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Untangling the nexus of stock price and trading volume: evidence from the Chinese stock market

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Abstract

This paper explores the linear and non-linear causal relationship between stock price and trading volume in China. The empirical results substantiate that there is a long-run level equilibrium relationship between the stock price and trading volume in China. The results from the linear causality tests indicate that there is unidirectional causality running from price to volume for the case of Shanghai B and Shenzhen B shares in the short-run, but there is a bidirectional causal relation between price and volume for the case of Shanghai A share and Shenzhen A share. In the results of the non-linear Granger causality, evidence shows that there is neutral price-volume relation for Shanghai B share. However, there is a bidirectional non-linear price-volume causal relation for the case of Shanghai A share and Shenzhen A share. For the case of Shenzhen B share, there is a unidirectional non-linear Granger causal relationship running from the stock price to the trading volume.

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1 Introduction

Highlighting the importance of understanding the price-volume relationship, Karpoff (1987) provides a comprehensive review of theoretical and empirical work. And, while there are several explanations for the presence of a causal relation between price and volume, the most widely cited hypotheses, albeit competing ones, are the sequential information arrival model (hereafter SIA) and the mixture of distribution model (hereafter MD). The former was proposed by Copeland (1976) and Jennings et al. (1981), and the latter by Clark (1973) and Epps and Epps (1976).

The SIA model argues that when new innovations reach the marketplace, they are not transmitted to all market participants at once. The model assumes that such innovations only reach one participant at a time, leading to a final information equilibrium only after a sequence of transitional equilibriums has occurred. According to this model, therefore, lagged trading volume may contain information that can be useful in predicting current stock returns, and lagged stock returns may contain information that can be useful in predicting current trading volume. Empirically, this hypothesis indicates that there is bidirectional causality between trading volume and stock returns.

The MD model, however, tells a different story about the relationship between trading volume and stock returns. In the mixture model of Epps and Epps (1976), trading volume is used to measure disagreement among traders as investors revise their reservation prices based on the arrival of new information to the market. The level of trading volume increases as the degree of disagreement among market participants widens. Their model indicates a positive causal relation running from trading volume to absolute stock returns. On the other hand, Clark's (1973) mixture of distribution model does not predict causality from trading volume to stock returns because trading volume is a proxy for the speed of information flow. A latent common factor affects contemporaneous stock returns and volume. Therefore, the MD hypothesis of Clark (1973) predicts a neutral relationship between trading volume and stock returns. Kandel and Pearson (1995) is another paper with a model and evidence about the price-volume relation around public announcements. Other theoretical contributions to this debate can be found in Campbell et al. (1993), Wang (1994) and He and Wang (1995).[1]

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[1] Two other related models are the noise-trader model of DeLong et al. (1990) and the tax- and non-tax-related

A significant volume of studies has investigated price-volume relationships, especially in the stock market (see, for example, Smirlock and Starks, 1988; Chordia and Swaminathan, 2000; Chen et al., 2001; Campbell et al., 1993; Hiemstra and Jones, 1994; Lee and Rui, 2000; Lee and Rui, 2002; Lee et al., 2004; Gurgul and Majdosz, 2005; and Pisedtasalasai and Gunasekarage, 2006). Studies on other markets are limited due to the unavailability of data on trading volume.[2] Two important features characterize these studies. First, the findings are mixed, if not contradictory, which means no corroborative conclusion vis-à-vis the causal relationship between the stock price and trading volume. Second, the majority overlooks the non-linear property inherent in stock market but only apply the traditional method in testing for the Granger causality of stock price and trading volume.

In keeping with previous literature, the aim of this paper is to determine whether there is a non-linear causal relation in the Chinese stock price-volume nexus.[3] The methodology used in this study differs from that in earlier studies in two ways. First, we model the long-run relationship based on Pesaran's *et al.* (PSS, 2001) bounds test approach. The advantages of the bounds test for cointegration are that (i) it can be applied to models consisting of variables with order of integration less or equal to one, and (ii) it can distinguish dependent from independent variables. Second, in addition to the linear Granger causality (GC) test, we employ Hiemstra and Jones' (HJ, 1994) non-linear method and Diks and Panchenko's (DP, 2006) modified non-parametric method which enables us to test for non-linear Granger causality and, at the same time, avoid making spurious inferences. The empirical investigation also enables us to evaluate the applicability of, for example, the sequential information arrival hypothesis. The evidence gained from the empirical work on the lead-lag relation helps us determine the suitability of the theoretical explanation.

