical results bring about two important findings. First, it is found that there is a two-way causal relationship between China's stock market and the housing market. Second, from the housing market to the stock market, we found a causality-in-mean and a causality-in-variance.

In three different ways, this study makes a contribution to the existing body of research on the topic of the connection between China's stock market and the housing market. First, in 2021, the World Federation of Exchanges reported that the value of the real estate market in China, which was now estimated to be $ 62 trillion US dollars, was the greatest asset in the world. Meanwhile, based on the Wind Database, when compared to the average size of 5 trillion yuan in 2001, the entire market value of A shares was around 80 trillion yuan by the end of December 2020. This represented a growth of almost 15 times compared with size of the market in 2001. The number of listed firms surpassed 4,100, which was almost four times as much as in 2001. To sum up, it is more representative to take China as a sample to investigate the relationship between China's stock market and the housing market, compared with Jang et al. [13], who studied this issue with the sample of Korea, and Sing et al. [14], who studied this topic with the sample of Singapore. Second, the cross-correlation function approach used in this study to conduct empirical analysis might produce more reliable findings, compared with Li et al. [15] and Bahmani-Oskooee and Wu [16], who used the bootstrap Granger causality test, and Yousaf and Ali [17], who used the vector error correction method. Third, one of the most intriguing discoveries, which represents a substantial divergence from past research, is the bidirectional causal link between the stock market and the housing market. Another intriguing finding is the discovery of a causality-in-mean and a causality-in-variance from the housing market to the stock market. Only a few previous studies have examined this accomplishment in the contest of China.

The remainder of this work is delivered in the following order, according to its organizational structure. The literature review is presented in Section 2. The approach known as the cross-correlation function is shown in Section 3. The results and discussions are provided in Section 4. The conclusion is reported in Section 5.

2. Literature Review

Despite the vast amounts of research that have been conducted on the subject of the connection between the stock market and the housing market, many researchers have not been able to arrive at a consensus about this proposition. The reason for this is that various pieces of research could use various econometric methodologies, samples, and time periods to come to their conclusions.

According to Hartzell et al. [18], the features of common stock may be seen as a hedge against inflation. They came to the conclusion that the actual return on equity had a negative impact, regardless of whether it was anticipated or unanticipated inflation. Gyourko and Keim [19] explored the link between the returns of real estate stock and the returns of a typical appraisal-based index in the context of the American real estate markets. When the consistency in appraisal series was taken into account, they found that the returns of real estate portfolio lags could predict the returns of an appraisal-based index. However, Quan and Titman [20] investigated the association between shifts in property prices and rents and stock returns using data spanning fourteen years and fourteen countries throughout a total of fourteen years. They looked at the data and came to the conclusion that there was no statistically significant connection between fluctuations in annual real estate prices and returns on stock investments. In contrast to the study conducted by Gyourko and Keim

[19], Okunev et al. [21] investigated the connection between the S&P 500 stock markets and real estate in the United States using year-to-year time-series data spanning the period from 1972 to 1998. They carried out empirical studies using both the linear causality test and the nonlinear causality test, and the results showed that there was a link running only one way, from the real estate market to the stock market. However, the financial hypothesis was disproved by this discovery. On the contrary, the findings of the nonlinear causality test indicated that there was a robust one-way link running from the stock market to the real estate market. This conclusion was reached as a direct consequence of the findings. Furthermore, this finding confirmed the presence of structural breaks. Moreover, these outcomes were supported by Tzeremes [22], Hui and Yu [23], and Sing [24].

In the context of Greece, Kapopoulos and Siokis [25] investigated the connection between fluctuations in the value of real estate and the stock market. They supplied two different interpretations of this interaction between the two of them. There were a wealth effect and a credit price effect. The former suggested that when there was a rise in share price, the household earned unforeseen benefits, and there was a tendency for the quantity of housing to grow. The latter suggested that a rise in real estate prices was beneficial to economic activity and the future profitability of businesses. They used the Granger causality to provide an all-encompassing understanding of both systems. They came to the conclusion that the wealth effect hypothesis could only be substantiated for the real estate values in Athens. However, the wealth effect hypothesis about the pricing of other urban real estates could not be supported. In addition, Liow and Yang [26] used the vector error correction model and the fractional integrated vector error correction model to investigate whether or not the stock market and the securitized real estate market shared long-run co-memories. They found a fractional cointegration between the price of stocks on the market, the price of securitized real estate, and certain important factors affecting the macroeconomy. Given the predominance of fractional cointegration, this indicated that securitized real estate and common stock were, in the long term, alternative assets that might not be placed together in a diverse manner. Similarly, Liow [27] investigated the long-run and short-run links between the property and stock markets. He identified a long-term contemporaneous link between property prices and stock prices using autoregressive distributed lag cointegration. Furthermore, when adjusting for changes in macroeconomic impact, the long-run and short-run effects of residential and office building comprehensive pricing on the stock market were diminished. While the price of office property had the greatest long-run influence on the stock market, the impact of residential property prices on the stock market was greater in the short run. Meanwhile, Chiang and Chen [28] and Liang et al. [29] agreed with the above findings.

