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Novel evidence on the asymmetric causality between the Chinese stock and real estate markets: evidence from city-level data

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ABSTRACT

Our study re-examines the asymmetric causality between the Chinese stock and real estate markets in 70 cities. Prior research using symmetry hypotheses, has not yet linked these two markets or paid attention to their heterogeneity. We uniquely employed the nonlinear autoregressive distributed lag model, which permits the exploration of bidirectional asymmetric causality. Decreases and increases in stock prices caused short-run changes to real estate prices in 18 of the cities studied; this short-run effect was ultimately carried on in Guangzhou and in three cities. Even after switching the study variables, similar results were obtained. Our findings show that real estate policymakers in specific cities need to take into consideration the asymmetric performance of real estate prices as caused by the asymmetry within stock prices. If government stabilises the real estate market, it can in turn facilitate stock-market stability.

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1. Introduction

Since the Chinese real estate sector reform in 1998, real estate prices have experienced a continuous surge. The average real estate price in urban China more than tripled, from 1,854 RMB per square meter in 1998 to 9,310 RMB per square meter in 2019. China's real estate market is characterised by a significant housing shortage in first-tier cities and a polarization of housing transactions in second-tier cities, with third-tier cities being under great pressure to reduce their unsold housing inventory (Li et al., 2019). The Shanghai Stock Exchange (SSE) Composite Index fell from a peak of 2242 in 2001 to its lowest point of 1012 at the end of 2005. After 2011, the stock market experienced a downward trend, and was relatively stable from 2012 to 2014. Between 2015 and 2016, the SSE Index had almost broken through 5000 points but then, after August 2015, it plunged to approximately 1500. Following the stock

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market crash, real estate prices began to rise rapidly in 2016, especially in certain first-tier cities (Su et al., 2019). The real estate and stock markets are the two primary investment channels for Chinese investors, accounting for more than 80% of residents' properties in China (Jin & Chu, 2015). Therefore, the performance of the two asset markets have intensified the debate on the implementation of market stabilization policies by the government, highlighting the need to understand the relationship between them.

Several studies have argued that macroeconomic economic variables showcase asymmetries due to either the business cycle or the complexity of the financial markets. Asymmetric behaviours of macroeconomic variables are common in the social sciences, and inherent in economics. Over time, most economic and financial markets tend to exhibit asymmetric behaviours and interact in an asymmetric manner. Overall, factors such as financial crises, abrupt changes in business cycles, or the complexity of financial markets contribute to asymmetric phenomena (Katrakilidis & Trachanas, 2012). Stock and real estate indices are examples of macroeconomic variables. Therefore, applying these two indices to a given symmetric model may result in a specification error. To that end, if changes in macroeconomic variables have asymmetric effects on stock and real estate prices, we should expect the same between the two markets.

This study assumes that stock and real estate prices are mutually determinant factors, and presents the following innovations and contributions. First, we consider the bidirectional symmetrical and asymmetrical causality between the Chinese stock and real estate markets using the ARDL and NARDL models, which expand on previous research findings. Second, the heterogeneity of real estate markets from 70 cities is examined, as this has received insufficient focus in extant literature.

2. Theoretical framework and literature review

Empirical studies have identified various theoretical frameworks for explaining the integrated relationship between these two asset markets. The first is known as the wealth effect, which assumes that causality occurs from the stock market to the real estate market. The rationale behind this theory is that, when stock prices increase, households rebalance their portfolios and shift their funds to either the real estate market or other forms of investment.[1] Green (2002) finds that the wealth effect takes place only in the context of high real estate prices (e.g. California), and Kakes and Van Den End (2004) provides evidence from the Dutch market of the wealth effect of real estate prices in different regions.

The second theory is the credit price effect, which assumes that causality runs from the real estate to the stock market. The rationale behind this theory is that a rise in real estate prices can stimulate economic activity and future profitability of firms, and consequently stock prices, by raising the collateral value and reducing the cost of borrowing for both firms and households. Sim and Chang (2006) observed that the credit price effect on real estate and land prices causes stock prices to rise in most regional real estate and land markets. Using similar approaches, Kapopoulos and Siokis (2005) and Lin and Lin (2011) obtained similar results in Greece and Singapore.

The third theory is the substitution effect that suggests an inverse relationship between the real estate and stock markets. The rationale behind this theory is that when the price of an investment instrument is high, it is difficult for it to generate profits, so the investor may turn to alternative investments for high returns or risk aversion (Lizieri & Satchell, 1997).[2]

Based on the above literature review, there could be a positive correlation between the two markets due to the wealth and credit effects, although a negative correlation may also exist due to the substitution effect. Moreover, given the high profitability and poor liquidity of China's real estate market, we assume that the Long-term price effect in the two asset markets is more meaningful for policymakers and investors.

Attempts by some studies to accurately determine the association between the Chinese stock and real estate markets remain somewhat contradictory. Ba et al. (2009) discover that stock prices have a causal effect on real estate prices, while Chan and Chang (2014) find significant price transmission effects from the Chinese stock market to the real estate market. Conversely, Lin and Fuerst (2014) find evidence that the stock and real estate markets are segregated. Adcock et al. (2016) demonstrate that real estate investment returns and the A-share market are integrated in the long run; in the short run, real estate investment returns impact A-share prices, but not vice versa. Finally, Li et al. (2017) report that stock prices have both positive and negative impacts on real estate prices across several sub-periods, with the latter always having the same effects on the former.

Recently, studies have emphasised the need to employ asymmetric models to account for the long-run asymmetric impact of macroeconomic variables on the real estate market, which may improve policymakers' and other stakeholders' understanding of the market. Bahmani-Oskooee and Ghodsi (2018) employ the Non-linear Autoregressive Distributed Lag model to analyse the asymmetric causality between asset markets in the United States. Their empirical results indicate that, in 39 of the 41 states studied, a decline in real estate prices led to a rise in stock prices in the short run. Extant research suggests that a symmetric framework may not be appropriate for the analysis of the relationship between the two asset markets and suggest a reappraising of the asymmetry between the two.

While empirical studies have identified both the asymmetric causality and the price effect between these asset markets and their responses using asymmetric methods, they have paid relatively less attention to the real estate markets in different cities. Liu and Su (2010) employed an asymmetric threshold cointegration test to analyse the relationship between real estate and stock prices. Their results indicate that the price transmissions between the real estate market and the Shenzhen Composite Stock Index are asymmetric in the long run. Ding et al. (2014) employ the quantile causality test to analyse the asymmetric causality between the two asset markets, indicating a bidirectional causality in the short run.

In fact, heterogeneity of cities results in the investment risk difference in each city, and in turn the difference in price fluctuations in each city due to the varying risk preference of investors. Their investment in real estate and stock markets of different cities is congruous to their risk preferences. Thus, an investigation into the heterogeneity of cities would help both investors and policymakers when formulating optimal portfolio strategies and policies.

3. Methodology and data sources

3.1. Methodology

Following Bahmani-Oskooee and Ghodsi (2018), the bivariate model between the two variables of concern in this study is expressed as:

$$HP_t^j = \alpha + bSP_t + \varepsilon_t \tag{1}$$

Eq. (1) represents the stock price (*SP*) as a determinant of real estate prices (*HP*) of city *j*, and *b* represents the long run estimate of stock price. To infer the short-run effects, we follow Pesaran et al. (2001) and write Eq. (1) as an error-correction model.

$$\Delta HP_t^j = \alpha + \sum_{i=1}^{\Phi} \beta_i \Delta HP_{t-i}^j + \sum_{i=0}^{\Phi} \gamma_i \Delta SP_{t-i} + \lambda HP_{t-i}^j + \lambda b SP_{t-1} + \mu_t \tag{2}$$

