Cross-Autocorrelation of Dual-Listed Stock Portfolio Returns:
Evidence from the Chinese Stock Market

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ABSTRACT

In this paper, we apply a GARCH model to examine the cross-autocorrelation pattern between daily returns of portfolios composed of dual-listed stocks in Chinese stock market, before and after China opened its once foreign-exclusive B-share market. A lead-lag relationship between the A-share and B-share portfolio returns is identified during our sample periods, with the A-share portfolio leading the B-share portfolio. Upon the opening of B-share market, a change from underreaction to overreaction is found in the response pattern of B-share market, producing a rarely seen negative cross-autocorrelation. The results of two additional tests are reported. First, by decomposing the portfolio return into portfolio-specific and market-wide returns, we find that the market-wide information contained in A-share portfolio return is strongly associated with the cross-autocorrelation structure. Second, we document a directional asymmetry in which B-share portfolio shows either slow or over response to bad, but not good, news of A-share portfolio. We conclude that information asymmetry alone is not enough to explain the lead-lag relationship, and investor behavior must be taken into consideration. [JEL G14, G18]

Keywords: Cross-Autocorrelation; Segmented Stock Markets; Dual-Listed Stocks; Market-Wide and Portfolio-Specific Information.

I. Introduction

Efficient market hypothesis suggests that financial asset returns should not be predictable based on all publicly available information. However, the existence of the asymmetric cross-autocorrelation between large and small market capitalization portfolios has been well documented in U.S. stock market by Lo and MacKinlay (1990). Their study indicates that short-horizon returns on the portfolio of stocks with large market capitalization predict those with smaller market capitalization better than vice versa. This asymmetric cross-autocorrelation is called the lead-lag effect. Similar pattern has been identified in other markets, such as several Asian markets (Chang *et al.*, 1999), United Kingdom (Kanas and Kauretas, 2001), German and Turkish (Altay, 2003), and Brazil (Ratner and Leal, 2003). [1]

Cross-autocorrelation may account for a large percent of some documented contrarian profits. If returns on some stocks systematically lead or lag those of others, rational investors can condition their leading shares' trading decisions on the previous price movement of lagged shares, and a portfolio strategy that sells "winners" and buys "losers" can produce positive expected returns. Several explanations have been proposed for the lead-lag effect structure, including information adjustment asymmetry (Chan, 1993; Badrinath *et al.*, 1995), nonsynchronous trading (Boudoukh *et al.*, 1994), transaction costs (Mench, 1993; Bernhardt and Mahani, 2004), and contemporaneous correlations (Hameed, 1997).

The information adjustment asymmetry, emphasizing the differences in the speeds of asset price adjustment processes to information, is the most popular explanation. According to Chan (1993), if market makers observe noisy signals about their stocks and correct pricing errors by observing the additional signals inferred from previous price changes in other stocks, then stock returns become positively cross-autocorrelated. The signal quality differences among stocks could cause the asymmetric cross-autocorrelation. As a result, if there is higher-quality information in large stocks than in small stocks, possibly due to the lower marginal costs of producing information, as proposed by Ho and Michaely (1988), then the returns of large stock portfolios would lead that of small stock portfolios.

[1] The six Asian stock markets are Hong Kong, Japan, Singapore, South Korea, Taiwan, and Thailand.

Badrinath *et al.* (1995) associate cross-autocorrelation with the institutional ownership of the stocks. The institutional investors concentrate on specific groups of stocks, usually large capitalized ones, and produce more information about these stocks. Then the price change of the informational favored stocks produce additional signal for other informational unfavored ones.

According to nonsynchronous trading, cross-autocorrelation relationship results from the assumption that multiple time series are sampled simultaneously when in fact they are nonsynchronous, which induces spurious cross-effects among stocks. Lo and MacKinlay (1990) conclude that unrealistically thin markets are required for the noncynchronous trading to explain the observed cross-autocorrelation; however, Boudoukh *et al.* (1994) argue that Lo and MacKinlay seriously understate the potential effects of nonsynchronous trading. Actually, the nonsynchronous trading and the information asymmetric pattern do not have to be exclusive to each other in explaining the cross-autocorrelation. As Bernhardt and Davies (2005) indicate, the prices of less active stocks do not incorporate some of the recent information that is already contained in the prices of more active stocks. As a specific case, the trading of small stocks is mostly thinner than that of large stocks, with a result that last transactions of small stocks on any trading day are usually completed before those of large stocks. Therefore, the price of large stocks will likely reflect any news arriving in the market toward the end of the trading day, while the price of small stocks will only show the effect of this information on the following day.

Mench (1993) lists transaction costs, low transactions and market microstructure as the reasons of the cross-autocorrelation. Bernhardt and Mahani (2001) show that, on top of information asymmetry, additional friction such as transaction costs is necessary to explain the cross-autocorrelation pattern. They offer a model with non-fundamental speculation featured with a common liquidity-traded component and agents with information related to liquidity trade. With this model, negative cross-autocorrelation is possible.

As an opposing view from the above mentioned authors, Hameed (1997) argues that the portfolio cross-autocorrelation is simply a restatement of portfolio autocorrelations, and once portfolio autocorrelations are taken into account, the cross-autocorrelation should disappear.

Should these reasons exist behind the lead-lag effect, then the cross-autocorrelation pattern applies to segmented financial markets, where various types of shares of the same stock are issued and different shareholders have different access to market segmentation. Chui and Kwok (1998) test the Chinese A-share and B-share markets, and they find that B-share market leads A-share market during the period of 1993-1996. Two factors are reported to account for the phenomena: the mechanism of information transmission and differences between market participants. More specifically, A-shares are mainly traded by domestic individual investors, compared to the majority of foreign institutional investors in B-share market, who are more likely to have more advanced technology for processing and analyzing information. In addition, foreign investors get information from the free market of Hong Kong, while domestic investors are constrained by the mainland media and publishing industry which is under firm controls of central government. Accordingly, public information is expected to reach the B-share market before the A-share market.