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motives for the trading model of Lakishok and Smidt (1989).

[2]Studies on the price-volume relation have also been extended to bond and futures markets (Tauchen and Pitts, 1983; Grammatikos and Saunders, 1986), the foreign exchange market (Chung and Joo, 2005; Chen and Chen, 2006) and to the agricultural futures market (Malliaris and Urrutia, 1998).

[3]As pointed by Wang et al. (2005), "Over the last decade, Chinese Stock Exchanges (CSEs) have experienced rapid growth and development. Because of the ever-growing importance of the Chinese economy in East Asia, CSEs have attracted great attention in empirical research, for example, Su and Fleisher (1998, 1999), Lee and Rui (2002), Lee et al. (2004) and among others."

The organization of the paper is as follows. Section 2 briefly introduces the econometric methodology that we employ. Section 3 describes the data and discusses the empirical test results. Section 4 presents the conclusions that we draw from this research.

2 Methodology

2.1 The ARDL Bounds Test

Pesaran *et al.* (2001) have recently developed the bounds test procedure based on the estimation of the AutoreRressive Distributed Lag (ARDL) model, and it outperforms other estimators when samples are small (see Pesaran and Shin, 1995). When written in the Error Correction model (ECM) form, the ARDL model is much less vulnerable to spurious regression (Pesaran and Smith, 1998). The following Unrestricted Error Correction model (UECM) is estimated by taking each of the variables individually as a dependent variable:

$$\Delta \ln PR_t = \alpha_0 + \pi_1 \ln PR_{t-1} + \pi_2 \ln TV_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta \ln PR_{t-i} + \sum_{j=0}^{q} \theta_j \Delta \ln TV_{t-j} + \varepsilon_{1t} \quad (1)$$

$$\Delta \ln TV_t = \bar{\alpha}_0 + \bar{\pi}_1 \ln PR_{t-1} + \bar{\pi}_2 \ln TV_{t-1} + \sum_{i=1}^{p} \bar{\gamma}_i \Delta \ln TV_{t-i} + \sum_{j=0}^{q} \bar{\theta}_j \Delta \ln PR_{t-j} + \varepsilon_{2t} \quad (2)$$

Here, $\ln PR$ is the natural log of the stock price index, and $\ln TV$ is the natural log of the trading volume. When a long-run relationship exists, the F-test indicates which variable should be normalized. The bounds test for examining evidence for a long-run relationship in Equation (1), denoted by $F(PR|TV)$, is conducted using the F-test by testing the joint significance of the coefficients on the one-period lagged levels of the variables $H_0 : \pi_1 = \pi_2 = 0$ against the alternative $H_1 : \pi_1 \neq \pi_2 \neq 0$. Similarly, the null hypothesis for testing the nonexistence of a long-run relationship in Equation (2) is denoted by $F(TV|PR)$.

The bounds test procedure is applicable irrespective of whether the underlying regressors are integrated on the order of one or zero, or are mutually cointegrated. By contrast, the ARDL regression yields a test statistic which can be compared to two asymptotic critical values. If the test statistic is above a certain upper critical value, the null hypothesis of no long-run relationship must be rejected regardless of whether the underlying orders of integration of the regressors are zero or one. Alternatively, if the test statistic falls below a certain lower critical value, the null hypothesis of a no long-run relationship between the regressors cannot be rejected. If the test statistic falls between these two bounds, the results are, in a word, inconclusive.