The long-run effect is given by the estimates of λb normalised on λ. The normalised estimates of Eq. (2) stand for the *b* of Eq. (1) (i.e. $b = -\lambda b/\lambda$). To introduce the asymmetric view, we follow Shin et al. (2014) who used the asymmetry methodology and reconsidered the long-run equilibrium as:

$$HP_t^j = \alpha + b^+ SP_{\mathrm{t}}^+ + b^- SP_t^- + \varepsilon_t, \tag{3}$$

where b^+ and b^- represents the long-run asymmetric estimates of stock price, respectively. According to Shin et al. (2014), which can be used to generate the partial sum of both positive and negative changes in stock price:

$$SP_t^+ = \sum_{q=1}^{t} \Delta SP_q^+ = \sum_{q=1}^{t} \max(\Delta SP_q, 0), \quad SP_t^- = \sum_{q=1}^{t} \Delta SP_q^- = \sum_{q=1}^{t} min(\Delta SP_q, 0) \tag{4}$$

where SP_t^+ denotes the partial sum of positive variations in stock prices, while SP_t^- denotes the partial sum of negative variations in stock prices.

$$\Delta HP_t^j = \alpha + \sum_{i=1}^{\Phi} \beta_i \Delta HP_{t-i}^j + \sum_{i=0}^{\Phi} \gamma_i^+ \Delta SP_{t-i}^+ + \sum_{i=0}^{\Phi} \gamma_i^- \Delta SP_{t-i}^- + \rho_0 HP_{t-1}^j + \rho_1^+ SP_{t-1}^+ + \rho_1^- SP_{t-1}^- + \xi_t \tag{5}$$

The long-run asymmetric effect is given by the estimates of ρ_1^+ and ρ_1^- normalised on ρ_0, while the normalised estimates of Eq. (5) stand for the b^+ and b^- of Eq. (3). To infer the long-run symmetry, a Wald test under the null hypothesis of $b^+ = b^-$ must be conducted. To infer the long-run effects meaningfully, the existence of cointegration between stock and real estate prices can be established using two approaches: Pesaran et al. (2001) F test (F), or Banerjee et al. (1998) t-test (t). The F-test is a bound test for a null hypothesis where the estimate of the level variable is equal. The t-test (t) assumes that the error correction term (i.e. ECM_{t-1}) is generated by normalising the long run estimates and is more efficient in justifying the existence of cointegration. In the t-test (t), the null hypothesis of $\rho_0 = 0$ is adopted against the one-sided alternative hypothesis of $\rho_0 < 0$. According to Shin et al. (2014), not only are the estimation techniques for both models the same, but so are the diagnostic tests. This means that the same critical values of the F test should be used to establish co-integration in both models. Further, this methodology procedure has the advantage of avoiding the classification of variables into I(1) or I(0) and there remains no need for unit root pre-testing.

As a guideline for these tests, both the ARDL and NARDL models can be used to determine whether there is a cointegration relationship between real estate and stock prices and a long-run asymmetric effect. As they do not indicate the direction of any causality, the next step would be to determine this factor. We employed the asymmetric causality test from Bahmani-Oskooee and Ghodsi (2018), which is an improved causality test that includes long- and short-run improvements based on the ARDL and NARDL models. To examine any symmetric short-run causality, a Wald test was run under the null hypothesis on the sum of coefficients for ΔSP (i.e. $\sum \gamma_i = 0$) of Eq. (2), as this would support the symmetric short-run causality from the stock price to the real estate prices of a given city.[3] Similarly, the asymmetric short-run causality was tested under the null hypotheses of $\sum \gamma_i^+ = 0$ and $\sum \gamma_i^- = 0$ of Eq. (5), which would support such a causality. The long-run causality between the two variables was established using a t-test (t) to examine the significance of a negative λ and the ρ_0 of Eqs. (2) and (5), respectively. Further, the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) of the recursive residual stability of all the estimated models was tested. By switching the study variables, it is possible to detect whether the causality runs symmetrically or asymmetrically from HP^j to SP.

3.2. Data sources

Monthly data were used in our study, with the sample period being from December 2010 to December 2020 for both real estate and stock price data. The reasons for choosing the NCRB index are as follows. A national uniform data source was reformulated and released by the National Bureau of Statistics of China (NBSC) in January 2011, and is the only publicly accessible index system that provides consistent long-term information about the real estate market. It enabled us to perform a more detailed analysis of the heterogeneity of each city. The NCRB 70 city indices represent half of the Chinese real estate markets in terms of their overall supply and demand (Zhu & Zhang, 2021). The China Securities Index 300 (CSI300) was used as the proxy for China's stock market performance. It is a capitalisation-weighted stock market index designed to replicate the top 300 stocks traded on the Shanghai and Shenzhen Stock Exchange, and is widely regarded as mirroring the Chinese stock market (Xiao et al., 2021).

Next, we followed Hui and Wang (2014) real estate price index pre-processing method. The first step involves transforming the raw data to a baseline of January 2010. As seasonality of data is always considered in econometrics analysis (Hui & Wang, 2014), we allow a seasonal adjustment. Moreover, before entering them into the analytical model, all variables were subjected to preliminary unit root testing, so that none of them are I (2).[4]

4. Analysis and discussion

4.1. The effect of stock prices on real estate prices

We estimated the ARDL (2) and NARDL models (5) for each city. According to Shin et al. (2014), each model was estimated using the General-To-Specific (GETS) approach to select the final ARDL and NARDL models. The preferred model is chosen by starting with the largest lag length of 12 and dropping all insignificant stationary regressors. The estimates of the effect of stock price on real estate price was the first to be conducted, and the results from each model are reported in Table 1.

First, as can be seen from Panel A in Table 1, the null hypothesis that $\sum \gamma_i \neq 0$ was rejected, which indicates that stock prices have a causal effect on real estate prices in the short run for 32 out of 70 cities. Second, the F- and t-statistics of four cities (Shenzhen, Hangzhou, Tianjin, and Xiamen) allowed us to reject the null hypothesis of no cointegration. This reveals that the short-run effects found in this study lasts into the long run within these four cities. As for the long-run effects in Shenzhen, Hangzhou, Tianjin, and Xiamen, Panel A provides evidence for the symmetric positive effects of stock price on real estate price.

However, it remains unclear whether increases or decreases in the stock price cause real estate prices to change. We further examined the asymmetry of the impact of stock prices on real estate prices for the sampled cities. Panel B in Table 1 reports the results of our NARDL. There is evidence of an asymmetric short-run causality from stock price to real estate prices in 44 cities. The null hypothesis of $\sum \gamma_i^- \neq 0$ is thus rejected, which indicates that decreases in stock prices have a causal effect on real estate prices in the short run for 17 of 44 cities. Further, the null hypothesis $\sum \gamma_i^+ \neq 0$ is also rejected, which indicates that increases in stock prices have a causal effect on the real estate prices in the short run within 15 out of 44 cities. Meanwhile, both null hypotheses are rejected in the remaining 12 cites. This reflects the asymmetric short run effect of stock price on real estate prices.

The F- and t-statistics of six cities allowed us to reject the null hypothesis of no cointegration. This outcome shows that decrease in stock prices has a short-run effect on real estate prices in 17 of the included cities. Furthermore, we found that this short run effect only lasts into the long run within Guangzhou. Meanwhile, increases in stock prices were found to cause changes to the short run real estate prices in 15 cities, lasting into the long run effect in three of them (Beijing, Shanghai, and Wenzhou). As for long run effects in Beijing, Shanghai, and Wenzhou, Panel B provides evidence that positive changes in the stock price (b^+) are both positive and significant, whereas negative changes in stock price (b^-) are not. This means that these three cities are affected by positive changes in stock price, but not by any negative

Table 1. The effect of stock prices on real estate prices.