However, whether foreign investors in China possess information advantage deserves closer examinations. The existence of information asymmetry on values of local assets between foreign investors and domestic investors has been documented extensively in Brennan and Cao (1997), Stulz and Wasseerfallen (1995), and Kang and Stulz (1997). It is typically assumed by the literature that domestic investors are better informed than foreign investors. The case is confirmed in Chinese market by Chakravarty *et al.* (1998), and Su and Fleisher (1999). The reasons they provide include language barriers, different accounting standards, and a lack of reliable information about the local economy and firms available to foreign investors. On top of this, the trading of a B-share stock is usually much thinner than that of its A-share counterpart. So the conclusion of Chui and Kwok (1998) is subject to further testing.

The main purpose of this paper is three-fold. First, we re-examine the cross-autocorrelation pattern in Chinese stock market with the portfolios of dual-listed stocks. Second, we test the impacts of China's opening of its once foreign-exclusive B-share market to its domestic individual investors. In February 2001, Chinese government announced that domestic individual investors were permitted to invest in B-shares. Accordingly, the cross-autocorrelation between A- and B-shares, if they existed, might have changed. Third, we explore the sources of the lead-lag pattern. The paper will shed lights on both the policy making and the investment strategy of active traders in segmented stock markets.

The remainder of this paper is organized as follows. Section II describes the data and sample selection. Section III examines the general cross-autocorrelation pattern. Section IV evaluates the relative importance of various components by decomposing the portfolio returns. Section V proposes the potential reasons behind the empirical results. The paper ends with a brief summary of conclusions.

II. Data and Sample Selection

Chinese stock market was established in early 1990s. Over the past decade, it has undergone a substantial increase and become the second largest stock market in Asia. Despite the rapid growth, the market remains underdeveloped in many senses. For instance, Greonewold *et al.* (2001) study the efficiency of the market. They find evidence of departures from weak and semi-strong form efficiency in the sense that predictability of security returns can be obtained on the basis of their own past values.

A distinguishing feature of Chinese stock market is the privilege listed companies have, upon meeting certain requirements, of issuing either A-shares or B-shares that can be freely traded.[2] A-shares are denominated in RMB, and B-shares are denominated in US Dollar (Shanghai Stock Exchange, SSE) or HK Dollar (Shenzhen Stock Exchange, SHSE). Other than who can own them, these shares are legally identical, with the same voting rights and dividends. Before February 2001, China's stock market was listed by International Finance Corporation as the only equity market with completely segmented trading between domestic and foreign investors, since A-shares were traded among P.R. China citizens, while B-shares were traded among non-P.R. China citizens. Two measures have been taken in the Chinese market to break the segmentation. First, since February 19, 2001, domestic individuals with legal foreign exchanges have been permitted to trade B-shares, but not the vice versa. Second, in December 2002, QFII (Qualified Foreign Institutional Investors) was introduced in the market, with the hope that foreign investment institutions will spur on

[2] In addition to A-share and B-shares, a Chinese company can also issue H- and N-shares in Hong Kong and New York, respectively. There are also some state owned Chinese companies incorporated and listed in Hong Kong that have the name of "red chips".

better and more effective functioning. Under QFII, certain foreign institutional investors have been allowed to trade in A-share market. [3]

We obtain daily adjusted price of stocks dual-listed in both A-share and B-Share markets of SSE and SHSE from Datastream, covering the period between January 1, 1995 and September 30, 2005. This timeframe effectively avoids the infancy period of the Chinese stock market and the RMB's foreign exchange rate adjustment period in 1994. To test the structural change brought by China's opening its once foreign-only shares to domestic individual investors, we divide the total sample period into two subperiods: January 1, 1995 - January 31, 2001 (PRE-FEB) and February 1, 2001 - September 30, 2005 (POST-FEB).

The sample population consists of 72 pairs of firms, which form A-share portfolio and B-share portfolio on an equal-weighted basis. Since the portfolios are formed by dual-listed stocks, we diminish the influence of factors associated with stock-specific components. For a stock to be included into the portfolio on a specific day, both its A-share and B-share must be traded on that day; otherwise, the stock is excluded. In order to reduce the IPO under-pricing effect documented by Mok and Hui (1998), the first 20 days trading data following the IPO of each stock are removed. The descriptive statistics for the portfolio in the sample period is reported in Table 1. [4]

Insert Table 1 about here

From Table 1, the returns of the portfolios appear non-normally distributed with fat-tail over various time horizons, except the monthly return for the A-share portfolio. Longer horizon returns appear more normal than shorter horizon returns for A-share portfolio, but not for B-share portfolio.

[3] Until June 30, 2005, twenty-seven companies have acquired licenses, with a combined US$4 billion investment quota to buy A-shares, bonds and mutual funds. As of September 30, 2005, seventeen of these companies are investing in A-share stocks.

[4] Here, portfolio returns are calculated first from simple returns and then are converted to continuously compounded returns. The weekly return of each security is computed as the return from Tuesday's closing price to the following Tuesday's closing price. If the following Tuesday's price is missing, then Wednesday's price (or Monday's price, if Wednesday's price is also missing) is used. If both Monday's and Wednesday's prices are missing, then the return for that week is reported as missing. The monthly return of each security is computed as the return from the closing price of the last trading day of the month to that of the following month.

Except the PRE-FEB subperiod, the B-share portfolio has a higher average return than the A-share portfolio, followed by its total higher risk levels.

Table 2 exhibits the autocorrelation for daily, weekly and monthly portfolio returns over the sample periods. A significant first order autocorrelation can be observed for daily returns of both portfolios, with smaller and sometimes negative high-order autocorrelations.[5] The weekly and monthly return autocorrelations reported in panel B and C of Table 2 exhibit different patterns: mixed sign and statistically insignificant at the first lag over the entire periods for A-share portfolio, while positive and mixed statistically significance for B-share portfolio. The evidence indicates that information on own price transmits faster in A-share market than in B-share market.

Insert Table 2 about here

III. General Cross-Autocorrelation Pattern

In this section, we study the general cross-autocorrelation pattern between A-share and B-share portfolios. Then, we check the structural change of the pattern before and after the B-share market opening in February 2001. We focus on several propositions, which are tested with associated models.

