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Trend Changes in Real Estate Stock Prices: A Break-date Test

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Abstract: This paper argues that in 2007, the Chinese A-share market held a significant change in its entire progressing process. The interest rate shock in late May 2001 may be a noteworthy event causing the trend change. The paper aims to test for the trend change in real estate stock prices. Two leading listed real estate stocks were employed. Monthly series spanned the period from 1998M01–2014M12. Unit root, break-date and cointegration tests were conducted. Both the Perron test (in a mixed IO Model C) and the Zivot-Andrews test (Model C) were performed. A long-run memory of real estate share markets was suggested. Breakpoints occurred in March 2007. Long-run equilibrium did not exist between the stock prices. Real estate shares responded fast and independently to the interest rate shock in 2007. The interest rate shock may result in a trend change in real estate stock prices.
Keyword: Break date, interest rate, price, real estate, shock, stock

INTRODUCTION

The Shanghai Composite Index peaked in October 2007 (Figure-1) [1]. Then, it seems to move downwards until early 2010. This paper aims to test for the structural break of real estate stock prices in the Chinese A-share market. A shift in the stochastic trend of the data was treated as a structural change or break [2]. Significant historical events or shocks such as the 1929 Great Crash might lead to the break in security markets, a shift in the trend function of the data.

From 1999 to 2006, People's Bank of China (China's central bank) increased the interest rate for RMB loans five times. However, only in 2007, the one-year loan interest rate increased six times. Rates rose from 6.57% on March 18, 2007 to 7.47% on September 15, 2007, a 13.70% growth for five-time rate adjustments. The rate reached 7.56% in the 2007's sixth adjustment on December 21, 2007, a 15.07% growth compared with that in early 2007.

We argue that the loan interest rate shock in 2007 might cause a structural change in security markets such as the A-Share Market in China. The real estate sector is money intensive. The interest rate shock must markedly reduce the flow of funds into this sector. Stock prices are sensitive to changes in interest rates [3]. There is a lead-lag relationship between them [4]. In particular, real estate securities are very susceptible to interest rate movements [5]. Interest rates have a significant adverse effect on share prices [6].

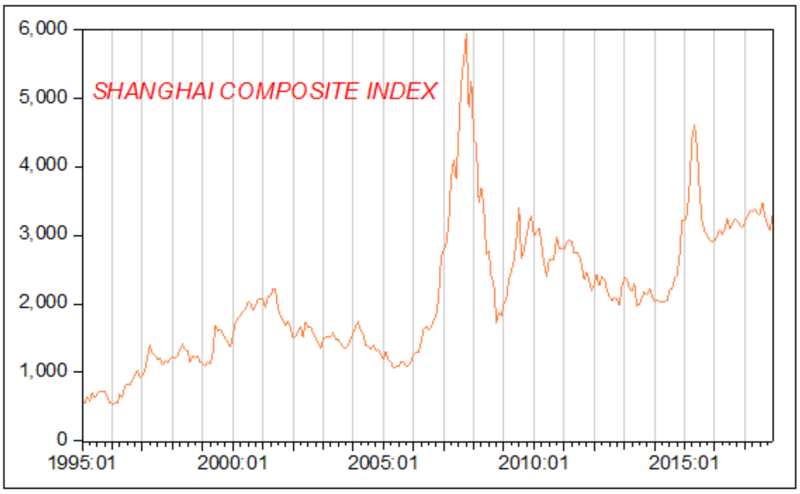

Fig-1: Monthly Changes in Shanghai Composite Index (1995-2017)

METHODS

Unit root tests can examine whether real estate stock prices had a long memory of an interest rate shock. Structural break tests can detect where the trend changed. We examined unit roots using the standard augmented Dickey–Fuller (ADF) test [7, 8], the Phillips–Perron (PP) test [9]. The standard ADF test may suffer from the power loss as well as severe size distortions and accordingly lead to over-rejection of the unit root hypothesis [10, 11]. A Dickey-Fuller GLS technique (the Elliott-Rothenberg-Stock DF-GLS test or ERS DF-GLS test) in conjunction with the modified AIC (MAIC) could realize a trade-off between the power and size [11, 12].