In the case of China, Liu and Su [30] examined the link between the real estate market and the stock market using the asymmetrical threshold cointegration test. In the long term, they discovered a nonlinear correlation between the Shenzhen Composite Index and the Real Estate Price Index. He discovered that there was a unidirectional causality flowing from stock price to house price using the vector autoregressive framework for empirical analysis. Su [31] used the nonparametric rank test on a sample of Western European countries to confirm the nonlinear equilibrium link between the real estate market and the stock market. Using the threshold error correction model, he found that, in the long run, the real estate market and the stock market were linked in a way that only ran in one direction. Similarly, Su et al. [32] used both the threshold error correction model and the threshold autoregressive model to look into the same topic. Even though the methods of analysis were distinct, they both ended up with the same conclusion. In addition, Su et al. [33] used a case study of China to reexamine this subject by including more factors in their analysis. In the long run, they discovered that changes in the price of real estate might have an effect on the price of shocks. Yousaf and Ali [17] looked at the relationship between real estate and the stock market in Pakistan using the vector error correction model. They discovered that there was a cointegration relationship between the real estate market and the stock market. In a more concrete sense, the long-run causal link between housing markets and stock markets was seen to run from one to the other. Furthermore, the above results were consistent with Nong [34], and Zou and Deng [35].

In contrast to the previous studies, the objective of this investigation is to determine whether or not there is a connection between the stock market and the housing market using the causality-in-mean test and the causality-in-variance test in the case study of China. As a result of this investigation, it has been found that there is a two-way link between the stock market and the housing market. This is a new development based on previously conducted research. The findings of the tests of causality-in-mean and causality-in-mean have shown that the casual link runs from the housing market to the stock market. These tests study whether or not the housing market has an effect on the stock market. This finding has never been highlighted in any of the previous investigations.

3. Methodology

Caporale et al. [36] and Whang and Kim [37] say to assume that there are two time series, H and S, that are stationary. Meanwhile, they define the information sets as $A_{1,t}$, $A_{2,t}$, and $A_{3,t}$. The forms of these three information sets are shown as follows:

$$\begin{aligned} A_{1,t} &= \left(H_t, H_{t-1}, H_{t-2}, H_{t-3}, \ldots\right), \\ A_{2,t} &= \left(S_t, S_{t-1}, S_{t-2}, S_{t-3}, \ldots\right), \\ A_{3,t} &= \left(H_t, H_{t-1}, H_{t-2}, H_{t-3}, \ldots, S_t, S_{t-1}, S_{t-2}, S_{t-3}, \ldots\right). \end{aligned} \tag{1}$$

If $E(H_t|A_{1,t-1}) \neq E(H_t|A_{t-1})$, S is stated to be the cause of H in the mean. Likewise, if $E(S_t|A_{2,t-1}) \neq E(S_t|A_{t-1})$, H is stated to be the cause of S in the mean. Moreover, if $E(H_t|A_{1,t-1}) \neq E(H_t|A_{t-1})$ and $E(S_t|A_{2,t-1}) \neq E(S_t|A_{t-1})$ hold simultaneously, there will be a feedback effect between

H and S in the mean. However, if $E((H_t - m_{H,t})^2|A_{1,t-1}) \neq E((H_t - m_{H,t})^2|A_{t-1})$, S is stated to be the cause of H in the variance. Likewise, if $E((S_t - m_{S,t})^2|A_{2,t-1}) \neq E((S_t - m_{S,t})^2|A_{t-1})$, H is stated to be the cause of S in the variance. There into, $m_{H,t}$ is the mean of H under the condition of $A_{1,t-1}$. $\mu_{m,t}$ is the mean of S_t under the condition of $A_{2,t-1}$. Similarly, if $E((H_t - m_{H,t})^2|A_{1,t-1}) \neq E((H_t - m_{H,t})^2|A_{t-1})$ and $E((S_t - m_{S,t})^2|A_{2,t-1}) \neq E((S_t - m_{S,t})^2|A_{t-1})$ hold at the same time, there will be a feedback effect between H and S in the variance. Taking these four inequalities into consideration, the causality-in-mean and causality-in-variance can be examined. Then, H_t and S_t can be defined as follows:

$$\begin{aligned} H_t &= m_{H,t} + (\omega_H \varepsilon_t)^{1/2}, \\ S_t &= m_{s,t} + (\omega_s \mu_t)^{1/2}, \end{aligned} \tag{2}$$

where ε_t and μ_t denote the white noise and independence. The standardized innovation for the causality-in-mean test is as follows:

$$\begin{aligned} \zeta_t &= \frac{(H_t - m_{H,t})^2}{\omega_H} = \varepsilon_t^2, \\ \xi_t &= \frac{(S_t - m_{S,t})^2}{\omega_S} = \mu_t^2, \end{aligned} \tag{3}$$

where ζ_t and ξ_t denote the standardized residuals. We use estimates for these residuals because they are unobservable. The sample cross-correlation of the squared standardized residual series, $r_{\zeta\xi}(k)$, is then calculated using their estimations. The sample cross-correlation is computed utilizing the standardized residual series, $r_{\varepsilon\mu}(k)$, with lag k.

Using the cross-correlation function method, the number of $r_{\zeta\xi}(k)$ and $r_{\varepsilon\mu}(k)$ is employed to identify causality-in-mean and causality-in-variance, correspondingly. Then, the following cross-correlation function statistic allows to identify the null hypothesis that there is no causality-in-mean.

$$T_{CCF} = T^{1/2} r_{\varepsilon\mu}(k). \tag{4}$$

The null hypothesis cannot be rejected if the cross-correlation function test statistic, T_{CCF}, falls under the critical value obtained by employing the standard normal distribution. Similarly, using the following test statistic, the null hypothesis that causality-in-variance does not exist may be identified.

$$T_{CCF} = T^{1/2} r_{\zeta\xi}(k). \tag{5}$$

The null hypothesis cannot be rejected if the cross-correlation function test statistic, T_{CCF}, falls under the critical value obtained by employing the standard normal distribution. The test of the cross-correlation function technique consists of two parts. One is that the univariate time-series models, which take into account the conditional means and variances that vary throughout time, are estimated. Following Engle and Bollerslev [38], and Hwang and Valls Pereira [39], the AR-EGARCH formulation is used in this study. The other is that we compute the standardized residuals of the estimated AR-EGARCH model and then the standardized squared residuals' series via conditional variances from the estimated model. As previously stated, the cross-correlation function of these standardized residuals is used to confirm the null hypothesis that there are no causality-in-mean and causality-in-variance.

4. Results and Discussion

4.1. Basic Statistic Description. Using monthly time-series data regarding China's stock and housing markets from January 2000 to January 2021, this study investigates the link between the stock market and housing market by employing casualty-in-mean and casualty-in-variance tests. The housing price index and the CSI300 index are obtained from Investing.com. The basic characteristics of the housing price index and the CSI300 index are presented in Table 1.

Following Jarque and Bera [40], the Jarque–Bera statistics are used to determine whether the change rates of both the housing market and the shock market have a normal distribution. According to the findings of Table 1, the normality of both the housing market and the shock market is rejected at a 5% significant level due to the value of probability. It is known that stationary variables serve as the foundation for the AR-EGARCH model and the causality test. Following Damianov and Elsayed [41] and Lee et al. [42], unit root tests such as KwiatKowski–Phillips–Schmidt–Shin (KPSS) test and Zivot and Andrews (ZA) test are employed in this study. The results of KPSS test indicate that the null hypothesis is not rejected. It means that the variables investigated are stationary. Moreover, the results of ZA test indicate that the null hypothesis is rejected at a 1% significant level, as shown in Table 1. In other words, the variables highlighted in this study are stationary.

4.2. AR-EGARCH Model. The cross-correlation function technique is used to assess the link between change rates in stock and housing prices. The AR(k)-EGARCH (p, q) model is shown as follows:

$$x_t = a_0 + \sum_{i=1}^{k} a_i x_t + b_0 du\ m_t + \omega_t, \tag{6}$$

$$\log(\sigma_t^2) = \nu + \sum_{i=1}^{q} (a_i |z_{t-i} + \delta_i z_{t-i}) + \sum_{i=1}^{p} \beta_i \log(\sigma_{t-1}^2), \tag{7}$$

where ω_t denotes the white noise; $du\ m_t$ denotes the dummy variable (before January 2008, the value is zero; otherwise, the value is one); z_t denotes the ω_t/σ_t; and $\log(\sigma_t^2)$ denotes the conditional variance in log. Following Jane and Ding [43], Martinet and McAleer [44], and Chang and McAleer [45], employing the log version of the EGARCH (p, q) model, it is feasible to ensure non-negativeness without applying coefficient restrictions. The EGARCH (p, q) model represents the asymmetric impact of negative and positive shocks by incorporating the term z_{t-i}. When δ_i is greater than zero, $z_{t-1} = \omega_{t-1}/\sigma_{t-1}$ is positive. $\sum_{i=1}^{p} \beta_i$ describes the

Table 1: Results of basic statistic description.