2.2 Non-linear Granger Causality Test

Baek and Brock (1992) proposed a nonparametric statistical method to detect non-linear causal relationships for independently and identically distributed time series. The rationale behind their approach is that after any linear predictive power is removed from a linear model, any remaining incremental predictive power of one residual series on another can be considered non-linear predictive power and, therefore, can be regarded as evidence of non-linear causality. Hiemstra and Jones (1994) modified Baek and Brock's test by lifting their i.i.d. assumption. HJ allow the variables to which the test is applied to exhibit serial dependence rather than just be mutually independent and identically distributed. The test statistic proposed by HJ (1994) is specified as follows.[4]

$$\sqrt{n}\left[\frac{C_1(m+L_x,L_y,e,n)}{C_2(L_x,L_y,e,n)}-\frac{C_3(m+L_x,e,n)}{C_4(L_x,e,n)}\right]/\sqrt{\sigma^2}\sim N(0,1)). \tag{3}$$

Commenting on HJ's method, Diks and Panchenko (2006) argue that it lacks consistency, and in its place, they propose a new test statistic for non-linear Granger causality as follows.

$$\sqrt{n}(\frac{T_n(\varepsilon_n)-q}{S_n})\sim N(0,1). \tag{4}$$

3 Data and Results

We obtain weekly data for Shanghai A share, Shanghai B share, Shenzhen A share and Shenzhen B share from the *Datastream*. PR_t and TV_t are the abbreviations of the stock price and trading volume, respectively. For all variables the data are from different starting date but they are all end with 2006M12. For example, the data starts from January 1993 for Shanghai A share and it starts from December 1994 for Shanghai B. All of the variables used are in natural logarithms. The scatter plots of price index and trading volume for these shares are presented in Figure 1 and 2.

[4]Readers are referred to Hiemstra and Jones (1994) and Diks and Panchenko (2005, 2006) for detail explanation on notations and definitions.

First, we apply the Augmented Dickey-Fuller (ADF) unit root test to determine the order of integration of the variables. The key here is to account for serial correlation; we set $k = 12$, which is the lagged difference, and use the Schwarz Bayesian Criterion (BIC) to select the optimal lag length. The results are not reported here due to space constraints, but they are available from the author upon request. We find strong evidence in favor of the unit root hypothesis based on the ADF test in their respective level data. When we apply the ADF test to the first difference of these series, again, we are able to reject the null hypothesis of a unit root at the 5% level or better. Therefore, we conclude that the stock price the trading volume are I(1) processes.

Since the two series are non-stationary processes, we conduct the bounds tests, proposed by Pesaran et al. (2001), to confirm the existence of a long-run equilibrium relationship, and the results are reported in Table 1. It is clear that, if the stock price is used as the dependent variable, then the computed F-statistic is smaller than the lower critical value. But if the trading volume is used as the dependent variable, then the computed F-statistic exceeds the upper critical value, a strong indicator that the null hypothesis of a no level long-run relationship must be rejected. The test results substantiate a long-run relationship between stock price and trading volume and indicate that the dependent variable must be the trading volume.

To check the causal relationship, we estimate an error correction model for $\ln PR$ and $\ln TV$. The reason for this is that in the presence of cointegration, the Granger causality requires the inclusion of an error correction term in the stationary model in order to capture short-run deviations of series from their long-run equilibrium path. This is represented as follows:

$$\Delta \ln PR_t = \alpha_0 + \sum_{i=1}^{k} \alpha_i \Delta \ln PR_{t-i} + \sum_{i=1}^{k} \beta_i \Delta \ln TV_{t-i} + \theta ECT_{t-1} + \varepsilon_{1t} \quad (5)$$

$$\Delta \ln TV_t = \bar{\alpha}_0 + \sum_{i=1}^{k} \bar{\alpha}_i \Delta \ln PR_{t-i} + \sum_{i=1}^{k} \bar{\beta}_i \Delta \ln TV_{t-i} + \bar{\theta} ECT_{t-1} + \varepsilon_{2t} \quad (6)$$

All variables are as previously defined. ε_{1t} and ε_{2t} are error terms that are assumed to be white noise with zero mean, constant variance and no autocorrelation. In Equation (5), short-term causality implies that $\ln TV$ 'Granger-causes' $\ln PR$ provided that $\beta_i \neq 0 \ \forall i$. The significance of the lagged error correction term, i.e., $\theta \neq 0$, denotes whether there is a long-run causal relationship. Similarly, in equation (6), causality implies that $\ln PR$ 'Granger-causes' $\ln T$ provided that $\bar{\alpha}_i \neq 0 \ \forall i$. The significance of the lagged error correction term, i.e., $\bar{\theta} \neq 0$, denotes whether there is a long-run causal relationship.