	Panel A: Results from the ARDL model						Panel B: Results from the NARDL model								
	F	t	b	$\sum\gamma_i$	Adj.R^2	CS(CS^2)	F	t	b^+	b^-	$b^+=b^-$	$\sum\gamma_i^+$	$\sum\gamma_i^-$	Adj.R^2	CS(CS^2)
Beijing	4.27	−2.79	0.92(0.21)***	−0.03(0.006)***	0.66	S(U)	6.79**	−4.00***	0.19(0.07)**	−0.03(0.09)	10.35***	0.01(0.01)	−0.05(0.01)***	0.87	S(S)
Guangzhou	2.13	−1.69	1.19(0.41)	−0.01(0.08)	0.63	S(U)	6.52**	−4.39***	0.05(0.06)	−0.24(0.08)***	15.32***	−0.07(0.02)***	−0.07(0.02)***	0.65	S(S)
Shanghai	4.67	−2.95*	1.11(0.20)	−0.04(0.01)**	0.79	S(S)	6.11**	−3.80**	0.34(0.13)**	0.10(0.16)	37.19***	0.006(0.01)	−0.04(0.02)	0.84	S(S)
Shenzhen	10.1***	−4.47***	1.26(0.16)***	0.03(0.01)*	0.81	S(S)	1.54	−0.26	4.68(19.12)	6.01(26.43)	0.03	0.17(0.03)***	0.06(0.02)**	0.85	S(S)
Changchun	3.16	−2.23	0.48(0.17)*	−0.01(0.004)**	0.64	S(U)	2.71	−2.61	0.17(0.17)	0.07(0.21)	3.59	−0.02(0.01)	−0.02(0.009)**	0.65	S(S)
Changsha	3.59	−1.52	1.10(0.50)*	−0.04(0.01)***	0.67	S(S)	1.40	−1.75	0.08(0.26)	−0.13(0.34)	6.09**	0.07(0.06)	0.003(0.02)	0.70	S(S)
Chengdu	2.31	−1.02	−0.73(1.31)	−0.08(0.03)	0.50	S(U)	1.68	−0.43	0.18(2.05)	−0.76(2.68)	0.22	−0.04(0.07)	−0.22(0.09)*	0.16	S(U)
Chongqing	1.95	−0.61	1.42(1.84)	−0.09(0.004)*	0.68	S(S)	1.28	−0.99	0.22(0.53)	−0.03(0.65)	1.52	−0.01(0.007)*	−0.01(0.008)*	0.69	S(S)
Dalian	1.74	−1.38	0.60(0.31)	0.01(0.009)	0.68	S(S)	8.12***	−0.47	5.73(4.93)	6.90(7.62)	0.18	−0.07(0.01)***	−0.06(0.02)**	0.72	S(U)
Fuzhou	4.94*	−2.40	0.91(0.23)***	−0.07(0.01)***	0.65	S(S)	1.87	−1.57	−0.07(0.18)	−0.36(0.24)	15.95***	−0.05(0.02)**	−0.12(0.33)***	0.71	S(S)
Guiyang	1.65	−0.93	1.02(0.76)	−0.14(0.10)	0.60	S(U)	1.20	−1.10	0.25(0.52)	0.01(0.65)	1.68	−0.03(0.01)	0.01(0.01)	0.62	S(U)
Harbin	2.95	−2.30	0.50(0.20)**	0.22(0.08)	0.58	S(U)	3.53	−2.01	0.59(0.42)	0.52(0.55)	0.003	−0.01(0.01)	−0.01(0.01)	0.60	S(S)
Hangzhou	5.64*	−2.99*	0.75(0.20)***	−0.04(0.01)***	0.66	S(S)	4.05	−2.68	0.15(0.17)	−0.07(0.22)	15.59***	−0.02(0.01)	−0.03(0.27)	0.71	S(S)
Hefei	5.29*	−2.83	1.15(0.24)***	−0.05(0.01)***	0.89	S(S)	2.98	−1.99	0.37(0.28)	0.11(0.33)	14.67***	−0.004(0.01)	−0.12(0.03)***	0.91	S(S)
Hohht	3.85	−2.20	0.56(0.20)**	−0.02(0.01)	0.68	S(U)	3.63	−2.84	0.48(0.23)	0.51(0.31)	0.10	−0.04(0.03)	−0.04(0.02)	0.69	S(S)
Haikou	2.32	−1.24	0.99(0.22)	−0.02(0.01)*	0.31	S(U)	2.45	−1.44	0.25(0.99)	−0.33(1.18)	0.74	0.004(0.10)	−0.05(0.02)*	0.30	S(U)
Jinan	1.67	−1.15	0.97(0.58)	−0.03(0.01)***	0.66	S(U)	1.91	−1.63	0.08(0.24)	−0.16(0.30)	9.66***	−0.05(0.02)	−0.03(0.02)	0.68	S(U)
Kunming	6.01**	−1.98	0.84(0.31)**	−0.02(0.01)**	0.68	S(S)	2.48	−1.98	0.61(0.47)	0.56(0.58)	0.16	−0.039(0.01)***	−0.03(0.015)	0.68	S(S)
Lanzhou	2.24	−0.51	1.37(2.17)	−0.02(0.007)***	0.58	S(S)	1.94	−0.94	−0.45(0.61)	−0.84(0.93)	1.35	−0.02(0.01)*	0.002(0.016)	0.63	S(S)
Nanchang	2.43	−1.65	0.75(0.29)	−0.02(0.007)**	0.66	S(S)	1.24	−1.38	0.22(0.31)	0.06(0.39)	3.03	−0.004(0.024)	−0.03(0.015)**	0.68	S(S)
Nanjing	1.82	−1.87	0.94(0.30)***	−0.01(0.01)	0.86	S(S)	3.17	−2.98*	0.13(0.11)	−0.14(0.14)	7.82**	0.22(0.01)	−0.04(0.02)	0.87	S(S)
Nanning	2.29	−0.13	−2.74(3.23)	−0.01(1.78)*	0.50	S(S)	3.89	−1.98	−0.41(0.58)	−1.05(1.00)	1.89	−0.02(0.01)	−0.004(0.01)	0.52	S(S)
Ningbo	4.27	−1.00	1.44(1.32)	−0.02(0.008)***	0.66	S(S)	6.85**	−3.27**	0.009(0.12)	0.26(0.16)	24.54***	−0.03(0.01)**	0.04(0.01)	0.71	S(S)
Qingdao	3.02	−1.15	0.97(0.64)	−0.034(0.01)***	0.58	S(U)	4.02	−2.25	0.56(1.41)	0.35(1.56)	0.50	−0.01(-1.50)	−0.05(0.01)***	0.62	S(S)
Shenyang	3.10	−2.39	0.46(0.21)	−0.001(0.007)*	0.76	S(U)	2.33	−0.84	1.26(1.60)	1.32(1.88)	0.0386	−0.07(0.01)***	0.0002(0.01)	0.79	S(U)
Shijiazhuang	1.95	−0.74	−1.78(1.83)	−0.04(0.01)**	0.56	S(S)	2.97	−2.14	−0.01(0.20)	−0.34(0.26)	17.11***	−0.002(0.12)	−0.03(0.03)	0.60	S(S)
Taiyuan	1.36	−0.66	0.60(0.54)	−0.02(0.007)**	0.63	S(S)	1.66	−1.95	−0.17(0.20)	0.38(0.26)	8.97***	−0.021(0.01)	−0.001(0.02)	0.65	S(S)
Tianjin	9.04***	−3.83**	0.70(0.10)***	0.056(0.09)*	0.78	S(S)	5.27*	−2.92*	0.26(0.13)	0.13(0.16)	13.56***	−0.04(0.01)***	−0.08(0.02)***	0.86	S(S)
Urnmqi	2.70	−2.19	3.26(1.37)	−3.15(1.11)***	0.07	S(U)	2.37	−2.53	0.002(0.11)	−0.09(0.13)	9.62***	0.01(0.01)	−0.006(0.01)	0.57	S(S)
Wuhan	2.23	−0.81	1.78(1.57)	−0.03(0.01)	0.72	S(S)	4.57	−2.24	0.16(0.19)	−0.16(0.23)	23.63***	−0.26(0.01)**	−0.09(0.02)***	0.77	S(S)
Xiamen	6.27**	−3.27*	1.25(0.24)***	−0.07(0.01)***	0.80	S(S)	3.87	−2.87	0.31(0.19)	0.029(0.23)	26.96***	−0.003(0.01)	−0.11(0.02)***	0.85	S(S)
Xi'an	1.47	−0.82	1.70(1.59)	−0.01(0.01)	0.23	S(U)	1.51	−1.01	0.01(0.72)	−0.50(1.00)	0.52	−0.053(0.02)**	0.03(0.01)	0.53	S(S)

(*continued*)

Table 1. Continued.