Nevertheless, the presence of a break date in the series may lead to a spurious unit root [2]. A break date is assumed to be unknown *priori*. Hence, the shift variable was endogenous [13-15]. The innovational outlier (IO) Model C simultaneously allows for a change in the level (intercept) as well as a change in the slope of the trend function [2, 14, 16]. The mixed model is more appropriate given an unknown break date [17].

We conducted structural break tests using the Perron test and the Zivot–Andrews test [14, 18]. The Perron test rejects the null hypothesis of a unit root more frequently than the Zivot–Andrews test.

The Perron test Model C is [2, 14]

$$y_t = \mu + \theta DU_t + \beta t + \gamma DT_t + \delta D(TB)_t + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + \varepsilon_t \quad (1)$$

Where $DU = 1$ if $t > T_b$ and 0 otherwise; $DT = t - T_b$ if $t > T_b$ and 0 otherwise; and $D(TB) = 1$ if $t = T_b + 1$ and 0 otherwise with 1(.) the indicator function. T is the sample. T_b is the break date. Under the null hypothesis of a unit root, $\mu \neq 0$ (in general), $\theta = 0$ (except in Model C), $\beta = 0$, $\gamma = 0$, $\delta \neq 0$, and $\alpha = 1$. Under the alternative hypothesis of stationary fluctuations around a deterministic trend function, $\mu \neq 0$, $\theta = 0$, $\beta = 0$, $\gamma = 0$ (in general), $\delta \neq 0$, and $\alpha < 1$.

We argue that real estate stocks should move together. We conducted the residual-based Z_α Engle-Granger test [19]. Also, the residual-based Z_α Phillips-Ouliaris test should have superior power properties in small samples [20].

An error-correction model (ECM) is valid where variables are $I(1)$ but cointegrated. A traditional vector-autoregression model (VAR) is still valid where variables are $I(1)$ but not cointegrated. Working with the VAR, we can estimate the short-run dynamics of a system such as the short-run elasticity and Granger causality between variables [21, 22].

Data

Data were real estate stock prices on the Chinese A-Share Market. They were closing prices of the last trading day in a month. Monthly changes covered the period of 1998-2014. Two series were Shanghai Lujiazui Finance and Trade Zone Development Co., Ltd stock prices (*LUJIAZUI FINANCE AND TRADE*), and Nanjing Gaoke (hi-technology) Co., Ltd stock prices (*NANJING HI-TECH*) [1].

Data were seasonally adjusted using the same X13 procedure [23] and converted into logarithms before the tests. Table-1 are details of the data. Figure-2 plots the series.

Table-1: Descriptive Statistics of the Data

Variable	*LUJIAZUI FINANCE AND TRADE*	*NANJING HI-TECH*
Definition	Closing stock price of the last trading date in a month (Chinese RMB) for Shanghai Lujiazui Finance and Trade Zone Development Co., Ltd	Closing stock price of the last trading date in a month (Chinese RMB) for Nanjing Gaoke (hi-technology) Co., Ltd
Mean	15.38	13.67
Median	14.85	12.06
Maximum	36.39	37.08
Minimum	4.74	3.74
Std. Dev.	5.77	6.78
Skewness	0.76	0.97
Kurtosis	3.85	3.81
Jarque–Bera	26.04	37.40
Probability	0.00	0.00
Type	Time series	
Frequency	Monthly	
Period of study	Jan 1998 to Dec 2014	
Seasonally adjustment method	X-13	