The Granger causality test results are presented in Table 2. The results in Table 2 show that, for the cases of Shanghai B share and Shenzhen B share, there is a unidirectional relation running from the stock price to the trading volume in the short-run. However, there is no evidence that trading volume Granger-causes the stock price because the F-statistic is insignificant at the 5% level or better. This means that the information contained in the trading volume is not an adequate determinant of the stock price. For the case of Shanghai A share and Shenzhen A share, the stock price Granger-causes the trading volume and vice versa, implying that there is a feedback relation between stock price and trading volume in the short-run.

In equation (5), for all cases the coefficient on the lagged error correction term is significant at the 5% level and has a negative sign, which confirms the findings from the bounds test that there is a long-run relationship. Thus, in the long-run, the stock price Granger-causes the trading volume with the causality running interactively through the error correction term. In equation (6), the coefficient on the lagged error correction term is insignificant different from zero at the 5% level for all cases except for the Shanghai A share. The results show that the past information of trading volume is helpless to predict the behavior of the stock price in the long-run.

In the next phase of this study, we implement HJ's test to examine any non-linear causal relations in the errors after removing linear dependence in the ECM model. The HJ non-linear Granger causal test results are summarized in Table 3. For the case of Shanghai B share, we cannot find any non-linear Granger causality between the stock price and trading volume. For the case of Shanghai A, Shenzhen A and B shares, they show that we cannot reject the absence of non-linear Granger causality from the trading volume to the stock price at the 5% significance level, but important to note, we can reject the absence of non-linear Granger causality from the price to volume, indicating that the stock price does non-linear Granger-cause the trading volume.

DP (2005) claim that HJ (1994) test results are typically spurious and that when making inferences, one must be cautious. Thus, to avoid making spurious inferences while testing for non-linear Granger causality, we employ Diks and Panchenko's (2006) modified non-parametric method. Table 4 shows that, again, we cannot find the non-linear Granger causality between the stock price and trading volume for Shanghai B share. However, there is a bidirectional non-linear causal relation between the stock price and trading volume for the case of Shanghai A share and Shenzhen A share. For the case of Shenzhen B share, consistent with the HJ test, there is a unidirectional non-linear Granger causal relationship running from the stock price to the trading volume, but there is no non-linear Granger causality from the trading volume to the stock price. We therefore conclude that the causal relationship from the stock price to the trading volume is not only linear but also non-linear.

Based on these findings, we can determine which theoretical explanation holds for the presence of the causal relationships between the stock price and the trading volume. It is clear that the mixture of distribution model of Clark (1973) is not applicable to the price-volume relationship in the stock market of China because a neutral relationship between trading volume and stock price is rejected in the sense of linear Granger causality. The mixture of distribution model of Epps and Epps (1976) is also not applicable to the case of Shanghai B share and Shenzhen B share because there is no evidence that trading volume Granger-cause the stock price either in the sense of linear or non-linear Granger causality. The sequential information arrival model of Copeland (1976), either in the sense of linear or non-linear Granger causality, is applicable to the price-volume relationship in Shanghai A share because there is a bi-directional causal relation between stock price and trading volume. For the case of Shanghai B share, Shenzhen A share and Shenzhen B share, evidence of the long-run causality from price to volume is consistent with the noise trader model of DeLong et al. (1990). The fact that volume does not lead price implies the information contained in the stock trading volume cannot significantly improve the ability to predict the stock price. Evidence of non-linear causality might come from the fact that consumers generally make an attempt to optimize their behavior even when faced with changes in price. Based on the evidence, as opposed to focusing on changes in volume, the authority in China is well advised to be more mindful of changes in price.