3.1 General Cross-Autocorrelation Structure

Our first two propositions are built as follows:

Proposition 1: *The cross-autocorrelation between the return of B-share portfolio on day (t-1) and that of A-share portfolio on day t is significant.*

Proposition 2: *The cross-autocorrelation between the return of A-share portfolio on day (t-1) and that of B-share portfolio on day t is significant.*

The two propositions imply that A-share and B-share investors of the same stock could gain information from each other.

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[5] Several explanations about the portfolio autocorrelations has been offered in finance literature (Mench, 1993), including the slow adjustment of stock price to new information, autocorrelation in the underlying expected returns, and mispricing.

We use the following model with GARCH (Generalized Autoregressive Conditional Heteroskedasticity) disturbance to approximate the return generating process of A-share and B-share portfolios. To diminish the impact of own autocorrelation, we include the lagged return of each portfolio in explaining its return.

$$R_{A,t} = \alpha_A + \beta_{AB} R_{B,t-1} + \beta_{AA} R_{A,t-1} + \varepsilon_{A,t}$$
$$\varepsilon_{A,t} = \sigma_{A,t}\mu_{A,t}, \quad \sigma^2_{A,t} = \gamma_{A,0} + \gamma_{A,1}\varepsilon^2_{A,t-1} + \omega_{A,1}\sigma^2_{A,t-1} \tag{1}$$

$$R_{B,t} = \alpha_B + \beta_{BA} R_{A,t-1} + \beta_{BB} R_{B,t-1} + \varepsilon_{B,t}$$
$$\varepsilon_{B,t} = \sigma_{B,t}\mu_{B,t}, \quad \sigma^2_{B,t} = \gamma_{B,0} + \gamma_{B,1}\varepsilon^2_{B,t-1} + \omega_{B,1}\sigma^2_{B,t-1} \tag{2}$$

where $R_{A,t}$ ($R_{B,t}$) is the A-share (B-share) portfolio return at time *t*, β_{AB} (β_{BA}) is the sensitivity of A-share (B-share) portfolio return on one-day lagged B-share (A-share) portfolio return, β_{AA} (β_{BB}) is the sensitivity of A-share (B-share) portfolio return on its own one-day lagged return, α_A (α_B) is the regression coefficient of the A-share (B-share) portfolio return, $\varepsilon_{A,t}$ ($\varepsilon_{B,t}$) is the error term, and $\{\mu_{A,t}\}$ and $\{\mu_{B,t}\}$ are both sequences of independent and identically distributed random variables with mean zero and variance 1.

In the model, a positive β_{AB} implies that A-share portfolio partly reacts to the B-share portfolio return with a lag, while a negative β_{AB} implies that A-share portfolio overreacts to the B-share portfolio return and this overreaction gets corrected in the subsequent period. The same implications apply to B-share portfolio as well.

The statistical results of the model are reported in table 3. Consistent with Richardson and Peterson (1999) but inconsistent with Hameed (1997), the cross-autocorrelation effect is significant after taking the autocorrelation effect into account.

Insert Table 3 about here

In the PRE-FEB subperiod, β_{BA} is larger than zero at 5% significant levels (t-statistic of 2.60), i.e., there is a positive and statistically significant one-day lagged effect of A-share portfolio returns on B-share portfolio returns. On the contrary, we do not observe the significant lagged effect of B-share portolio return on A-share portfolio returns (t-statistic of 1.40). For the POST-FEB subperiod, the correlation changes its sign and there is no evidence of significant one-day lagged effect on B-share portfolio returns (t-statistic of -1.16). In this subperiod, we do not observe the lagged effect on A-share portfolio returns either. So, for both subperiods, we reject Proposition 1, but not Proposition 2 for the PRE-FEB subperiod, at 5% significant level. In other words, the evidence is consistent with Chui and Kwok (1998) in that the cross-autocorrelation of the portfolio returns is asymmetric, but inconsistent with Chui and Kwok in that the returns of A-share portfolio lead those of B-share portfolio.

Figure 1 shows the evolution of $\sigma^2_{A,t}$ and $\sigma^2_{B,t}$, variance of residuals in Eq. 1 and Eq. 2, respectively. The correlation between $\sigma^2_{A,t}$ and $\sigma^2_{B,t}$ is 0.126, and we do not find strong co-movement between the residual variances.

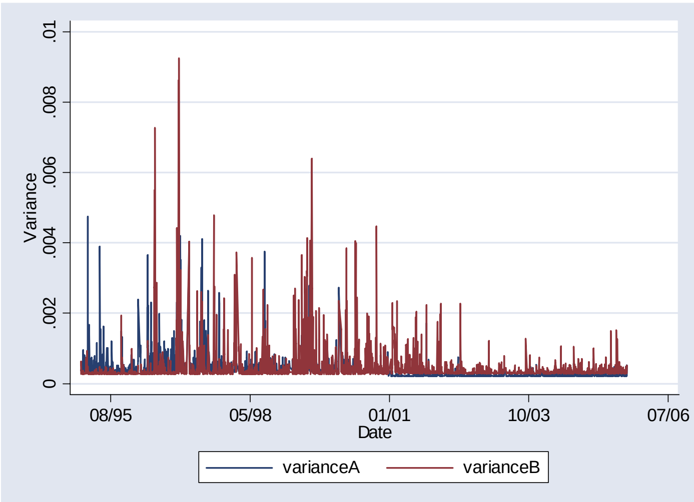

Figure 1. Co-evolution of residual variances

To check the possible spurious correlations between the portfolio returns, we run the regression of the equations with the first differences of the series. We define the first differences of the portfolio return series as $\Delta R_{A,t} (= R_{A,t} - R_{A,t-1})$ and $\Delta R_{B,t} (= R_{B,t} - R_{B,t-1})$, and replace $R_{A,t}$, $R_{B,t}$, $R_{A,t-1}$, and $R_{B,t-1}$ in *Eq.1&2* with $\Delta R_{A,t}$, $\Delta R_{B,t}$, $\Delta R_{A,t-1}$ and $\Delta R_{B,t-1}$, respectively. Through the results reported in Panel B of Table 3, we find that correlations between the first differences almost keep the original level of significance, so we conjecture that the correlations in the portfolio returns are not spurious.