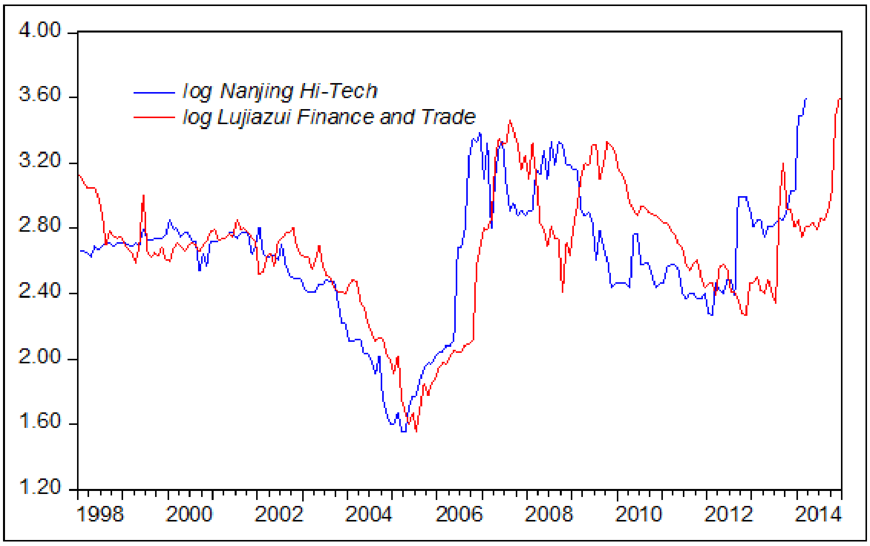

Fig-2: Real Estate Stock Prices in the Chinese A-Share Market

Empirical Results

The ADF, PP and ERS DF-GLS tests consistently suggest a unit root for the two variables (Tables 2, 3 and 4).

For *LUJIAZUI FINANCE AND TRADE*, the Perron test indicated a change in February 2007 (Table-5). The Zivot-Andrews test indicated a change in April 2007 (Table-6). To be a tradeoff, we suggest a break in March 2007 for this variable.

For *NANJING HI-TECH*, the Perron test indicated a change in February 2007 (Table-7). The Zivot-Andrews test indicated a change in March 2007 (Table-8). Thus, we suggest a break also in March 2007 for the variable.

The Engle-Granger test rejected the cointegration between these two variables (Table-9). Using the small sample critical values [24], the Phillips-Ouarilis test also showed no cointegration (Table-10).

Hence, a first-differenced VAR was estimated (Table-11). Overall, estimates were statistically significant. Granger causality tests suggest no short-run dynamics between the two variables (Table-12).

Table-2: The Unit Root Tests (ADF Tests)

Log variable	*k*	Level	*P*-value	*k*	First difference	*P*-value
LUJIAZUI FINANCE AND TRADE	12	-1.82	0.69	13	-4.12*	0.01
NANJING HI-TECH	2	-1.50	0.83	13	-3.48**	0.04

Notes: All tests encompass an intercept as well as a trend according to [25, 26]. The lag length *k* was decided using the *t*-test for the ADF test. The *k* was selected between two and thirteen to search a tradeoff between the size and power [27]. *P*-value denotes MacKinnon's *P*-value [28]. *, **, and ***denote rejection of the null of a unit root at the levels of 10%, 5% and 1% , respectively.

Table-3: The Unit Root Tests (PP Tests)

Log variable	*k*	Level	*P*-value	*k*	First difference	*P*-value
LUJIAZUI FINANCE AND TRADE	6	-2.07	0.56	5	-13.82***	0.00
NANJING HI-TECH	6	-1.76	0.72	6	-15.96***	0.00

Notes: All tests encompass an intercept as well as a trend according to [25, 26]. The lag *k* was decided using the Newey–West (NW) bandwidth technique for the PP test [29]. *P*-value denotes MacKinnon's *P*-value [28]. *, **, and ***denote rejection of the null of a unit root at the levels of 10%, 5% and 1 %, respectively.

Table-4: The Unit Root Tests (the ERS DF-GLS Tests)

Log Variable	*k*	Level	*k*	First difference
LUJIAZUI FINANCE AND TRADE	2	-1.42	8	-3.36**
NANJING HI-TECH	2	-1.62	10	-3.34**

Notes: Truncation lags, *k*, were chosen using the modified Akaike information criterion (MAIC). The *k* was selected between two and thirteen to search a tradeoff between the size and power [27]. Following Figure 2, test equations contained the trend and intercept. Critical values used are in Table 1 [12]. **, ***Rejection of a unit root at 5% and 1% levels, respectively.