4 Concluding Remarks

This paper examines the nature of the stock price-volume relationship in China. Some interesting conclusions emerge from our empirical findings. First, the results from the cointegration tests, i.e., the ARDL bounds test, show that there is a long-run level equilibrium relationship between the stock price and trading volume in China. Second, the results from the linear causality tests indicate that there is unidirectional causality running from price to volume for the case of Shanghai B and Shenzhen B shares in the short-run, but there is a bidirectional causal relation between price and volume for the case of Shanghai A share and Shenzhen A share. There is long-run causality running from price to volume for all shares. Third, in the results of the non-linear Granger causality, evidence shows that there is neutrality between the stock price and trading volume for Shanghai B share. However, there is a bidirectional non-linear causal relation between price and volume for the case of Shanghai A share and Shenzhen A share. For the case of Shenzhen B share, there is a unidirectional non-linear Granger causal relationship running from the stock price to the trading volume.

Based on these findings, it is clear that the mixture of distribution model of Clark (1973) is not applicable to the price-volume relationship in the stock market of China because a neutral relationship between trading volume and stock price is rejected in the sense of linear Granger causality. The mixture of distribution model of Epps and Epps (1976) is also not applicable to the case of Shanghai B share and Shenzhen B share because there is no evidence that trading volume Granger-cause the stock price either in the sense of linear or non-linear Granger causality. The sequential information arrival model of Copeland (1976), either in the sense of linear or non-linear Granger causality, is applicable to the price-volume relationship in Shanghai A share because there is a bi-directional causal relation between stock price and trading volume. For the case of Shanghai B share, Shenzhen A share and Shenzhen B share, evidence of the long-run causality from price to volume is consistent with the noise trader model of DeLong et al. (1990). There is one important implication. This paper urges caution in using changes in volume in the stock market. Instead, policy-makers in China should take changes in price into account when formulating new policy.

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Table 1: Bounds Test for Cointegration

	95% critical value	
	I(0)=4.94	I(1)=5.73
Shanghai A	F(PR | TV)=4.548	F(TV | PR)=6.067*
Shanghai B	F(PR | TV)=2.508	F(TV | PR)=9.185*
Shenzhen A	F(PR | TV)=3.365	F(TV | PR)=5.977*
Shenzhen B	F(PR | TV)=2.522	F(TV | PR)=6.095*

* denote significance at the 5% level.

Table 2: Results from the Linear Granger Causality Test

$PR \nRightarrow TV$: Price does not Granger-cause Trading Volume.		
	short-run	long-run
	F-statistic[p-value]	F-statistic [p-value]
Shanghai A	3.643[0.000]*	7.059[0.008]*
Shanghai B	4.843[0.000]*	15.167[0.000]*
Shenzhen A	6.236[0.000]*	8.146[0.004]*
Shenzhen B	7.003[0.000]*	9.491[0.002]*
$TV \nRightarrow PR$: Trading Volume does not Granger-cause Price.		
	short-run	long-run
	F-statistic [p-value]	F-statistic [p-value]
Shanghai A	2.633[0.008]*	4.713[0.030]*
Shanghai B	1.130[0.332]	0.587[0.444]
Shenzhen A	3.579[0.001]*	0.720[0.397]
Shenzhen B	1.699[0.077]	0.698[0.404]

Numbers in square brackets are p-values.
* denote significance at the 5% level.