3.2 The Effect of Financial Policy on the Cross-Autocorrelation Structure

Regarding the effects of the B-share market opening on the cross-autocorrelation pattern, we establish the following proposition.

Proposition 3: *The leading pattern of A-share portfolio return on B-share portfolio return has significantly changed after the opening policy.*

To test the proposition, we set $\beta_{BA-PRE-FEB} = \beta_{BA-POST-FEB}$ as the null hypothesis and $\beta_{BA-PRE-FEB} \neq \beta_{BA-POST-FEB}$ as the alternative hypothesis. The alternative hypothesis implies the lead effect of A-share portfolio returns on that of B-share portfolio returns has changed after February, 2001.

The results are shown in panel C of Table 3. The t-statistic of 1.98 on the difference between $\beta_{BA-PRE-FEB}$ and $\beta_{BA-POST-FEB}$ is significant at the 5% level, so we do not reject Proposition 3, i.e., a significant change is found in the cross-autocorrelation pattern.

IV. Cross-Autocorrelation Pattern with Decomposed Returns

In section 3, we conclude that there is a general lead-lag pattern of the A-share and B-share portfolio returns, with the former leading the latter. In this section, by decomposing the portfolio returns into portfolio-specific and market-wide components, we study the effects of the market information on lead-lag pattern. We also study the speed of B-share portfolio returns in responding the lagged good news and bad news from A-share portfolio. By doing so, we can further identify the source of the lead-lag effect.

4.1 Market-Wide and Portfolio-Specific Information

In order to decompose the total portfolio returns into market-wide and portfolio specific components, we use the following equation as an estimation of the CAPM:

$$\nabla R_{A,t} = \alpha + \beta_A \nabla R_{M,t} + \varepsilon'_{A,t}$$
$$\varepsilon'_{A,t} \sim N(0, \phi^2) \tag{3}$$

where r_t is the return on a risk-free asset at time *t*, $\nabla R_{A,t}\,(= R_{A,t} - r_t)$ and $\nabla R_{M,t}\,(= R_{M,t} - r_t)$ are the excess return on A-share portfolio and the market portfolio at time *t*, respectively,

β_A is the sensitivity of excess A-share portfolio return on the market portfolio return, α is the regression coefficient, and $\varepsilon'_{A,t}$ is the error term. In estimating the model, *Datastream China Country Price Index* and *China Time Deposit* are used as the proxies for market portfolio and the risk-free asset, respectively.

The statistical results are reported in Table 4. From the table, market beta coefficients are highly significant in both subperiods. The explanation power of the model is also high, with an R^2 over 0.7.

Insert Table 4 about here

Since the risk-free interest rate and the constant of *Eq. 3* are very small, we use the error term $\varepsilon'_{A,t}$ estimated by the above CAPM as portfolio-specific returns in testing the effect of the lagged A-share portfolio-specific information on B-share portfolio returns. Similarly, the systematic return, $R^M_{A,t}$ ($= R_{A,t} - \varepsilon'_{A,t}$), can be used as the indicator of market-wide information in the cross-autocorrelation structure.[6]

The following GARCH (1, 1) model is used to test the effects of lagged A-share portfolio-specific and market-wide information on the B-share portfolio return:

$$R_{B,t} = \alpha_B + \beta^P_{BA}\varepsilon'_{A,t-1} + \beta^M_{BA}R^M_{A,t-1} + \beta_{BB}R_{B,t-1} + \varepsilon_{B,t}$$
$$\varepsilon_{B,t} = \sigma_{B,t}\mu_{B,t}, \quad \sigma^2_{B,t} = \gamma_{B,0} + \gamma_{B,1}\varepsilon^2_{B,t-1} + \omega_{B,1}\sigma^2_{B,t-1} \qquad (4)$$

where $\varepsilon'_{A,t}$ is the one-day lagged A-share portfolio-specific return, $R^M_{A,t-1}$ is the one-day lagged systematic return of A-share portfolio, β^P_{BA} (β^M_{BA}) is the sensitivity of B-share portfolio return to one-day lagged A-share portfolio-specific (systematic) return, and the other variables with the same implication as *Eq. 2*.

The summary statistics of the system estimation are reported in Table 5. From the table, one-day lagged market-wide information reflected in A-share portfolio returns has a

[6] We try decomposing the portfolio return (not the excess return) with a one-factor model: $R_{A,t} = \mu_A + b_A R_{M,t} + e_{A,t}$, where μ_A represents the expected components, $b_A R_{M,t}$ the unexpected market-wide component, and $e_{A,t}$ the unexpected portfolio-specific component. We run the regression and get similar results which do not affect our conclusions. Therefore, we only report the results based on the CAPM.

significant effect on B-share portfolio returns in both subperiods (t-statistic of 2.17 for the PRE-FEB subperiod and -2.16 for the POST-FEB subperiod), while the A-share portfolio-specific information does not have any statistically significant effect on the B-share portfolio returns (t-statistic of 1.23 for the PRE-FEB subperiod and 0.30 for the POST-FEB subperiod). This evidence shows that the general significant cross-autocorrelation between A-share and B-share portfolios is due to the market-wide information content of A-share portfolio returns, as predicted from Chan (1993).

Insert Table 5 about here

A further test in Panel B of Table 5 shows that the difference of the β_{BA}^{M} between PRE- and POST-FEB subperiods is significant (t-statistic of 2.81), but it is not the case for β_{BA}^{P} (t-statistic of 0.29). The B-share portfolio return tends to underreact to the market-wide information contained in the A-share portfolio in the PRE-FEB subperiod but overreact in the POST-FEB subperiod.

4.2 Directional Asymmetry with Down and Up Market

McQueen *et al.* (1996) employ a methodology of directional asymmetry to further analyze the cross-autocorrelation structure of the size-sorted portfolios in NYSE. They find that small and large cap portfolios' reactions to bad news are fast, but the reactions of small cap portfolio to good news are slower than that of the large cap portfolio. Chang *et al.* (1998) find that the good news and bad news pattern is not universal across Asian markets.