	Panel A: Results from the ARDL model						Panel B: Results from the NARDL model								
	F	*t*	b	$\sum \gamma_i$	Adj.R^2	CS(CS^2)	*F*	*t*	b^+	b^-	$b^+=b^-$	$\sum \gamma_i^+$	$\sum \gamma_i^-$	Adj.R^2	CS(CS^2)
Xining	3.42	−2.18	0.48(0.15)***	−0.01(0.006)**	0.49	S(S)	2.54	−2.12	0.28(0.24)	0.18(0.31)	1.30	−0.01(0.01)	−0.05(0.01)***	0.49	S(S)
Yinchuan	1.00	0.13	−1.97(6.76)	−0.009(0.005)	0.66	S(S)	1.00	−0.38	−0.29(1.38)	−0.63(2.19)	0.16	−0.01(0.008)	0.02(0.01)	0.68	S(S)
Zhengzhou	2.63	−2.20	0.75(0.25)***	−0.01(0.008)	0.69	S(S)	2.73	−2.74	0.05(0.12)	−0.19(0.15)	6.34**	−0.06(0.02)	−0.006(0.03)	0.74	S(S)
Anqing	1.04	−0.97	0.47(0.37)	0.01(0.005)	0.54	S(S)	1.31	−1.63	0.11(0.22)	0.03(0.28)	1.45	−0.04(0.016)	0.02(0.01)	0.60	S(S)
Baotou	5.89**	−2.69	0.33(0.12)**	0.007(0.007)	0.46	S(U)	5.94**	−2.57	0.57(0.28)	0.33(0.35)	1.18	−0.02(0.012)	−0.001(0.02)	0.47	S(S)
Beihai	1.83	−1.76	0.50(0.22)	−0.01(0.008)	0.47	S(S)	1.87	−2.21	0.11(0.22)	−0.02(0.29)	3.23	0.23(0.09)*	−0.03(0.01)	0.48	S(S)
Bengbu	1.20	−0.19	2.62(2.76)	−0.02(0.009)**	0.63	S(U)	1.76	−1.52	−0.09(0.27)	−0.32(0.36)	3.30	−0.09(0.03)*	−0.01(0.02)	0.65	S(U)
Changde	0.81	−1.27	0.21(0.24)	−0.013(0.007)	0.38	S(S)	1.24	−1.90	−0.05(0.20)	−0.17(0.26)	2.14	−0.06(0.01)**	−0.04(0.01)**	0.43	S(S)
Dali	1.00	−1.31	0.36(0.24)	−0.01(0.01)	0.77	S(S)	3.45	−2.81	−0.0003(0.22)	−0.18(0.30)	3.90	−0.03(0.01)*	−0.01(0.02)	0.81	S(S)
Dandong	2.00	−0.99	0.62(0.5)	−0.01(1.57)	0.56	S(U)	2.89	−1.09	1.50(1.40)	1.82(1.76)	0.73	−0.03(0.02)	−0.02(0.11)*	0.57	S(U)
Ganzhou	1.52	−0.83	0.80(0.70)	−0.01(0.006)**	0.49	S(S)	1.94	−2.68	−0.07(0.10)	−0.25(0.14)	20.75***	−0.029(0.01)	0.05(0.02)	0.58	S(S)
Guilin	2.24	−1.76	0.45(0.23)	−0.01(0.006)	0.38	S(S)	2.53	−2.63	−0.21(0.17)	−0.39(0.23)	9.16***	0.003(0.02)	0.04(0.01)***	0.45	S(S)
Huizhou	4.62	−1.90	0.93(0.33)**	−0.05(0.01)	0.70	S(S)	3.90	−2.19	0.22(0.20)	0.04(0.24)	10.93***	0.01(0.01)	−0.14(0.02)***	0.76	S(S)
Jilin	1.66	−0.81	0.63(0.66)	−0.005(0.006)	0.68	S(S)	1.51	−2.10	−0.07(0.23)	−0.23(0.30)	0.32	−0.01(0.01)	0.001(0.01)	0.69	S(S)
Jinhua	3.04	−0.79	−1.07(1.38)	−0.01(0.009)	0.31	S(U)	5.69*	−1.93	−0.27(0.23)	−0.67(0.36)	6.79**	−0.07(0.04)	−0.05(0.03)	0.40	S(S)
Jining	1.78	−0.12	2.04(7.03)	−0.01(0.007)	0.65	S(S)	1.00	−0.63	0.35(0.83)	0.09(0.93)	0.50	−0.01(0.008)*	0.009(0.01)	0.66	S(S)
Jinzhou	1.55	−1.60	0.20(0.20)	−0.16(0.09)	0.52	S(U)	1.73	−2.11	−0.21(0.25)	−0.33(0.33)	1.75	−0.006(0.01)	0.05(0.02)**	0.53	S(U)
Jiujiang	1.41	−0.32	2.14(5.86)	−0.01(0.005)	0.62	S(S)	1.48	−1.14	0.09(0.39)	−0.17(0.50)	2.35	−0.01(0.008)	−0.01(0.009)	0.65	S(S)
Luoyang	1.17	−0.03	0.002(1.16)	−0.02(0.009)	0.56	S(S)	1.28	−0.93	−0.07(0.51)	−0.42(0.76)	1.24	−0.04(0.01)***	−0.002(0.01)*	0.58	S(S)
Luzhou	1.89	−1.21	0.35(0.22)	−0.02(0.01)	0.51	S(S)	0.67	−1.38	0.03(0.26)	−0.04(0.34)	0.95	−0.01(0.01)	−0.25(0.09)	0.50	S(S)
Mudanjiang	1.05	−1.31	0.25(0.08)	−0.01(0.005)*	0.50	S(U)	3.27	−2.92*	0.09(0.15)	0.05(0.20)	0.51	0.01(0.001)	−0.04(0.01)*	0.52	S(U)
Nanchong	2.43	−1.65	0.75(0.29)	−0.02(0.007)**	0.66	S(S)	1.24	−1.38	0.22(0.31)	0.06(0.39)	3.03	−0.004(0.024)	−0.03(0.015)**	0.68	S(S)
Pingdingshan	2.18	−0.26	1.27(3.87)	−0.006(0.005)	0.51	S(S)	0.93	−0.51	−0.54(1.40)	−1.14(2.40)	0.33	−0.05(0.01)***	−0.02(0.009)	0.56	S(S)
Qinghuangdao	3.96	−1.33	1.10(0.66)	−0.05(0.01)***	0.66	S(S)	1.92	−0.85	1.07(1.45)	1.06(1.70)	1.20	−0.06(0.02)***	−0.02(0.009)**	0.67	S(S)
Quanzhou	2.34	−0.76	0.18(0.24)	0.01(0.005)***	0.54	S(S)	3.48	−3.21*	−0.05(0.06)	−0.12(0.07)	10.21***	0.02(0.01)*	0.12(0.03)***	0.59	S(S)
Sanya	1.33	−0.27	3.87(12.74)	−0.02(0.03)	0.13	S(U)	1.45	−1.00	0.26(0.68)	−0.08(0.78)	1.74	−0.05(0.02)	−0.01(0.01)	0.14	S(U)
Shaoguan	1.78	−1.57	0.33(0.22)	0.001(0.01)	0.24	S(S)	1.00	−0.95	0.32(0.56)	0.27(0.66)	0.11	0.03(0.01)	−0.05(0.01)**	0.244	S(S)
Tangshan	2.15	−0.45	−1.20(2.92)	−0.01(0.006)	0.61	S(U)	3.95	−0.65	−0.79(1.46)	−0.45(1.20)	0.30	−0.06(0.01)***	−0.12(0.009)*	0.66	S(S)
Wenzhou	9.17***	−1.61	0.74(0.43)	−0.02(0.01)	0.60	S(S)	4.78*	−3.75**	0.19(0.12)*	0.04(0.14)	11.39***	−0.08(0.02)***	−0.07(0.05)	0.63	S(S)
Wuxi	3.37	−1.62	1.08(0.48)*	−0.01(0.01)***	0.57	S(S)	3.02	−2.01	0.14(0.25)	−0.13(0.30)	11.14***	−0.04(0.02)	−0.069(0.04)	0.66	S(S)
Xiangyang	1.00	−1.43	0.59(0.38)	−0.008(0.009)	0.62	S(U)	1.40	−1.88	0.27(0.32)	0.18(0.40)	0.85	−0.02(0.01)	−0.0004(0.01)	0.63	S(S)
Xuzhou	1.02	0.09	−2.19(6.21)	−0.008(0.006)	0.60	S(U)	1.38	−0.86	−0.53(1.01)	−1.21(1.65)	1.04	−0.01(0.01)	−0.0009(0.01)	0.61	S(U)

(continued)

Table 1. Continued.