Statistics and variable	HPI	CSI300
Mean	0.049	0.005
Median	0.052	0.003
Maximum	0.126	0.258
Minimum	−0.061	−0.210
Standard error	0.048	0.068
Skewness	−0.541	0.383
Kurtosis	2.500	5.041
Jarque–Bera	6.460	21.584
Probability	0.040	0.000
Observations	109	109
KPSS test	0.715	0.491
ZA test	12.943***	6.012***

Note. HPI represents the change rate of the house price index; CSI300 represents the change rate of the stock index; and ***represents a 1% significant level; null hypothesis of KPSS test is that the variable is stationary; null hypothesis of ZA test is that the variable has a unit root.

Table 2: Results of the AR-EGARCH model.

Model	AR (3)-EGARCH (1, 1)	AR (1)-EGARCH (1, 1)
Coefficient and variable	HPI	CSI300
a_0	0.049***(0.002)	−0.020*** (0.000)
a_1	1.108*** (0.269)	0.981*** (0.000)
a_2	0.476*** (0.008)	
a_3	−0.629** (0.012)	
b_0	−0.001 (0.004)	0.015** (0.042)
ν	−0.724** (0.019)	−0.894*** (0.006)
a_1	0.746*** (0.008)	0.758*** (0.000)
γ_1	−0.028 (0.864)	−0.120*** (0.001)
β_1	0.429* (0.099)	0.471* (0.053)
Log likelihood	468.642	390.649
SBIC	−8.358	−6.931
$Q(20)$	21.620 (0.523)	24.143 (0.453)
$Q^2(20)$	41.205 (0.214)	40.832 (0.266)

Note. * represents a 10% significant level; ** represents a 5% significant level; *** represents a 1% significant level; Q represents the Ljung–Box statistics; () represents the p value.

persistence of shocks to the conditional variance. Equation (6), which represents the conditional mean, is expressed as a k-order autoregressive model. Following Schwarz [46], the Schwartz–Bayesian information criterion is used to calculate the optimal lag length, k, for each variable. In equation (7), the Schwartz–Bayesian information criterion is also used to find out the optimal lag lengths p and q. The model utilized in this study is from EGARCH (p, q), in which $p \in [1, 2]$ and $q \in [1, 2]$. Table 2 displays the results of the AR(k)-EGARCH (p, q) model.

The value of β_1, which is shown in Table 2, is used to figure out how persistent the volatility is. It is found that β_1 is significant at a 10% level. This indicates that the persistence of volatility shocks occurs. A possible explanation of this outcome is that the stock market and housing market in China are both experiencing a period of fast expansion. The volatile performance of listed companies, the severe imbalance between supply and demand in the stock market, the imperfect market operation mechanism, the aggravation of stock market fluctuations caused by stock market policies, and the excessive manipulation of market makers are some of the factors that may lead to the continued occurrence of volatility shocks. Moreover, this study's findings may offer policymakers a foundation for formulating policies to lessen the volatility of the stock market and housing market. The findings of this study may potentially serve as a foundation for future research on the subject, particularly if it is conducted in conjunction with other economic information or methodologies. The findings of this article also provide potential investors with a foundation on which to base their decisions. It is possible for investors to maximize their profit chances while also reducing their investment risks if they have a thorough grasp of the persistent influence that volatility has on China's stock market and housing market. Meanwhile, the results of this study provide a basis for the public to participate in the stock market and purchase real estate because an in-depth understanding of the causes of the persistent volatility of China's stock market and real estate market and the linkage between them can assist the public in reducing the risk associated with participating in the stock market and purchasing real estate. In the meantime, the diagnostic test results for the AR (3)-EGARCH (1, 1) and AR (1)-EGARCH (1, 1) are reported in Table 2. According to Ljung and Box [47], the autocorrelation is diagnosed using the Ljung–Box statistic. Based on the results of $Q(20)$ and $Q^2(20)$, the null hypothesis of no autocorrelation is not rejected. In other words, no autocorrelation is detected up to 20th order. To conclude, these findings provide empirical evidence in favor of the AR-EGARCH model that is formulated. Then, we use the estimated sample cross-correlations to conduct an investigation of the causality-in-mean and causality-in-variance. The results are shown in Table 3.