Here we examine the reactions of B-share portfolio returns to increasing and decreasing lagged A-share portfolio returns. Like McQueen *et al.* (1996), we decompose the systematic component of A-share portfolio returns into two different new time series: First series, upward returns, equal to the original returns when they take positive values and zero otherwise; second series, downward returns, equal to the original returns when they take negative values and zero otherwise. The decomposition produces the following two series:

$$R_{A,t-1}^{M,u} = \begin{cases} R_{A,t-1}^{M}, & if \quad R_{A,t-1}^{M} > 0 \\ 0, & otherwise \end{cases}$$

$$R_{A,t-1}^{M,d} = \begin{cases} R_{A,t-1}^{M}, & if \quad R_{A,t-1}^{M} < 0 \\ 0, & otherwise \end{cases}$$

We estimate the pattern with the GARCH (1, 1) model:

$$R_{B,t} = \alpha_B + \beta_{BA}^{P} \varepsilon'_{A,t-1} + \beta_{BA}^{u} R_{A,t-1}^{M,u} + \beta_{BA}^{d} R_{A,t-1}^{M,d} + \beta_{BB} R_{B,t-1} + \varepsilon_{B,t}$$

$$\varepsilon_{B,t} = \sigma_{B,t}\mu_{B,t}, \quad \sigma_{B,t}^{2} = \gamma_{B,0} + \gamma_{B,1}\varepsilon_{B,t-1}^{2} + \omega_{B,1}\sigma_{B,t-1}^{2} \qquad (5)$$

where $R_{A,t-1}^{M,u}$ ($R_{A,t-1}^{M,d}$) is the one-day lagged upward (downward) systematic return of A-share portfolio, β_{BA}^{u} (β_{BA}^{d}) is the sensitivity of B-share portfolio systematic return to one-day lagged upward (downward) returns of A-share portfolio, and the other variables with the same implication as *Eq. 2*.

The statistical results are reported in Table 6. We document a directional asymmetry in the B-share portfolio lagged response to A-share portfolio movement. When the systematic returns on A-share portfolio are negative, the lagged beta is significant for the POST-FEB subperiod (t-statistic of -2.87) and weakly significant for the PRE-FEB subperiod (t-statistic of 1.66). When the systematic returns on A-share portfolio are positive, the lagged beta is insignificant (t-statistic of 1.41 for the PRE-FEB subperiod and -0.55 for the POST-FEB subperiod). This implies that the cross-autocorrelation is asymmetric in up and down markets. B-share portfolio react quickly to positive market news contained in A-share portfolio, but either underreact or overreact to negative market news contained in A-share portfolio.

Insert Table 6 about here

V. Explanations to the Empirical Results

We have identified the cross-autocorrelation structure in the portfolio returns of A-share and B-share market, with the return of A-share portfolio return leading that of B-share portfolio. Additional tests reveal that the pattern is discretional asymmetric, and B-share portfolio shows an under- or overreaction to the bad (not the good) information contained in A-share portfolio. By dividing the sample period into two subperiods, we find it interesting that the cross-autocorrelation pattern change its sign upon the implementation of the B-share opening policy by Chinese government. In this section, we will provide analysis to these findings.

5.1 Market Microstructure

We start by examining the reasons listed by Chui and Kwok (1998) concerning the information transmission mechanism in Chinese stock market.

At the early stage, there had been a sharp contrast between A-share and B-share market participants. Most traded A-shares were held by small retail investors, since there were relatively few large Chinese institutional investors; by contrast, B-shares were traded by institutional foreign investors such as mutual funds. So it is safe to say that domestic individual investors dominated the A-share market, while foreign institutional investors dominated the B-share market at that stage. However, the situation has changed since the Asian financial crisis in 1998, when the institutional foreign investors started to quit the market. Restrictions on foreign ownership and little control over poorly-performing enterprises had led to disappointing results for the B-share market long before February 2001. The Economist (March 3, 2001) and the Asian Wall Street Journal (February 21, 2001) suggest that by early 2001, 60 to 80 percent of B shares were held illegally by Chinese residents. The situation has been deteriorated after the implementation of B-share opening policy. On the other side, in late 2002, large foreign investors were allowed to trade in A-share market according to QFII, which has changed the investor profile in both A-share and B-share markets further.

Additionally, even though the media and publishing industry is still under monopoly in China through inspection systems, the entry of WTO and widespread use of internet has destroyed the advantages of foreign investors described by Chui and Kwok, if any. Chakravarty *et al.* (1998) argue that domestic investors tend to have access to more information than B-share investors even before 1998. In addition, the disclosure in B-share market is far from satisfactory. It has been much less studied by institutional investors, reflecting the fact that it is even harder to find a company research report on B-share market. Thus we believe that A-share investors get access to information faster than B-share investors, as reflected in the observed lead-lag pattern.

Finally, the difference of liquidity between the A-share and B-share markets also support the lead-lag pattern. The B-share market has expanded far less rapidly than the A-share market, in terms of issued shares, market capitalization, and number of companies. Figure 2 shows the movement of daily turnover (by volume) of the all stocks in SSE and SHSE A-share and B-share markets during the sample period. From the figures, we can easily tell that the B-share market has far less liquidity than A-share market. In the whole sample period, only in early 2001 has B-share market recorded turnovers that approximated those of A-share market. More specifically, Figure 3 shows the movement of average daily turnover (by volume) of the 58 pairs of A-share and B-share stocks in the sample portfolios during the sample period. Not surprisingly, the turnovers of B-share stocks only exceed their A-share counterparts during early 2001 and few other occasions. As a result, B-share stocks may well incorporate the information later than A-share stocks.

As for the demand elasticity, B-share market could be more elastic than A-share market. No new B-share stock has been listed in China since October 2000. In addition, H-share, N-share, and “red-chip” stock markets all provide good substitute for B-share market and thus makes demand for B-shares quite elastic (Sun and Tong, 2000). The implementation of QFII further squeezes B-share market. On the contrary, domestic Chinese investors have much fewer investment alternatives to low-yielding bank deposits or insurance accounts, thus the demand elasticity for A-shares is lower.