	Panel A: Results from the ARDL model						Panel B: Results from the NARDL model								
	F	*t*	b	$\sum\gamma_i$	Adj.R^2	CS(CS^2)	*F*	*t*	b^+	b^-	$b^+=b^-$	$\sum\gamma_i^+$	$\sum\gamma_i^-$	Adj.R^2	CS(CS^2)
Yangzhou	3.96	−0.37	3.48(8.45)	−0.03(0.01)***	0.59	S(S)	3.22	−1.87	0.27(0.29)	0.009(0.34)	6.35**	0.023(0.009)	−0.0343(0.01)*	0.60	S(S)
Yantai	3.32	−0.80	1.21(1.21)	−0.01(0.007)	0.66	S(S)	2.90	−0.61	2.04(3.84)	2.24(4.59)	0.09	−0.001(0.01)	−0.01(0.009)	0.94	S(S)
Yichang	0.44	−0.07	−0.01(0.008)	−0.01(0.01)	0.66	S(U)	1.77	−2.01	−0.15(0.18)	−0.36(0.24)	9.19***	−0.05(0.01)***	0.02(0.01)	0.68	S(S)
Yueyang	3.64	−2.43	0.38(0.12)	−0.02(0.01)	0.56	S(S)	5.43*	−3.14	0.07(0.10)	0.003(0.13)	4.618	−0.08(0.01)***	0.04(0.02)	0.61	S(S)
Zhanjiang	1.84	−1.22	0.62(0.37)	−0.01(0.005)	0.60	S(S)	1.34	−1.15	0.27(0.41)	0.173(0.49)	0.09	−0.02(0.009)*	−0.02(0.01)	0.61	S(S)
Zunyi	1.36	−1.34	0.40(0.21)	−0.0004(0.006)	0.68	S(S)	1.11	−1.39	0.32(0.35)	0.30(0.45)	0.02	−0.02(0.01)*	0.02(0.01)	0.69	S(S)

Notes:
1. Bracketed numbers refer to standard errors, with *, **, and *** denoting significance at the 10%, 5%, and 1% levels, respectively.
2. The upper bound critical values of the F-test when there is one exogenous variable ($k=1$) are 4.78 (10%), 5.73 (5%) and 7.84 (1%), respectively (Pesaran et al., 2001; Table CI Case III). In the case when the computed F-statistic exceeds the upper critical value, the null hypothesis is rejected. If the F-statistic falls between the upper and lower bounds, a conclusive inference cannot be made.
3. The upper bound critical values of the t-test are −2.91 (10%), −3.22 (5%), and −3.82 (1%) when $k=1$, and are −3.21(10%), −3.53(5%), −4.10(1%) when $k=2$ (Pesaran et al., 2001; Table CII, Case III).
4. CUSUM (cumulative sum of residuals); CUSUMQ (cumulative sum of square residuals); stable and unstable estimates are, respectively, indicated by 'S' and 'U'; *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.
5. b+=b- refer to the Wald test for examining the null hypothesis of the long-run symmetry and the null effect of the additive short-run symmetry, respectively.

Source: Created using the data from the wind database (https://www.wind.com.cn/).

changes. As for the long run effects in Guangzhou, negative changes in stock price (b^-) are both negative and significant, whereas positive changes in the stock price (b^+) are not. This means that Guangzhou is affected by negative but not by positive changes in stock price. In addition, both positive and negative changes in stock price have no significant effect in either Ningbo or Tianjin.

Given the above analysis, both the ARDL and NARDL models are able to capture the wealth effect of the Chinese stock market on different high-priced real estate markets in the long run, especially in terms of the symmetric wealth effect in Shenzhen, Hangzhou, Tianjin, and Xiamen, with an asymmetric positive wealth effect being observed in Shanghai, Beijing, and Wenzhou. These findings are consistent with those of previous studies that argued that the wealth effect is only discernible in regions characterised by high real estate prices (Green, 2002). Interestingly, for the city of Guangzhou, our research revealed that only negative changes in stock price contribute to an increase in demand for real estate purchases, driving a real estate boom. This confirms the substitution effect of the Chinese stock market on the real estate markets of Guangzhou in the long run. A possible explanation for this may be the relaxation of housing purchase restrictions in Guangzhou (Lu et al., 2021).[5] Additionally, the short- and the long-run causality stability were checked using the CUSUM and the CUSUMQ tests on the model residuals.[6] The results of the hypothesis of the stability of the parameters cannot be rejected at the 5% significance level for most cities. The adjusted R-squared provides results that are in line with the main literature.

4.2. The effect of real estate prices on stock prices

We switched the dependent variable with the independent variable in the ARDL (2) and NARDL models (5) of each city and then estimated the possibility of real estate prices having an effect on stock prices. In Panel A in Table 2, the null hypothesis $\sum \gamma_i \neq 0$ is rejected, which indicates that changes in real estate prices have a causal effect on stock prices in the short run in 30 out of 70 cities. However, the F- and t-statistics of all cities cannot be used to reject the null hypothesis of no cointegration at any significance level. This result is consistent with those of previous studies that analysed the symmetry between these two markets (Ding et al., 2014).

In the NARDL model of Panel B in Table 2, there is evidence of an asymmetric causality from real estate prices to stock prices in the short run in 36 out of the 70 cities. The null hypothesis $\sum \gamma_i^- \neq 0$ is rejected, which indicates that a decrease in stock prices causes a change in real estate prices in the short run in 17 out of 36 cities. Furthermore, the null hypothesis $\sum \gamma_i^+ \neq 0$ is also rejected, which reveals that an increase in stock prices also causes changes in the real estate prices in the short run in 12 out of 36 cities. Meanwhile, both the null hypotheses are rejected in six of the included cites. The F- and t-statistics of 16 cities allow us to reject the null hypothesis of no cointegration, which shows that a decrease in real estate prices in these 17 cities causes a change in their short-run stock prices that last into the long run in the remaining eight cities. Further, an increase in the real estate prices in 12 cities has a

Table 2. Results of the effect of real estate prices on stock prices.