When the HPI and CSI300 ($-k$) are taken into consideration, the result suggests that in lag 5, the causality-in-mean emerges at a 10% significant level. Meanwhile, the results show that the causality-in-variance appears at a 5% and 10% significant level in lags 3 and 8, respectively. In addition, the results of the HPI and CSI300 ($+k$) sample show that the causality-in-mean appears at a 5% significant level in lag 15. Simultaneously, the result also indicates that both at lag 5 and at lag 13, the causality-in-variance occurs at a 10% significant level. In a nutshell, this study presents an overview of two interesting discoveries. One is that, in spite of the fact that Ding et al. [48] discovered a unidirectional causality extending from China's housing market to the stock market, this research demonstrates that bidirectional causality exists between the housing market and the stock market. This provided evidence for the existence of both a credit price effect and a wealth effect between stock market and the housing market. The other is that there is evidence of a causal link between stock and housing markets, in terms of both causality-in-mean and casualty-in-variance. In fact, only a few of the previous studies that have been done on China have highlighted this achievement. Moreover, either researchers working in the field or those working in academic institutions may gain something from the results reported in this work.

Table 3: Results of cross-correlation test.

Lag (k)	HPI and CSI300 ($-k$)		HPI and CSI300 ($+k$)	
	Mean	Variance	Mean	Variance
1	−0.052	−0.009	−0.130	−0.127
2	−0.042	−0.146	0.041	−0.052
3	−0.054	0.116**	−0.109	−0.087
4	0.022	−0.234	−0.073	−0.020
5	0.099*	−0.039	−0.101	0.033*
6	−0.123	−0.099	0.134	−0.029
7	0.047	−0.070	−0.090	−0.104
8	−0.064	0.184*	−0.150	0.128
9	0.043	0.022	−0.135	−0.073
10	0.042	0.038	−0.012	−0.082
11	0.216	0.006	0.159	0.064
12	−0.069	0.021	−0.107	−0.029
13	−0.049	0.033	−0.017	0.040*
14	−0.131	−0.122	0.129	−0.093
15	−0.104	0.118	0.177**	0.019
16	0.118	−0.206	−0.066	0.046
17	0.153	−0.179	0.043	−0.006
18	0.014	−0.012	−0.046	0.088
19	−0.101	−0.054	0.023	−0.085
20	0.180	0.218	0.177	0.111

Note. * represents a 10% significant level; ** represents a 5% significant level.

Table 4: Results of cross-correlation test.

Lag (k)	HPI and SSE50 ($-k$)		HPI and SSE50 ($+k$)	
	Mean	Variance	Mean	Variance
1	−0.059	−0.008	−0.116	−0.121
2	−0.074	−0.166	0.087	−0.064
3	−0.097	0.144*	−0.128	−0.028
4	0.08	−0.248	−0.040	−0.031
5	0.082***	−0.039	−0.103	0.087**
6	−0.151	−0.085	0.139	−0.030
7	0.02	−0.050	−0.087	−0.148
8	−0.073	0.145**	−0.198	0.142
9	0.012*	0.057	−0.114	−0.031
10	0.049	0.036	−0.083	−0.084
11	0.225	0.003	0.146	0.053
12	−0.062	0.24	−0.165	−0.075
13	−0.022	0.039	−0.027	0.036***
14	−0.072	−0.184	0.156	−0.086
15	−0.127	0.161	0.171*	0.026
16	0.184	−0.269	−0.097	0.083
17	0.125	−0.071	0.029	−0.034
18	0.056	−0.093	−0.074	0.080
19	−0.134	−0.012	0.030	−0.046
20	0.123	0.138	0.172	0.116

Note. * represents a 10% significant level; ** represents a 5% significant level; *** represents a 1% significant level.

4.3. Robustness Test. This subsection provides an explanation of a robust test that may be used to validate the findings of empirical research. Following Tsai [49], Shi et al. [50], and Mori [51], for the purpose of providing an explanation for the rationale behind utilizing CSI300 index as the proxy variable for stock market performance, the SSE50 index, which is another major Chinese stock index, is included in the process of assessing the relationship between the shock market and the housing market. Using the same method, the relationship between the stock market (SSE50 index) and the housing market is reestimated. The results are shown in Table 4.

As the results of Table 4 indicate, for HPI and SSE50 ($-k$), the causality-in-mean is found in lag 5 and lag 9. Meanwhile, the causality-in-variance is found in lag 3 and lag 8. For HPI and SSE50 ($+k$), the causality-in-mean is found in lag 15. In the meantime, the causality-in-variance is found in lag 5 and lag 13. Moreover, the above findings are consistent with the results reported in Table 2. Consequently, it can be concluded that the results presented in this study are reliable and robust.