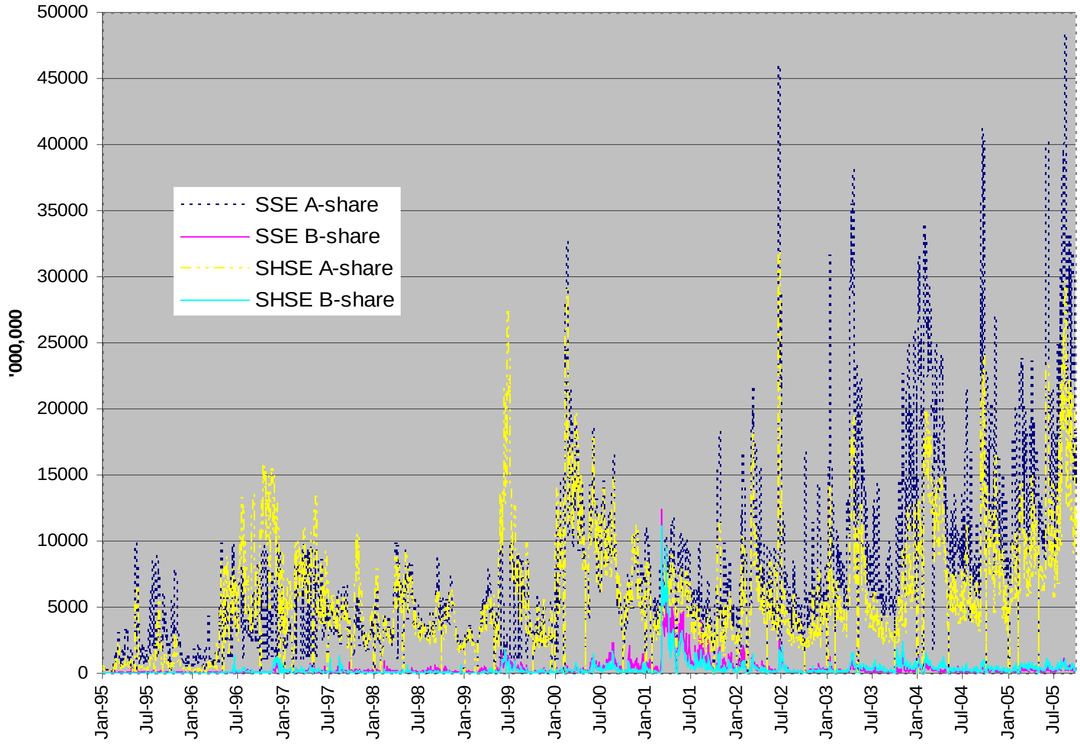

Figure 2. Daily turnover by volume of the all stocks trading in SSE and SHSE A-share and B-share markets

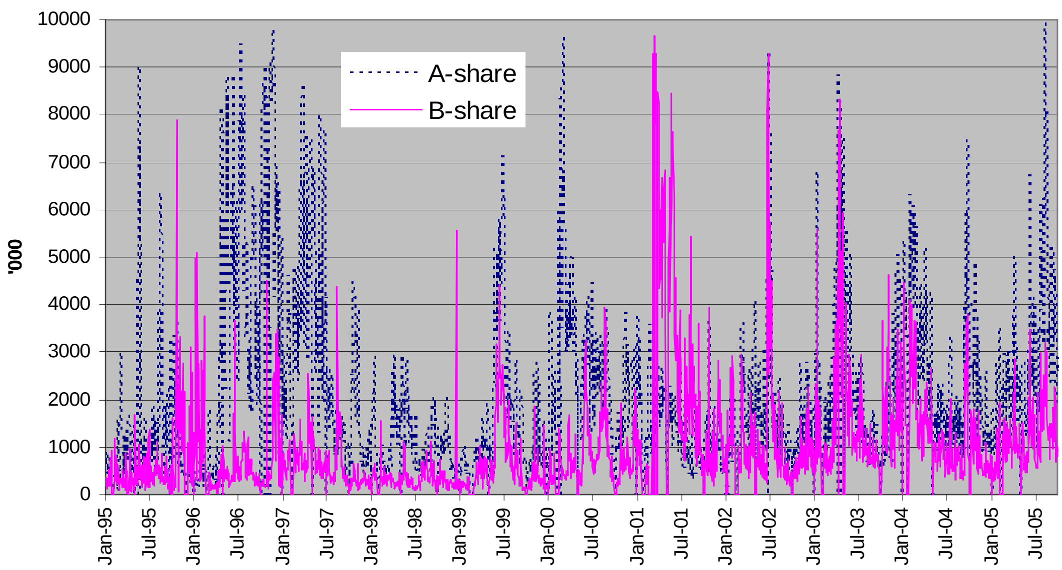

Figure 3. Average daily turnover of the A-share and B-share stocks trading in the sample portfolios

Based on these factors, both the information transmission and the nonsynchronous trading support the evidence that the return of A-share portfolio leads that of the B-share portfolio.

5.2 Investor Behavior

The information transmission asymmetry and thin trading seems to account for the cross-autocorrelation pattern, but the directional structural change upon the B-share opening remains without adequate explanations. We have documented a negative and significant cross-autocorrelation pattern in this paper, a notable difference from past empirical literature that has only reported positive ones. As Bernhardt and Mahani (2004) predict, it is hard to find negative patterns in the traditional models with asymmetric information. In their paper, they offer a model in which speculators with non-fundamental information use the trades of liquidity traders (noise traders) to make profits. They conclude that additional frictions such as transaction costs are necessary to produce such a pattern. However, we find that the gaps between trading costs in A-share and B-share markets are too small enough to support their argument.

McQueen *et al.* (1996) argue that Heretics could be used to explain why small stock returns can be predicted by past larger stock returns. Heretics attributes the return predictability of financial assets to market fads, herding and overreaction, and other investor behaviors that create a kind of "momentum" that causes prices to temporarily swing away from their fundamental values.[7] Although they, together with other authors, use Heretics to explain the traditional positive cross-autocorrelation pattern, we can extend their concept to yield helpful insights into our puzzle.

Daniel *et al.* (1998) develop a theory of securities market under- and overreactions based on investor overconfidence and biased self-attribution. An overconfident investor is defined as one who overestimates the precision of his private, not the public, information signal. Biased self-attribution means investors too strongly attribute events that confirm the validity of their actions to their own ability, and events that disconfirm the actions to external factors. In their model, stock prices overreact to private information signals and underreact to public signals, implying negative long-lag autocorrelations and positive short-lag autocorrelations.