	Panel A: Results from the ARDL model						Panel B: Results from the NARDL model								
	F	*t*	b	$\sum \gamma_i$	Adj.R^2	CS(CS^2)	*F*	*t*	b^+	b^-	$b^+=b^-$	$\sum \gamma_i^+$	$\sum \gamma_i^-$	Adj.R^2	CS(CS^2)
Beijing	4.27	−2.79	0.92(0.21)***	−0.03(0.006)***	0.66	S(U)[6]	6.79**	−4.00***	0.19(0.07)**	−0.03(0.09)	10.35***	0.01(0.01)	−0.05(0.01)***	0.87	S(S)
Guangzhou	2.13	−1.69	1.19(0.41)	−0.01(0.08)	0.63	S(U)	6.52**	−4.39***	0.05(0.06)	−0.24(0.08)***	15.32***	−0.07(0.02)***	−0.07(0.02)***	0.65	S(S)
Shanghai	4.67	−2.95*	1.11(0.20)	−0.04(0.01)**	0.79	S(S)	6.11**	−3.80**	0.34(0.13)**	0.10(0.16)	37.19***	0.006(0.01)	−0.04(0.02)	0.84	S(S)
Shenzhen	10.1***	−4.47***	1.26(0.16)***	0.03(0.01)*	0.81	S(S)	1.54	−0.26	4.68(19.12)	6.01(26.43)	0.03	0.17(0.03)***	0.06(0.02)**	0.85	S(S)
Changchun	3.16	−2.23	0.48(0.17)*	−0.01(0.004)**	0.64	S(U)	2.71	−2.61	0.17(0.17)	0.07(0.21)	3.59	−0.02(0.01)	−0.02(0.009)**	0.65	S(S)
Changsha	3.59	−1.52	1.10(0.50)*	−0.04(0.01)***	0.67	S(S)	1.40	−1.75	0.08(0.26)	−0.13(0.34)	6.09**	0.07(0.06)	0.003(0.02)	0.70	S(S)
Chengdu	2.31	−1.02	−0.73(1.31)	−0.08(0.03)	0.50	S(U)	1.68	−0.43	0.18(2.05)	−0.76(2.68)	0.22	−0.04(0.07)	−0.22(0.09)*	0.16	S(U)
Chongqing	1.95	−0.61	1.42(1.84)	−0.09(0.004)*	0.68	S(S)	1.28	−0.99	0.22(0.53)	−0.03(0.65)	1.52	−0.01(0.007)*	−0.01(0.008)*	0.69	S(S)
Dalian	1.74	−1.38	0.60(0.31)	0.01(0.009)	0.68	S(S)	8.12***	−0.47	5.73(4.93)	6.90(7.62)	0.18	−0.07(0.01)***	−0.06(0.02)**	0.72	S(U)
Fuzhou	4.94*	−2.40	0.91(0.23)***	−0.07(0.01)***	0.65	S(S)	1.87	−1.57	−0.07(0.18)	−0.36(0.24)	15.95***	−0.05(0.02)**	−0.12(0.33)***	0.71	S(S)
Guiyang	1.65	−0.93	1.02(0.76)	−0.14(0.10)	0.60	S(U)	1.20	−1.10	0.25(0.52)	0.01(0.65)	1.68	−0.03(0.01)	0.01(0.01)	0.62	S(U)
Harbin	2.95	−2.30	0.50(0.20)**	0.22(0.08)	0.58	S(U)	3.53	−2.01	0.59(0.42)	0.52(0.55)	0.003	−0.01(0.01)	−0.01(0.01)	0.60	S(S)
Hangzhou	5.64*	−2.99*	0.75(0.20)***	−0.04(0.01)***	0.66	S(S)	4.05	−2.68	0.15(0.17)	−0.07(0.22)	15.59***	−0.02(0.01)	−0.03(0.27)	0.71	S(S)
Hefei	5.29*	−2.83	1.15(0.24)***	−0.05(0.01)***	0.89	S(S)	2.98	−1.99	0.37(0.28)	0.11(0.33)	14.67***	−0.004(0.01)	−0.12(0.03)***	0.91	S(S)
Hohht	3.85	−2.20	0.56(0.20)**	−0.02(0.01)	0.68	S(U)	3.63	−2.84	0.48(0.23)	0.51(0.31)	0.10	−0.04(0.03)	−0.04(0.02)	0.69	S(S)
Haikou	2.32	−1.24	0.99(0.22)	−0.02(0.01)*	0.31	S(U)	2.45	−1.44	0.25(0.99)	−0.33(1.18)	0.74	0.004(0.10)	−0.05(0.02)*	0.30	S(U)
Jinan	1.67	−1.15	0.97(0.58)	−0.03(0.01)***	0.66	S(U)	1.91	−1.63	0.08(0.24)	−0.16(0.30)	9.66***	−0.05(0.02)	−0.03(0.02)	0.68	S(U)
Kunming	6.01**	−1.98	0.84(0.31)**	−0.02(0.01)**	0.68	S(S)	2.48	−1.98	0.61(0.47)	0.56(0.58)	0.16	−0.039(0.01)***	−0.03(0.015)	0.68	S(S)
Lanzhou	2.24	−0.51	1.37(2.17)	−0.02(0.007)***	0.58	S(S)	1.94	−0.94	−0.45(0.61)	−0.84(0.93)	1.35	−0.02(0.01)*	0.002(0.016)	0.63	S(S)
Nanchang	2.43	−1.65	0.75(0.29)	−0.02(0.007)**	0.66	S(S)	1.24	−1.38	0.22(0.31)	0.06(0.39)	3.03	−0.004(0.024)	−0.03(0.015)**	0.68	S(S)
Nanjing	1.82	−1.87	0.94(0.30)***	−0.01(0.01)	0.86	S(S)	3.17	−2.98*	0.13(0.11)	−0.14(0.14)	7.82**	0.22(0.01)	−0.04(0.02)	0.87	S(S)
Nanning	2.29	−0.13	−2.74(3.23)	−0.01(1.78)*	0.50	S(S)	3.89	−1.98	−0.41(0.58)	−1.05(1.00)	1.89	−0.02(0.01)	−0.004(0.01)	0.52	S(S)
Ningbo	4.27	−1.00	1.44(1.32)	−0.02(0.008)***	0.66	S(S)	6.85**	−3.27**	0.009(0.12)	0.26(0.16)	24.54***	−0.03(0.01)**	0.04(0.01)	0.71	S(S)
Qingdao	3.02	−1.15	0.97(0.64)	−0.034(0.01)***	0.58	S(U)	4.02	−2.25	0.56(1.41)	0.35(1.56)	0.50	−0.01(-1.50)	−0.05(0.01)***	0.62	S(S)
Shenyang	3.10	−2.39	0.46(0.21)	−0.001(0.007)*	0.76	S(U)	2.33	−0.84	1.26(1.60)	1.32(1.88)	0.0386	−0.07(0.01)***	0.0002(0.01)	0.79	S(U)
Shijiazhuang	1.95	−0.74	−1.78(1.83)	−0.04(0.01)**	0.56	S(S)	2.97	−2.14	−0.01(0.20)	−0.34(0.26)	17.11***	−0.002(0.12)	−0.03(0.03)	0.60	S(S)
Taiyuan	1.36	−0.66	0.60(0.54)	−0.02(0.007)**	0.63	S(S)	1.66	−1.95	−0.17(0.20)	0.38(0.26)	8.97***	−0.021(0.01)	−0.001(0.02)	0.65	S(S)
Tianjin	9.04***	−3.83**	0.70(0.10)***	0.056(0.09)*	0.78	S(S)	5.27*	−2.92*	0.26(0.13)	0.13(0.16)	13.56***	−0.04(0.01)***	−0.08(0.02)***	0.86	S(S)
Urnmqi	2.70	−2.19	3.26(1.37)	−3.15(1.11)***	0.07	S(U)	2.37	−2.53	0.002(0.11)	−0.09(0.13)	9.62***	0.01(0.01)	−0.006(0.01)	0.57	S(S)
Wuhan	2.23	−0.81	1.78(1.57)	−0.03(0.01)	0.72	S(S)	4.57	−2.24	0.16(0.19)	−0.16(0.23)	23.63***	−0.26(0.01)**	−0.09(0.02)***	0.77	S(S)
Xiamen	6.27**	−3.27*	1.25(0.24)***	−0.07(0.01)***	0.80	S(S)	3.87	−2.87	0.31(0.19)	0.029(0.23)	26.96***	−0.003(0.01)	−0.11(0.02)***	0.85	S(S)
Xi'an	1.47	−0.82	1.70(1.59)	−0.01(0.01)	0.23	S(U)	1.51	−1.01	0.01(0.72)	−0.50(1.00)	0.52	−0.053(0.02)**	0.03(0.01)	0.53	S(S)

(*continued*)

Table 2. Continued.