Table-5: The Structural Break Test for LUJIAZUI FINANCE AND TRADE (Perron Test Model C)

Log variable	Parameter & variable	Coefficient	Std. Error	*t*-Statistic	*P*-value	T_B
LUJIAZUI FINANCE AND TRADE	θ	0.07	0.06	1.13	0.26	
	β	0.00	0.00	-0.95	0.34	
	γ	0.00	0.00	0.94	0.35	
	δ	-0.04	0.13	-0.30	0.76	
	α	0.90	0.05	**18.16**	0.00	Feb 2007
	Δ, t-1	0.09	0.08	1.10	0.27	
	Δ, t-2	0.01	0.08	0.12	0.91	
	Δ, t-3	0.08	0.08	0.94	0.35	
	Δ, t-4	0.18	0.08	2.19	0.03	
	Δ, t-5	0.03	0.08	0.41	0.68	
	Δ, t-6	0.08	0.08	1.03	0.31	
	Δ, t-7	0.07	0.08	0.94	0.35	
	Δ, t-8	0.10	0.08	1.27	0.20	
	Δ, t-9	0.10	0.08	1.27	0.20	
	Δ, t-10	-0.10	0.08	-1.22	0.22	
	Δ, t-11	0.05	0.08	0.65	0.52	
	Δ, t-12	-0.14	0.08	-1.82	0.07	
	Intercept	0.29	0.16	1.84	0.07	
	R-squared	0.92	Mean dependent var	2.64		
	Adjusted R-squared	0.91	S.D. dependent var	0.40		
	S.E. of regression	0.12	Akaike info criterion	-1.33		
	Sum squared resid	2.44	Schwarz criterion	-1.03		
	Log likelihood	145.21	Hannan-Quinn criter.	-1.21		
	F-statistic	115.45	Durbin-Watson stat	1.99		
	Prob(F-statistic)	0.00				

Notes: Δ indicates the first difference. t-1, t-2, ..., t-*k* are lagged terms. Truncation lag orders *k* (between 2 and 12) were selected using the data-dependent method [14, 27]. The trimming fraction λ was 0.15. λ was suggested to be 0.15 [30]. *t*-statistic for the *k*th term was greater than or equal to 1.8 in absolute value. The critical values for $T = 100$ were −6.21, −5.55, and −5.25 at the 1%, 5%, and 10% levels, respectively [14].

Table-6: The Structural Break Test for LUJIAZUI FINANCE AND TRADE (Zivot-Andrews Test Model C)

Log variable	Parameter & variable	Coefficient	Std. Error	*t*-Statistic	*P*-value	T_λ
LUJIAZUI FINANCE AND TRADE	θ	0.07	0.06	1.12	0.27	
	β	0.00	0.00	-0.92	0.36	
	γ	0.00	0.00	0.92	0.36	
	α	0.90	0.05	**18.58**	0.00	Apr 2007
	Δ, t-1	0.09	0.08	1.08	0.28	
	Δ, t-2	0.01	0.08	0.12	0.91	
	Δ, t-3	0.08	0.08	0.95	0.34	
	Δ, t-4	0.18	0.08	2.33	0.02	
	Δ, t-5	0.03	0.08	0.41	0.68	
	Δ, t-6	0.08	0.08	1.02	0.31	
	Δ, t-7	0.07	0.08	0.94	0.35	
	Δ, t-8	0.10	0.08	1.26	0.21	
	Δ, t-9	0.10	0.08	1.27	0.21	
	Δ, t-10	-0.10	0.08	-1.24	0.22	
	Δ, t-11	0.05	0.08	0.64	0.52	

	Δ, t-12	-0.15	0.08	-1.84	0.07	
	Intercept	0.28	0.15	1.84	0.07	
	R-squared	0.92	Mean dependent var	2.64		
	Adjusted R-squared	0.91	S.D. dependent var	0.40		
	S.E. of regression	0.12	Akaike info criterion	-1.34		
	Sum squared resid	2.45	Schwarz criterion	-1.05		
	Log likelihood	145.18	Hannan-Quinn criter.	-1.22		
	F-statistic	123.33	Durbin-Watson stat	1.99		
	Prob(F-statistic)	0.00				

Notes: Δ indicates the first difference. t-1, t-2, ..., t-*k* are lagged terms. Truncation lag orders *k* (between 2 and 12) were selected using the data-dependent method [14, 27]. The break fraction λ was 0.30. λ was suggested to be 0.15 [30]. *t*-statistic for the *k*th term was greater than or equal to 1.8 in absolute value. T_λ was the possible break date. the critical values for T (the sample size) = 159 were −5.40, −4.84, and −4.57 at the 1%, 5%, and 10% levels, respectively [18].