5. Conclusions

The objective of this study is to determine whether or not there is a causal relationship between the stock market and the housing market in China by analyzing the monthly data from January 2000 to January 2021. Using the cross-correlation approach for empirical analysis, two fascinating results have been obtained. One discovery is the identification of a two-way causal relationship between the stock market and the housing market. In contrast to previous studies, such as the one conducted by Zhou et al. [52], who discovered that there was a unidirectional link of causality between the stock market and the housing market, the current finding is different from the previous ones. As a direct result of this, it is possible to identify not just the credit price effect but also the wealth effect that exists between the stock market and the housing market. The other discovery is that the causality-in-mean and the causality-in-variance between the stock market and the housing market are detected. In point of fact, only a very small percentage of the previous studies that were conducted on China recognized this accomplishment.

In addition, some policy implications are suggested in light of the results and conclusions of this article. First, our findings are straightforward enough to reassure financial institutions and investors that failing to account for the presence of a time-scale dimension in stock and housing relationships, particularly during the economic crisis in 2008 and the COVID-19 pandemic in 2020, will almost certainly lead to an inaccurate assertion of portfolio measuring performance and diversification benefits. Second, the bubble that has developed in China's housing market is becoming an increasingly severe problem, which has posed a significant risk to China's overall economic growth. As a result of the connection between China's shock market and the housing market, the Chinese government is able to manage and relieve the froth in China's housing market by regulating the corresponding stock markets.

This study contributes to the current body of knowledge on the relationship between China's stock market and housing market in three distinct ways. First, since China has the greatest housing market and the fastest-growing stock market, China is a more representative sample to study the relationship between the stock market and the housing market. Second, compared with the bootstrap Granger causality test and the vector error correction technique, the cross-correlation function approach utilized in this study to undertake empirical analysis may yield more accurate results. Third, the bidirectional causal relationship between the stock market and the housing market is one of the most exciting conclusions, which constitutes a significant departure from prior studies. The observation of a causality-in-mean and a causality-in-variance from the housing market to the stock market is another noteworthy conclusion. Only a few prior studies have studied this achievement in China.

In conclusion, this article has several limitations, some of which might open up new avenues of investigation for specialists in the relevant fields. First, this study does not take into account other macroeconomic variables, such as consumer price index and interest rate, so it does not cover such topics. It is possible for future researchers to reexamine this subject in conjunction with these macroeconomic variables, which may lead to findings that are both more effective and more intriguing. Second, due to the limitations of the cross-correlation function approach, future researchers may attempt some additional methods, such as threshold cointegration approach and vector autoregressive approach, which may result in some interesting results than the method that was used in this study. Third, to investigate the subject at hand, this study exclusively focuses on China as its case study. In the future, academics may examine this issue using the United States, Japan, Britain, and other countries as examples, which may result in some alternative findings being drawn. Four cyclical fluctuations, such as booms and busts, will have an impact on the stock and housing markets. It is possible for future researchers to take this into account in their empirical investigation, which may lead to results that are both more trustworthy and interesting.

Data Availability

The data used in this study can be available upon reasonable request from the author.

Conflicts of Interest

The author declares that there are no conflicts of interest.

References

[1] D. Gounopoulos, K. Kosmidou, D. Kousenidis, and V. Patsika, "The investigation of the dynamic linkages between real estate market and stock market in Greece," *The European Journal of Finance*, vol. 25, no. 7, pp. 647–669, 2019.

[2] B. Abuzayed, N. A. Fayoumi, and E. Bouri, "Co-movement across European stock and real estate markets," *International Review of Economics & Finance*, vol. 69, pp. 189–208, 2020.

[3] T. Lou, "Nonlinear causality relationship between stock and real-estate returns in PIGS countries: wealth effect or credit-price effect," *Applied Economics Letters*, vol. 24, no. 11, pp. 736–741, 2017.

[4] Y. Deng, E. Girardin, R. Joyeux, and S. Shi, "Did bubbles migrate from the stock to the housing market in China between 2005 and 2010?" *Pacific Economic Review*, vol. 22, no. 3, pp. 276–292, 2017.

[5] C. M. Hafner and H. Herwartz, "Testing for causality in variance using multivariate GARCH models," *Annales d'Economie et Statistique*, no. 89, p. 215, 2008.

[6] V. T. Alaganar and R. Bhar, "An international study of causality-in-variance: interest rate and financial sector returns," *Journal of Economics and Finance*, vol. 27, no. 1, pp. 39–55, 2003.