	Panel A: Results from the ARDL model						Panel B: Results from the NARDL model								
	F	*t*	b	$\sum\gamma_i$	Adj.R^2	CS(CS^2)	*F*	*t*	b^+	b^-	$b^+=b^-$	$\sum\gamma_i^+$	$\sum\gamma_i^-$	Adj.R^2	CS(CS^2)
Xining	3.42	−2.18	0.48(0.15)***	−0.01(0.006)**	0.49	S(S)	2.54	−2.12	0.28(0.24)	0.18(0.31)	1.30	−0.01(0.01)	−0.05(0.01)***	0.49	S(S)
Yinchuan	1.00	0.13	−1.97(6.76)	−0.009(0.005)	0.66	S(S)	1.00	−0.38	−0.29(1.38)	−0.63(2.19)	0.16	−0.01(0.008)	0.02(0.01)	0.68	S(S)
Zhengzhou	2.63	−2.20	0.75(0.25)***	−0.01(0.008)	0.69	S(S)	2.73	−2.74	0.05(0.12)	−0.19(0.15)	6.34**	−0.06(0.02)	−0.006(0.03)	0.74	S(S)
Anqing	1.04	−0.97	0.47(0.37)	0.01(0.005)	0.54	S(S)	1.31	−1.63	0.11(0.22)	0.03(0.28)	1.45	−0.04(0.016)	0.02(0.01)	0.60	S(S)
Baotou	5.89**	−2.69	0.33(0.12)**	0.007(0.007)	0.46	S(U)	5.94**	−2.57	0.57(0.28)	0.33(0.35)	1.18	−0.02(0.012)	−0.001(0.02)	0.47	S(S)
Beihai	1.83	−1.76	0.50(0.22)	−0.01(0.008)	0.47	S(S)	1.87	−2.21	0.11(0.22)	−0.02(0.29)	3.23	0.23(0.09)*	−0.03(0.01)	0.48	S(S)
Bengbu	1.20	−0.19	2.62(2.76)	−0.02(0.009)**	0.63	S(U)	1.76	−1.52	−0.09(0.27)	−0.32(0.36)	3.30	−0.09(0.03)*	−0.01(0.02)	0.65	S(U)
Changde	0.81	−1.27	0.21(0.24)	−0.013(0.007)	0.38	S(S)	1.24	−1.90	−0.05(0.20)	−0.17(0.26)	2.14	−0.06(0.01)**	−0.04(0.01)**	0.43	S(S)
Dali	1.00	−1.31	0.36(0.24)	−0.01(0.01)	0.77	S(S)	3.45	−2.81	−0.0003(0.22)	−0.18(0.30)	3.90	−0.03(0.01)*	−0.01(0.02)	0.81	S(S)
Dandong	2.00	−0.99	0.62(0.5)	−0.01(1.57)	0.56	S(U)	2.89	−1.09	1.50(1.40)	1.82(1.76)	0.73	−0.03(0.02)	−0.02(0.11)*	0.57	S(U)
Ganzhou	1.52	−0.83	0.80(0.70)	−0.01(0.006)**	0.49	S(S)	1.94	−2.68	−0.07(0.10)	−0.25(0.14)	20.75***	−0.029(0.01)	0.05(0.02)	0.58	S(S)
Guilin	2.24	−1.76	0.45(0.23)	−0.01(0.006)	0.38	S(S)	2.53	−2.63	−0.21(0.17)	−0.39(0.23)	9.16***	0.003(0.02)	0.04(0.01)***	0.45	S(S)
Huizhou	4.62	−1.90	0.93(0.33)**	−0.05(0.01)	0.70	S(S)	3.90	−2.19	0.22(0.20)	0.04(0.24)	10.93***	0.01(0.01)	−0.14(0.02)***	0.76	S(S)
Jilin	1.66	−0.81	0.63(0.66)	−0.005(0.006)	0.68	S(S)	1.51	−2.10	−0.07(0.23)	−0.23(0.30)	0.32	−0.01(0.01)	0.001(0.01)	0.69	S(S)
Jinhua	3.04	−0.79	−1.07(1.38)	−0.01(0.009)	0.31	S(U)	5.69*	−1.93	−0.27(0.23)	−0.67(0.36)	6.79**	−0.07(0.04)	−0.05(0.03)	0.40	S(S)
Jining	1.78	−0.12	2.04(7.03)	−0.01(0.007)	0.65	S(S)	1.00	−0.63	0.35(0.83)	0.09(0.93)	0.50	−0.01(0.008)*	0.009(0.01)	0.66	S(S)
Jinzhou	1.55	−1.60	0.20(0.20)	−0.16(0.09)	0.52	S(U)	1.73	−2.11	−0.21(0.25)	−0.33(0.33)	1.75	−0.006(0.01)	0.05(0.02)**	0.53	S(U)
Jiujiang	1.41	−0.32	2.14(5.86)	−0.01(0.005)	0.62	S(S)	1.48	−1.14	0.09(0.39)	−0.17(0.50)	2.35	−0.01(0.008)	−0.01(0.009)	0.65	S(S)
Luoyang	1.17	−0.03	0.002(1.16)	−0.02(0.009)	0.56	S(S)	1.28	−0.93	−0.07(0.51)	−0.42(0.76)	1.24	−0.04(0.01)***	−0.002(0.01)*	0.58	S(S)
Luzhou	1.89	−1.21	0.35(0.22)	−0.02(0.01)	0.51	S(S)	0.67	−1.38	0.03(0.26)	−0.04(0.34)	0.95	−0.01(0.01)	−0.25(0.09)	0.50	S(S)
Mudanjiang	1.05	−1.31	0.25(0.08)	−0.01(0.005)*	0.50	S(U)	3.27	−2.92*	0.09(0.15)	0.05(0.20)	0.51	0.01(0.001)	−0.04(0.01)*	0.52	S(U)
Nanchong	2.43	−1.65	0.75(0.29)	−0.02(0.007)**	0.66	S(S)	1.24	−1.38	0.22(0.31)	0.06(0.39)	3.03	−0.004(0.024)	−0.03(0.015)**	0.68	S(S)
Pingdingshan	2.18	−0.26	1.27(3.87)	−0.006(0.005)	0.51	S(S)	0.93	−0.51	−0.54(1.40)	−1.14(2.40)	0.33	−0.05(0.01)***	−0.02(0.009)	0.56	S(S)
Qinghuangdao	3.96	−1.33	1.10(0.66)	−0.05(0.01)***	0.66	S(S)	1.92	−0.85	1.07(1.45)	1.06(1.70)	1.20	−0.06(0.02)***	−0.02(0.009)**	0.67	S(S)
Quanzhou	2.34	−0.76	0.18(0.24)	0.01(0.005)***	0.54	S(S)	3.48	−3.21*	−0.05(0.06)	−0.12(0.07)	10.21***	0.02(0.01)*	0.12(0.03)***	0.59	S(S)
Sanya	1.33	−0.27	3.87(12.74)	−0.02(0.03)	0.13	S(U)	1.45	−1.00	0.26(0.68)	−0.08(0.78)	1.74	−0.05(0.02)	−0.01(0.01)	0.14	S(U)
Shaoguan	1.78	−1.57	0.33(0.22)	0.001(0.01)	0.24	S(S)	1.00	−0.95	0.32(0.56)	0.27(0.66)	0.11	0.03(0.01)	−0.05(0.01)**	0.244	S(S)
Tangshan	2.15	−0.45	−1.20(2.92)	−0.01(0.006)	0.61	S(U)	3.95	−0.65	−0.79(1.46)	−0.45(1.20)	0.30	−0.06(0.01)***	−0.12(0.009)*	0.66	S(S)
Wenzhou	9.17***	−1.61	0.74(0.43)	−0.02(0.01)	0.60	S(S)	4.78*	−3.75**	0.19(0.12)*	0.04(0.14)	11.39***	−0.08(0.02)***	−0.07(0.05)	0.63	S(S)
Wuxi	3.37	−1.62	1.08(0.48)*	−0.01(0.01)***	0.57	S(S)	3.02	−2.01	0.14(0.25)	−0.13(0.30)	11.14***	−0.04(0.02)	−0.069(0.04)	0.66	S(S)
Xiangyang	1.00	−1.43	0.59(0.38)	−0.008(0.009)	0.62	S(U)	1.40	−1.88	0.27(0.32)	0.18(0.40)	0.85	−0.02(0.01)	−0.0004(0.01)	0.63	S(S)
Xuzhou	1.02	0.09	−2.19(6.21)	−0.008(0.006)	0.60	S(U)	1.38	−0.86	−0.53(1.01)	−1.21(1.65)	1.04	−0.01(0.01)	−0.0009(0.01)	0.61	S(U)

(*continued*)

Table 2. Continued.