Table-7: The Structural Break Test for NANJING HI-TECH (Perron Test Model C)

Log variable	Parameter & variable	Coefficient	Std. Error	*t*-Statistic	*P*-value	T_B
NANJING HI-TECH	θ	0.31	0.08	3.70	0.00	
	β	0.00	0.00	-3.46	0.00	
	γ	0.00	0.00	2.36	0.02	
	δ	-0.03	0.12	-0.24	0.81	
	α	0.79	0.05	**15.99**	0.00	Feb 2007
	Δ, t-1	0.15	0.08	1.96	0.05	
	Δ, t-2	0.16	0.07	2.19	0.03	
	Δ, t-3	0.17	0.07	2.35	0.02	
	Δ, t-4	0.29	0.07	4.11	0.00	
	Δ, t-5	0.04	0.07	0.54	0.59	
	Δ, t-6	0.11	0.07	1.43	0.15	
	Δ, t-7	0.05	0.07	0.63	0.53	
	Δ, t-8	0.12	0.07	1.75	0.08	
	Δ, t-9	0.06	0.07	0.78	0.44	
	Δ, t-10	-0.07	0.07	-1.04	0.30	
	Δ, t-11	0.15	0.07	2.10	0.04	
	Intercept	0.69	0.17	4.09	0.00	
	R-squared	0.96	Mean dependent var	2.46		
	Adjusted *R*-squared	0.95	S.D. dependent var	0.50		
	S.E. of regression	0.11	Akaike info criterion	-1.51		
	Sum squared resid	2.09	Schwarz criterion	-1.22		
	Log likelihood	161.72	Hannan-Quinn criter.	-1.39		
	F-statistic	243.30	Durbin-Watson stat	1.95		
	Prob(*F*-statistic)	0.00				

Notes: Δ indicates the first difference. t-1, t-2, ..., t-*k* are lagged terms. Truncation lag orders *k* (between 2 and 12) were selected using the data-dependent method [14, 27]. The trimming fraction λ was 0.15. λ was suggested to be 0.15 [30]. *t*-statistic for the *k*th term was greater than or equal to 1.8 in absolute value. The critical values for T = 100 were −6.21, −5.55, and −5.25 at the 1%, 5%, and 10% levels, respectively [14].

Table-8: The Structural Break Test for NANJING HI-TECH (Zivot-Andrews Test Model C)

Log variable	Parameter & variable	Coefficient	Std. Error	*t*-Statistic	*P*-value	T_λ
NANJING HI-TECH	θ	0.30	0.08	3.89	0.00	
	β	0.00	0.00	-3.57	0.00	
	γ	0.00	0.00	2.35	0.02	
	α	0.79	0.05	**17.14**	0.00	March 2007
	Δ, t-1	0.15	0.08	1.95	0.05	
	Δ, t-2	0.16	0.07	2.20	0.03	
	Δ, t-3	0.17	0.07	2.35	0.02	
	Δ, t-4	0.29	0.07	4.14	0.00	
	Δ, t-5	0.04	0.07	0.53	0.60	

	Δ, t-6	0.10	0.07	1.42	0.16	
	Δ, t-7	0.04	0.07	0.60	0.55	
	Δ, t-8	0.12	0.07	1.76	0.08	
	Δ, t-9	0.05	0.07	0.75	0.46	
	Δ, t-10	-0.08	0.07	-1.09	0.28	
	Δ, t-11	0.15	0.07	2.12	0.04	
	Intercept	0.67	0.16	4.27	0.00	
	R-squared	0.96	Mean dependent var	2.46		
	Adjusted R-squared	0.95	S.D. dependent var	0.50		
	S.E. of regression	0.11	Akaike info criterion	-1.52		
	Sum squared resid	2.09	Schwarz criterion	-1.25		
	Log likelihood	161.69	Hannan-Quinn criter.	-1.41		
	F-statistic	260.92	Durbin-Watson stat	1.97		
	Prob(F-statistic)	0.00				

Notes: Δ indicates the first difference. t-1, t-2, ..., t-*k* are lagged terms. Truncation lag orders *k* (between 2 and 12) were selected using the data-dependent method [14, 27]. The break fraction λ was 0.30. λ was suggested to be 0.15 [30]. *t*-statistic for the *k*th term was greater than or equal to 1.8 in absolute value. T_λ was the possible break date. the critical values for T (the sample size) = 159 were −5.40, −4.84, and −4.57 at the 1%, 5%, and 10% levels, respectively [18].