[7] Stock market overreaction implies that the asset returns are negatively autocorrelated over some holding period, so that "what comes down must go up," and vice versa. As De Bondt and Thaler (1985, 1987) suggest, individuals tend to overreact to information and stock prices also overreact to information. Investors with the tendency of overreacting are called "positive feedback traders" by De Long *et al.* (1990).

Figure 4 is the chart for the rebased A-share and B-share price index of Shanghai and Shenzhen stock markets in the period from January 1995 to September 2005. From the figure, we can find that the markets tend to be bullish before 2001 and bearish after 2001. Parallel to the private and public information in Daniel *et al.* (1998), bad news has been identified to play a vital role in determining the sign of cross-autocorrelation. When the market is bullish, the investors are optimistic and tend to underreact to bad news. However, when the market turns bearish, the investors become pessimistic and tend to overreact to bad news. The phenomenon is more obvious in B-share market, in which the liquidation is lower, the quality of information contained is believed to be inferior, and the presence of noisy traders in violation of Bayes' rule could be stronger. Thus, the cross-autocorrelations can be positive or negative, depending on the information transmission, market atmosphere, and the investor behavior. The overreaction to bad news in B-share market after February 2001 can be a result of the reverse to the continuing underreaction before February 2001.

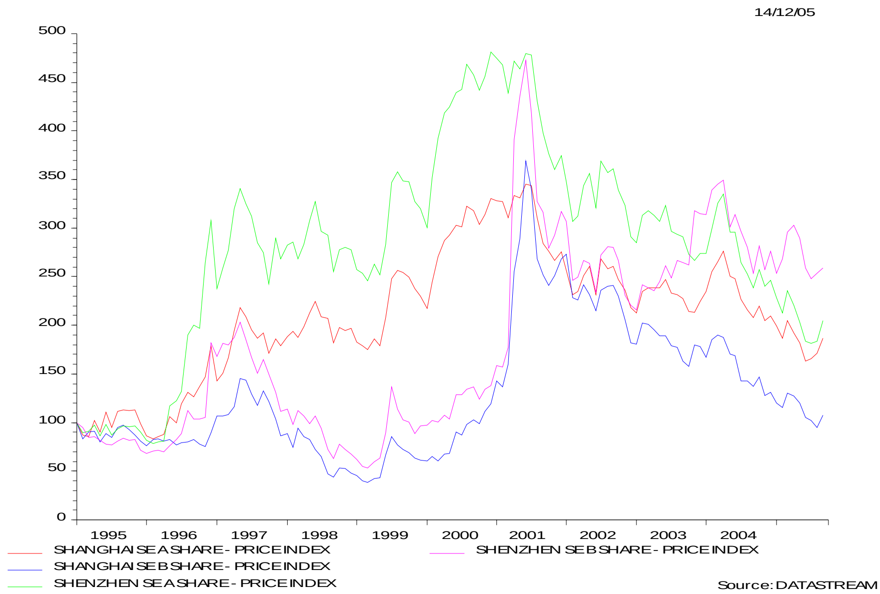

Figure4. Price of Stock Index in Chinese Stock Market

Combined with the imperfect information transmission mechanism and nonsynchronous trading, the investor behavior provides an explanation to the cross-autocorrelation structural change upon the B-share market opening.

VI. Conclusions

This paper examines the cross-autocorrelation pattern in the portfolios composed of dual-listed stocks in Chinese A-share and B-share markets. We find that A-share portfolio leading B-share portfolio, evidence against Chui and Kwok (1998). We also study the impact of China's opening of its once foreign exclusive B-share market on the lead-lag pattern, and document a structural change upon the policy change.

To find further clues, we decompose the returns into different sources and develop tests that allow us to evaluate their relative importance. First, by decomposing the portfolio return into portfolio-specific and market-wide returns, we find that the market-wide information contained in A-share portfolio return is strongly associated with the cross-autocorrelation structure. Second, we document a directional asymmetry in which B-share portfolio shows either slow or over response to bad, but not good, news of A-share portfolio.

The results lend further credence to the view of imperfect information transmission mechanism and nonsynchronous trading between A-share and B-share markets. A-share market has a higher liquidity than B-share market, and the return of A-share portfolio could reflect information that has yet to contain in B-share portfolio. Additionally, the emergence of negative cross-autocorrelation after the Chinese market going downturn in 2001 suggests that traditional asymmetric information model alone is not enough to explain the pattern, and a more sophisticated model concerning both market behavior and the psychology of individual decision making could yield more insights. To our knowledge, our paper is the first to document significant negative cross-autocorrelation and to explain it with market behavior and the psychology of investors.

Our results suggest several directions for future research. First, a theoretical behavioral model on cross-autocorrelation is necessary to provide the base for explaining the observed pattern. Second, there is a clear need to analyze with details the investor behavior in Chinese stock market. Third, from a practical investment perspective, it is of our interest to assess whether the contrarian strategy caused by the cross-autocorrelation will be profitable after taking account of frictions such as transaction costs.

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Table 1. Descriptive Statistics of Daily, Weekly, and Monthly Portfolio Return

Descriptive statistics of daily, weekly, and monthly equal-weighted portfolio return for the sample period from January 1, 1995 to September 30, 2005 and subperiods. The *p*-values are shown in the parentheses for Skewness and Kurtosis.