Table 3: Results from Hiemstra and Jones's (1994) Test

	Shanghai A	Shanghai B	Shenzhen A	Shenzhen B
PR $\not\Rightarrow$ TV: Price does not Granger-cause Trading Volume.				
$L_{PR} = L_{TV}$	TVAL [p-value]	TVAL [p-value]	TVAL [p-value]	TVAL [p-value]
1	−0.092[0.536]	0.312[0.377]	0.248[0.402]	0.074[0.470]
2	−0.069[0.527]	0.582[0.280]	0.386[0.350]	−0.065[0.526]
3	0.007[0.497]	0.796[0.213]	0.327[0.372]	−0.082[0.533]
4	−0.060[0.524]	0.857[0.196]	−0.096[0.538]	−0.094[0.538]
5	−0.403[0.656]	0.949[0.171]	−0.162[0.564]	0.045[0.482]
6	0.120[0.452]	0.493[0.311]	−0.108[0.543]	0.247[0.403]
7	−0.169[0.567]	0.096[0.462]	−0.094[0.537]	−0.169[0.567]
8	2.485[0.006]*	−0.253[0.600]	2.482[0.007]*	3.238[0.001]*
TV $\not\Rightarrow$ PR: Trading Volume does not Granger-cause Price.				
$L_{PR} = L_{TV}$	TVAL [p-value]	TVAL [p-value]	TVAL [p-value]	TVAL [p-value]
1	0.099[0.461]	0.141[0.444]	0.416[0.339]	0.634[0.263]
2	0.413[0.340]	0.670[0.252]	0.699[0.242]	0.773[0.220]
3	0.242[0.404]	0.429[0.334]	0.664[0.253]	0.809[0.209]
4	−0.554[0.710]	0.612[0.270]	0.270[0.393]	0.431[0.333]
5	−0.386[0.650]	0.479[0.316]	0.365[0.358]	0.448[0.327]
6	−0.361[0.641]	0.769[0.221]	0.730[0.233]	−0.082[0.533]
7	0.188[0.425]	0.356[0.361]	0.462[0.322]	0.100[0.460]
8	0.330[0.371]	NA	0.474[0.318]	0.207[0.418]

$L_{PR} = L_{TV}$ denotes the number of lags on the residuals series used in the test.
Numbers in square brackets are p-values.
* denote significance at the 5% level.
NA denote not available.

Table 4: Results from Diks and Panchenko's (2006) Test

	Shanghai A	Shanghai B	Shenzhen A	Shenzhen B
PR $\nRightarrow$ TV: Price does not Granger-cause Trading Volume.				
$L_{PR} = L_{TV}$	TVAL [p-value]	TVAL [p-value]	TVAL [p-value]	TVAL [p-value]
1	0.022[0.491]	0.690[0.245]	0.056[0.478]	0.096[0.462]
2	1.549[0.061]	0.574[0.283]	0.831[0.203]	0.109[0.457]
3	2.393[0.008]*	−0.028[0.489]	2.067[0.019]*	0.215[0.415]
4	2.380[0.009]*	0.995[0.160]	2.715[0.003]*	0.730[0.233]
5	2.605[0.005]*	1.265[0.103]	3.079[0.001]*	0.914[0.180]
6	2.641[0.004]*	1.042[0.149]	3.249[0.001]*	1.144[0.126]
7	2.746[0.003]*	1.337[0.091]	3.543[0.000]*	1.669[0.048]*
8	2.999[0.001]*	1.410[0.079]	NA	1.737[0.041]*
TV $\nRightarrow$ PR: Trading Volume does not Granger-cause Price.				
$L_{PR} = L_{TV}$	TVAL [p-value]	TVAL [p-value]	TVAL [p-value]	TVAL [p-value]
1	0.091[0.464]	0.517[0.303]	1.151[0.125]	0.816[0.207]
2	0.981[0.163]	0.801[0.211]	1.589[0.056]	0.919[0.179]
3	1.553[0.060]	0.732[0.232]	1.799[0.036]*	1.033[0.151]
4	1.200[0.115]	0.921[0.179]	1.820[0.034]*	1.273[0.102]
5	1.456[0.073]	0.962[0.168]	2.264[0.012]*	0.958[0.169]
6	1.261[0.104]	1.033[0.151]	2.133[0.016]*	0.771[0.220]
7	1.680[0.047]*	0.563[0.287]	1.824[0.034]*	0.533[0.297]
8	1.717[0.043]*	0.354[0.362]	NA	−0.027[0.489]

$L_{PR} = L_{TV}$ denotes the number of lags on the residuals series used in the test.
Numbers in square brackets are p-values.
* denote significance at the 5% level.
NA denote not available.