	Panel A: Results from the ARDL model						Panel B: Results from the NARDL model								
	F	*t*	b	$\sum \gamma_i$	Adj.R^2	CS(CS^2)	*F*	*t*	b^+	b^-	b^+=b^-	$\sum \gamma_i^+$	$\sum \gamma_i^-$	Adj.R^2	CS(CS^2)
Yangzhou	3.96	−0.37	3.48(8.45)	−0.03(0.01)***	0.59	S(S)	3.22	−1.87	0.27(0.29)	0.009(0.34)	6.35**	0.023(0.009)	−0.0343(0.01)*	0.60	S(S)
Yantai	3.32	−0.80	1.21(1.21)	−0.01(0.007)	0.66	S(S)	2.90	−0.61	2.04(3.84)	2.24(4.59)	0.09	−0.001(0.01)	−0.01(0.009)	0.94	S(S)
Yichang	0.44	−0.07	−0.01(0.008)	−0.01(0.01)	0.66	S(U)	1.77	−2.01	−0.15(0.18)	−0.36(0.24)	9.19***	−0.05(0.01)***	0.02(0.01)	0.68	S(S)
Yueyang	3.64	−2.43	0.38(0.12)	−0.02(0.01)	0.56	S(S)	5.43*	−3.14	0.07(0.10)	0.003(0.13)	4.618	−0.08(0.01)***	0.04(0.02)	0.61	S(S)
Zhanjiang	1.84	−1.22	0.62(0.37)	−0.01(0.005)	0.60	S(S)	1.34	−1.15	0.27(0.41)	0.173(0.49)	0.09	−0.02(0.009)*	−0.02(0.01)	0.61	S(S)
Zunyi	1.36	−1.34	0.40(0.21)	−0.0004(0.006)	0.68	S(S)	1.11	−1.39	0.32(0.35)	0.30(0.45)	0.02	−0.02(0.01)*	0.02(0.01)	0.69	S(S)

Notes:

1. Bracketed numbers refer to standard errors, with *, **, and *** denoting significance at the 10%, 5%, and 1% levels, respectively.
2. The upper bound critical values of the F-test when there is one exogenous variable (k = 1) are 4.78 (10%), 5.73 (5%) and 7.84 (1%), respectively (Pesaran et al., 2001; Table CI Case III). In the case when the computed F-statistic exceeds the upper critical value, the null hypothesis is rejected. If the F-statistic falls between the upper and lower bounds, a conclusive inference cannot be made.
3. The upper bound critical values of the t-test are −2.91 (10%), −3.22 (5%), and −3.82 (1%) when k = 1, and are −3.21(10%), −3.53(5%), −4.10(1%) when k = 2 (Pesaran et al., 2001; Table CII, Case III).
4. CUSUM (cumulative sum of residuals); CUSUMQ (cumulative sum of square residuals); stable and unstable estimates are, respectively, indicated by 'S' and 'U'; *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.
5. b+ =b- refer to the Wald test for examining the null hypothesis of the long-run symmetry and the null effect of the additive short-run symmetry, respectively.

Source: Created using the data from the wind database (https://www.wind.com.cn/).

causal effect on their stock prices, which lasts into the long run for the remaining seven.

As for the long-run effects in Changsha, Chongqing, Hangzhou, Nanjing Nanning, Shijiazhuang, Tianjin, and Jiujiang, Panel B provides evidence that a positive change in real estate prices (b^+) has a significant and positive effect on stock prices, whereas any negative changes in real estate prices (b^-) do not. For the long run effects in Harbin, Jinan, Lanzhou, Ningbo, Beihai, Sanya, and Tangshan, Panel B in Table 2 provides evidence that any negative changes in real estate prices (b^-) has a significant and negative effect on stock prices, whereas any positive changes in real estate prices (b^-) do not. In addition, both positive and negative changes in the real estate prices of Beijing and Chengdu have no significant effect on their stock price.

The analysis shows that the NARDL model is adequate in capturing both the cointegration and asymmetric causality of real estate prices with stock prices, which is more suitable to our study than the ARDL model. The NARDL model is able to capture the positive credit-price effect of the high real estate prices of certain second-tier cities on their stock prices in the long run, and this finding is consistent with that of Adcock et al. (2016) on China's real estate market influencing its stock market. Additionally, our results provide novel long-run asymmetric evidence that shows differences in the low-priced real estate markets in second- and third- tier cities, including that negative changes in real estate prices have a substitution effect on stock prices. We then conclude that the substitution effect may be related to the 'policies distinctive among various cities' framework that is promulgated by differences in city governments since 2014 (Ding & Ni, 2017), meaning that the market liquidity of the slow-moving real estate markets in second- and third-tier cities has increased. In other words, compared with the saturation of the real estate market in first-tier cities, the rapid development of the real estate markets of second- and third-tier cities during this period resulted in more funds being invested into stock market transactions.[7]

5. Conclusion and policy implications

This study assumed that stock and real estate prices are mutually determinant factors and investigated the causality and long-run price effects between the Chinese stock market and 70 large and medium-sized cities' real estate markets. We adopted the NARDL model as outlined in the study of Shin et al. (2014), which permits the exploration of both symmetric and asymmetric bidirectional long-run price effects. Bahmani-Oskooee et al. (2019) also found that the NARDL model could also be used to investigate short- and long-run causality between two variables.

Our principal findings are as follows. First, we found evidence of cointegrated markets (i.e. not segmented ones) in different cities, which shows that both assets may be added to the same portfolio to reduce overall risk. Second, in the case of the NARDL model that embodies the asymmetry assumption, the real estate market has a stronger influence on the stock market. We identified the asymmetric positive credit-price effect, which runs from the high real estate prices of some second-tier cities' real estate market to the stock market, as well as the wealth effect (from a lower number of cities) from the stock market to the real estate market of high real estate prices in the long run. We identified the asymmetric substitution effect, which runs from different low-priced real estate markets in second- and third-tier cities to the overall stock market price, as well as the effect that runs from the stock price to Guangzhou's real estate markets.

Overall, these findings can be used by investors to consider that the existence of asymmetric causality and long-run price effects, especially in terms of the heterogeneity of the real estate market, may lead to inaccurate assessments of portfolio performance measures and diversification benefits. The implications of our asymmetry model findings are as follows. Real estate policymakers in specific cities need to take into consideration the asymmetric performance of real estate prices as caused by asymmetry within stock market prices. If government stabilised the real estate market, it would benefit the stability of the stock market. China's unique real estate market could be further investigated regarding these factors.

Notes

1. As real estate is considered a consumption as well as an investment good, whereas financial assets such as stocks do not involve direct consumption. Households with unexpected gains in the stock market are likely to rebalance their portfolios to favor the real estate markets (see Sim & Chang, 2006).
2. Early studies report that the relationship between the two asset markets is either significantly negative or segregated (see, Lizieri & Satchell, 1997).
3. Granger (1969) argued that the causal effect of the stock price on real estate price must be explained by concentrating on the past history of real estate price. After this, the lagged value of stock prices in the specification are jointly significant, indicating the causal effect of stock price on real estate prices. In a similar research, Granger (1988) employed the error-correction model to prove the causality between the two variables (see, Granger, 1988, p. 203). In recent research, Bahmani-Oskooee et al. (2020) employ the ARDL and NARDL models to prove the causality between stock returns and usual hedges.
4. Augmented Dickey-Fuller, Phillips-Person, and Kwiatkowski-Phillips-Schmidt-Shin unit root tests were used for measuring the first difference in the respective variables. The results indicate that all variables are stationary after differencing. The results are not included here and are available from the authors upon request.
5. Lu et al. (2021) examine the impact of real estate purchase restrictions on real estate markets in five large cities—Beijing, Shanghai, Guangzhou, Hangzhou, and Wuhan. They find evidence from all cities except for Guangzhou, that the price elasticity of real estate is weakened after the implementation of these kinds of purchase restrictions.
6. Both tests are reported in Table 1 as 'S' for stable estimates and 'U' for unstable estimates.
7. In addition, CUSUM and CUSUMSQ test results should be interpreted in the same manner as Table 1. Therefore, no further explanation is required.

Disclosure statement

No potential competing interest was reported by the authors.

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Data availability statement

For this article, data from the WIND database (https://www.wind.com.cn/) was used.

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