Table-9: Engle–Granger Tests

Log of dependent variable	Z_α-statistic	*P*-value*
LUJIAZUI FINANCE AND TRADE	-16.44	0.07
NANJING HI-TECH	-16.98	0.12

Notes: The null hypothesis was that the series did not contain a cointegrating vector. Lags were chosen as per the modified Akaike criterion (AIC). **P*-values followed [28].

Table-10: Phillips-Ouliaris Tests

Log of the dependent variable	Z_α-statistic	*P*-value**	Haug‘s Critical value**
LUJIAZUI FINANCE AND TRADE	−22.69	0.03	-31.02
NANJING HI-TECH	−20.14	0.06	

Notes: The null hypothesis was that the series did not contain a cointegrating vector. Lags were chosen as per the Akaike criterion (AIC). **P*-values followed [28]. **Haug provided critical values for the Z_α Phillips-Ouliaris test in small samples [24].

Table-11: Estimates of the VAR in First Differences

Log dependent variable	Log Independent variable	Lagged terms	Estimates	*t*-Statistic
LUJIAZUI FINANCE AND TRADE	*LUJIAZUI FINANCE AND TRADE*	t − 1	0.01	0.12
		t − 2	-0.03	-0.42
	NANJING HI-TECH	t − 1	-0.08	-1.14
		t − 2	0.16	2.32
	Constant		-0.002	-0.20
NANJING HI-TECH	*LUJIAZUI FINANCE AND TRADE*	t − 1	0.03	0.37
		t − 2	-0.06	-0.83
	NANJING HI-TECH	t − 1	-0.13	-1.84
		t − 2	0.10	1.42
	Constant		-0.005	0.56
	R-squared	0.04		
	Adj. R-squared	0.02		
	Sum sq. resids	2.45		
	S.E. equation	0.11		
	F-statistic	1.98		
	Log likelihood	146.42		
	Akaike AIC	-1.47		
	Schwarz SC	-1.39		
	Mean dependent	0.00		
	S.D. dependent	0.12		

Notes: Lag was chosen using the AIC.

Table-12: Granger Causality Tests

Hypothesis	Wald-χ^2	Degree of freedoms	*P*-value
LUJIAZUI FINANCE AND TRADE did not Granger cause *NANJING HI-TECH*	0.84	2	0.66
NANJING HI-TECH did not Granger cause *LUJIAZUI FINANCE AND TRADE*	7.68	2	0.22

Notes: Tests were conducted within the estimated VAR.

Concluding Remarks

In 2007, China's central bank increased the RMB interest rate six times. Rates rose by 13.70% from March 2007 to September 2007. We argue that the interest rate shock resulted in the A-Share Market crash in October 2007.

Real estate shares are sensitive to changes in interest rates. The paper tested for a structural break for two leading real estate stocks listed on the A-Share Market in China. We employed closing stock price series. Data spanned the period of 1998M01–2014M12.

Various unit root tests indicated a unit root for the variables. Break-date tests showed that a shift occurred in March 2007. The first rate increase occurred on March 18, 2007. Information on the growth in interest rates was publically available. So, real estate stock prices responded instantly to the interest rate shock. There was no cointegration between the variables examined, which implies that real estate stocks responded to the interest rate shock independently. Estimates of a first-differenced VAR and Granger causality tests suggest that there were few short-run dynamics between the shares.

Hence, real estate share markets appear to have a long memory. Real estate stocks tend to respond quickly and independently to the interest rate shock in 2007. In particular, the interest rate shock may have caused the trend change of real estate stock prices.

Conflicts of Interest

The author declare no conflicts of interest.

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