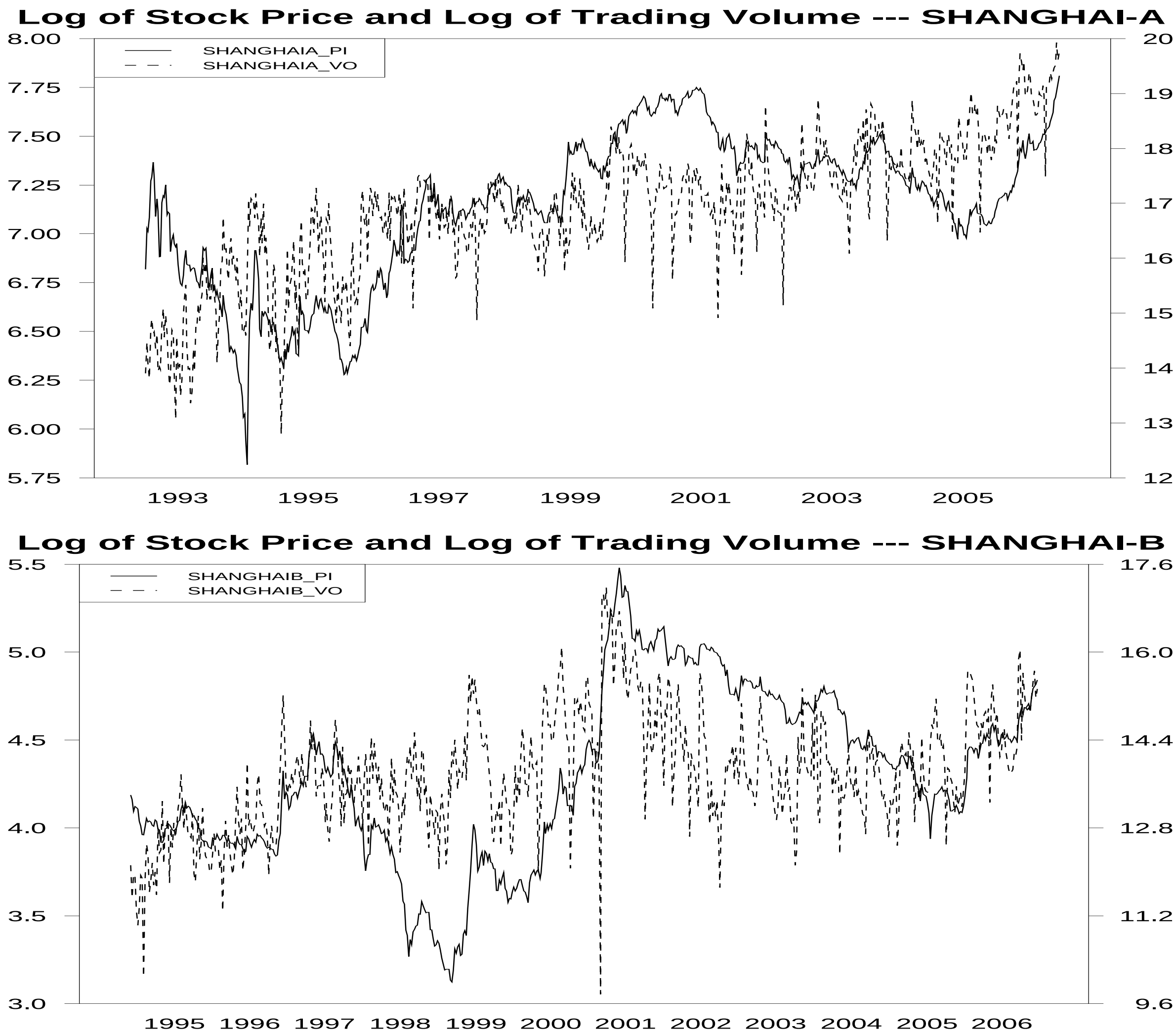

Figure 1: The scatter plots of price index and trading volume for Shanghai A and B shares.