[7] T. Nakajima and S. Hamori, "Causality-in-mean and causality-in-variance among electricity prices, crude oil prices, and yen-US dollar exchange rates in Japan," *Research in International Business and Finance*, vol. 26, no. 3, pp. 371–386, 2012.

[8] Y. Toyoshima and S. Hamori, "Volatility transmission of swap spreads among the US, Japan and the UK: a cross-correlation function approach," *Applied Financial Economics*, vol. 22, no. 11, pp. 849–862, 2012.

[9] M. McAleer and C. M. Hafner, "A one line derivation of EGARCH," *Econometrics*, vol. 2, no. 2, pp. 92–97, 2014.

[10] C.-L. Chang and M. McAleer, "The correct regularity condition and interpretation of asymmetry in EGARCH," *Economics Letters*, vol. 161, pp. 52–55, 2017.

[11] Y. A. Hong, "A test for volatility spillover with application to exchange rates," *Journal of Econometrics*, vol. 103, no. 1-2, pp. 183–224, 2001.

[12] I. Dakhlaoui and C. Aloui, "The interactive relationship between the US economic policy uncertainty and BRIC stock markets," *International Economics*, vol. 146, pp. 141–157, 2016.

[13] H. Jang, Y. Song, and K. Ahn, "Can government stabilize the housing market? The evidence from South Korea," *Physica A: Statistical Mechanics and Its Applications*, vol. 550, Article ID 124114, 2020.

[14] T. F. Sing, I. C. Tsai, and M. C. Chen, "Price dynamics in public and private housing markets in Singapore," *Journal of Housing Economics*, vol. 15, no. 4, pp. 305–320, 2006.

[15] J. P. Li, J. J. Fan, C. W. Su, and O. R. Lobonţ, "Investment coordinates in the context of housing and stock markets nexus," *Applied Economics Letters*, vol. 24, no. 20, pp. 1455–1463, 2017.

[16] M. B. Oskooee and T. P. Wu, "On the relation between housing and stock markets in 18 oecd countries: a bootstrap panel causality test," *Journal of Real Estate Portfolio Management*, vol. 24, no. 2, pp. 121–133, 2018.

[17] I. Yousaf and S. Ali, "Integration between real estate and stock markets: new evidence from Pakistan," *International Journal of Housing Markets and Analysis*, vol. 13, no. 5, pp. 887–900, 2020.

[18] D. Hartzell, J. S. Hekman, and M. E. Miles, "Real estate returns and inflation," *Real Estate Economics*, vol. 15, no. 1, pp. 617–637, 1987.

[19] J. Gyourko and D. B. Keim, "What does the stock market tell us about real estate returns?" *Real Estate Economics*, vol. 20, no. 3, pp. 457–485, 1992.

[20] D. C. Quan and S. Titman, "Do real estate prices and stock prices move together? An international analysis," *Real Estate Economics*, vol. 27, pp. 183–207, 1999.

[21] J. Okunev, P. Wilson, and R. Zurbruegg, "The causal relationship between real estate and stock markets," *The Journal of Real Estate Finance and Economics*, vol. 21, no. 3, pp. 251–261, 2000.

[22] P. Tzeremes, "The asymmetric effects of regional house prices in the UK: new evidence from panel quantile regression framework," *Studies in Microeconomics*, vol. 10, no. 1, pp. 7–22, 2022.

[23] E. C. M. Hui and K. H. Yu, "The interactions between Hong Kong's housing market and global markets upon unprecedented monetary policy changes," *Housing Studies*, pp. 1–35, 2022.

[24] B. Singh, "Housing and stock market wealth effects in developing economies," *International Economics and Economic Policy*, vol. 19, no. 1, pp. 29–49, 2022.

[25] P. Kapopoulos and F. Siokis, "Stock and real estate prices in Greece: wealth versus 'credit-price' effect," *Applied Economics Letters*, vol. 12, no. 2, pp. 125–128, 2005.

[26] K. H. Liow and H. Yang, "Long-term Co-memories and short-run adjustment: securitized real estate and stock markets," *The Journal of Real Estate Finance and Economics*, vol. 31, no. 3, pp. 283–300, 2005.

[27] K. H. Liow, "Dynamic relationship between stock and property markets," *Applied Financial Economics*, vol. 16, no. 5, pp. 371–376, 2006.

[28] S. H. Chiang and C. F. Chen, "From systematic to systemic risk among G7 members: do the stock or real estate markets matter?" *Journal of International Financial Markets, Institutions and Money*, Article ID 101594, 2022.