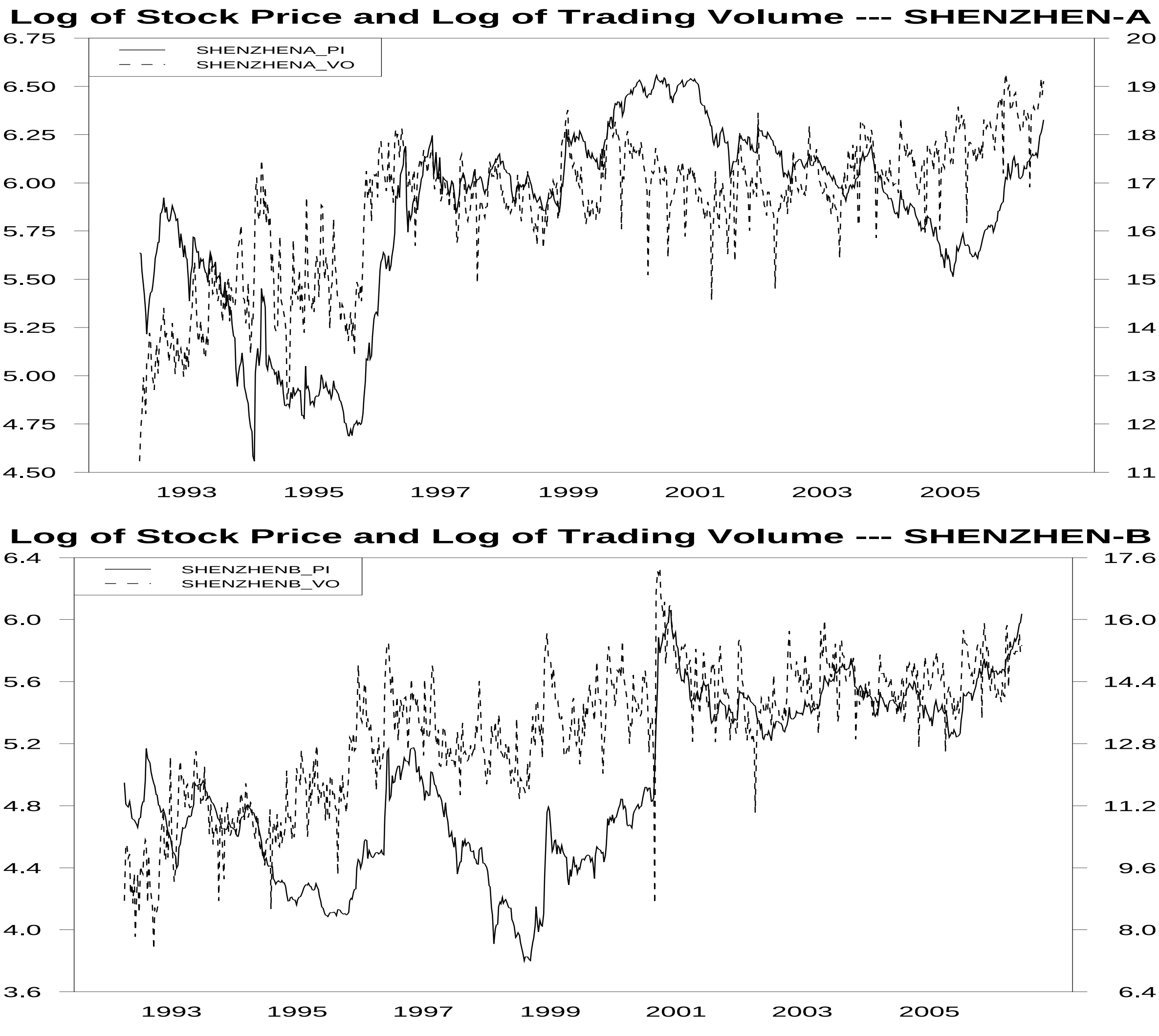

Figure 2: The scatter plots of price index and trading volume for Shenzhen A and B shares.