[29] J. Liang, Q. Fan, and Y. Hu, "Dynamic relationships between commodity prices and local housing market: evidence for linear and nonlinear causality," *Applied Economics*, vol. 53, no. 15, pp. 1743–1755, 2021.

[30] Y. S. Liu and C. W. Su, "The relationship between the real estate and stock markets of China: evidence from a nonlinear model," *Applied Financial Economics*, vol. 20, no. 22, pp. 1741–1749, 2010.

[31] C. W. Su, "Non-linear causality between the stock and real estate markets of western European countries: evidence from rank tests," *Economic Modelling*, vol. 28, no. 3, pp. 845–851, 2011.

[32] C. W. Su, H. L. Chang, and M. N. Zhu, "A non-linear model of causality between the stock and real estate markets of European countries," *J. Econ. Forecast*, vol. 1, pp. 41–53, 2011.

[33] C. W. Su, X. C. Yin, H. L. Chang, and H. G. Zhou, "Are the stock and real estate markets integrated in China?" *Journal of Economic Interaction and Coordination*, vol. 14, no. 4, pp. 741–760, 2019.

[34] H. Nong, "Understanding housing price–volume connectedness: the case of housing markets in major megacities of China," *Appl. Spat. Anal. Policy*, pp. 1–19, 2022.

[35] J. Zou and X. Deng, "Financial literacy, housing value and household financial market participation: evidence from urban China," *China Economic Review*, vol. 55, pp. 52–66, 2019.

[36] G. M. Caporale, N. Pittis, and N. Spagnolo, "Testing for causality-in-variance: an application to the east asian markets," *International Journal of Finance & Economics*, vol. 7, no. 3, pp. 235–245, 2002.

[37] Y. J. Whang and J. Kim, "A multiple variance ratio test using subsampling," *Economics Letters*, vol. 79, no. 2, pp. 225–230, 2003.

[38] R. F. Engle and T. Bollerslev, "Modelling the persistence of conditional variances," *Econometric Reviews*, vol. 5, no. 1, pp. 1–50, 1986.

[39] S. Hwang and P. L. V. Pereira, "Small sample properties of GARCH estimates and persistence," *The European Journal of Finance*, vol. 12, no. 6-7, pp. 473–494, 2006.

[40] C. M. Jarque and A. K. Bera, "A test for normality of observations and regression residuals," *International Statistical Review/Revue Internationale de Statistique*, vol. 55, no. 2, p. 163, 1987.

[41] D. S. Damianov and A. H. Elsayed, "On the transmission of spillover risks between the housing market, the mortgage and equity REITs markets, and the stock market," *Finance Research Letters*, vol. 27, pp. 193–200, 2018.

[42] M.-T. Lee, C. L. Lee, M. L. Lee, and C. Y. Liao, "Price linkages between Australian housing and stock markets: wealth effect, credit effect or capital switching?" *International Journal of Housing Markets and Analysis*, vol. 10, 2017.

[43] T. D. Jane and C. G. Ding, "On the multivariate EGARCH model," *Applied Economics Letters*, vol. 16, no. 17, pp. 1757–1761, 2009.

[44] G. G. Martinet and M. McAleer, "On the invertibility of EGARCH," *Econometric Reviews*, vol. 37, no. 8, pp. 824–849, 2018.

[45] C.-L. Chang and M. McAleer, "A simple test for causality in volatility," *Econometrics*, vol. 5, no. 1, p. 15, 2017.

[46] G. Schwarz, "Estimating the dimension of a model," *Annals of Statistics*, vol. 6, pp. 461–464, 1978.

[47] G. M. Ljung and G. E. P. Box, "On a measure of lack of fit in time series models," *Biometrika*, vol. 65, no. 2, pp. 297–303, 1978.

[48] H. Ding, T. T. L. Chong, and S. Y. Park, "Nonlinear dependence between stock and real estate markets in China," *Economics Letters*, vol. 124, no. 3, pp. 526–529, 2014.

[49] I. C. Tsai, "Dynamic information transfer in the United States housing and stock markets," *The North American Journal of Economics and Finance*, vol. 34, pp. 215–230, 2015.

[50] G. Shi, X. Liu, and X. Zhang, "Time-varying causality between stock and housing markets in China," *Finance Research Letters*, vol. 22, pp. 227–232, 2017.

[51] M. Mori, "Information diffusion in the U.S. Real estate investment trust market," *The Journal of Real Estate Finance and Economics*, vol. 51, no. 2, pp. 190–214, 2015.

[52] X. Zhou, M. S. Chang, and K. Gibler, "The asymmetric wealth effects of housing market and stock market on consumption in China," *Journal of the Asia Pacific Economy*, vol. 21, no. 2, pp. 196–216, 2016.