Sample Period	Sample Size	Mean ×100	Std. Dev.	Skewness	Kurtosis
Panel A: Daily Returns					
			A-share Portfolio		
Jan-01-95:Sep-30-05	2599	0.026	0.020	0.52	21.8
				(0.000)	(0.000)
Jan-01-95:Jan-31-01	1476	0.095	0.022	0.50	22.9
				(0.000)	(0.000)
Feb-01-01:Sep-30-05	1123	-0.066	0.016	0.36	5.8
				(0.000)	(0.000)
			B-share Portfolio		
Jan-01-95:Sep-30-05	2599	0.049	0.022	0.48	9.0
				(0.000)	(0.000)
Jan-01-95:Jan-31-01	1476	0.089	0.027	0.48	9.6
				(0.000)	(0.000)
Feb-01-01:Sep-30-05	1123	0.004	0.020	0.45	7.2
				(0.000)	(0.000)
Panel B: Weekly Returns					
			A-share Portfolio		
Jan-01-95:Sep-30-05	530	0.114	0.046	-0.18	6.7
				(0.082)	(0.000)
Jan-01-95:Jan-31-01	299	0.468	0.050	-0.35	7.5
				(0.014)	(0.000)
Feb-01-01:Sep-30-05	231	-0.345	0.041	0.04	3.9
				(0.792)	(0.021)
			B-share Portfolio		
Jan-01-95:Sep-30-05	530	0.176	0.061	0.38	12.5
				(0.001)	(0.000)
Jan-01-95:Jan-31-01	299	0.321	0.067	0.03	12.4
				(0.850)	(0.000)
Feb-01-01:Sep-30-05	231	-0.013	0.053	1.20	10.7
				(0.000)	(0.000)
Panel C: Monthly Returns					
			A-share Portfolio		
Jan-01-95:Sep-30-05	129	0.471	0.087	0.56	3.2
				(0.010)	(0.481)
Jan-01-95:Jan-31-01	73	1.921	0.093	0.44	3.0
				(0.105)	(0.677)
Feb-01-01:Sep-30-05	56	-1.420	0.075	0.51	2.9
				(0.100)	(0.847)
			B-share Portfolio		
Jan-01-95:Sep-30-05	129	0.584	0.126	2.04	12.2
				(0.000)	(0.000)
Jan-01-95:Jan-31-01	73	1.108	0.120	1.12	5.3
				(0.000)	(0.005)
Feb-01-01:Sep-30-05	56	-0.099	0.134	2.92	18.2
				(0.000)	(0.000)

Table 2. Autocorrelation of A-share and B-share Portfolio Returns

Autocorrelation for daily, weekly and monthly A-share and B-share portfolio return for the sample period from January 1, 1995 to September 30, 2005 and subperiods. $\hat{\rho}_j$ is the *j*-th order autocorrelation coefficient, and $\hat{Q}_k$ is the *k*-th order Box-Pierce *Q*-statistics for the portfolio return. The *p*-values are shown in the parentheses.

Sample Period	$\hat{\rho}_1$	$\hat{\rho}_2$	$\hat{Q}_5$	$\hat{Q}_{10}$
Panel A: Daily Returns				
		A-share Portfolio		
Jan-01-95:Sep-30-05	0.058	0.004	9.3	14.6
	(0.005)	(0.391)	(0.098)	(0.148)
Jan-01-95:Jan-31-01	0.040	0.006	3.3	11.3
	(0.122)	(0.388)	(0.66)	(0.336)
Feb-01-01:Sep-30-05	0.098	-0.0038	13.9	17.6
	(0.002)	(0.396)	(0.016)	(0.061)
		B-share Portfolio		
Jan-01-95:Sep-30-05	0.179	0.042	109.7	120.2
	(0.000)	(0.040)	(0.000)	(0.000)
Jan-01-95:Jan-31-01	0.208	0.043	74.7	77.0
	(0.000)	(0.102)	(0.233)	(0.000)
Feb-01-01:Sep-30-05	0.131	0.042	38.0	56.7
	(0.000)	(0.148)	(0.000)	(0.000)
Panel B: Weekly Returns				
		A-share Portfolio		
Jan-01-95:Sep-30-05	0.031	-0.067	9.1	16.9
	(0.309)	(0.121)	(0.107)	(0.076)
Jan-01-95:Jan-31-01	0.011	-0.127	13.9	21.3
	(0.392)	(0.036)	(0.012)	(0.019)
Feb-01-01:Sep-30-05	0.047	0.023	7.5	8.9
	(0.309)	(0.375)	(0.183)	(0.543)
		B-share Portfolio		
Jan-01-95:Sep-30-05	0.085	0.042	7.8	13.7
	(0.059)	(0.250)	(0.167)	(0.185)
Jan-01-95:Jan-31-01	0.015	-0.014	2.9	5.3
	(0.386)	(0.387)	(0.722)	(0.871)
Feb-01-01:Sep-30-05	0.227	0.151	18.0	24.2
	(0.001)	(0.029)	(0.003)	(0.007)
Panel C: Monthly Returns				
		A-share Portfolio		
Jan-01-95:Sep-30-05	-0.023	0.047	0.5	6.0
	(0.386)	(0.346)	(0.991)	(0.811)
Jan-01-95:Jan-31-01	-0.074	0.022	0.6	9.3
	(0.327)	(0.392)	(0.989)	(0.500)
Feb-01-01:Sep-30-05	-0.046	-0.023	4.8	8.2
	(0.376)	(0.393)	(0.436)	(0.611)
		B-share Portfolio		
Jan-01-95:Sep-30-05	0.155	0.076	5.1	9.9
	(0.084)	(0.275)	(0.409)	(0.447)
Jan-01-95:Jan-31-01	0.164	0.048	2.4	11.1
	(0.149)	(0.367)	(0.788)	(0.351)
Feb-01-01:Sep-30-05	0.142	0.109	6.3	7.7
	(0.227)	(0.286)	(0.276)	(0.662)

Table 3. General Lead-Lag Relation between Daily Returns of A-share and B-share Portfolios

$R_{A,t}$ ($R_{B,t}$) is the A-share (B-share) portfolio return at time *t*, α_A (α_B) is the regression coefficient of the A-share (B-share) portfolio return, β_{AB} (β_{BA}) is the sensitivity of A-share (B-share) portfolio return on one-day lagged return of B-share (A-share) portfolio return, and $\varepsilon_{A,t}$ ($\varepsilon_{B,t}$) is the error term. *N* is the number of observations of daily return. *t*-statistics are shown in the parentheses. * means different from zero at 5 percent level of significance. Panel B reports the results with series of first differences. Panel C is the test statistics on beta coefficients in Panel A.

Specification:

$$R_{A,t} = \alpha_A + \beta_{AB} R_{B,t-1} + \beta_{AA} R_{A,t-1} + \varepsilon_{A,t}$$

$$\varepsilon_{A,t} = \sigma_{A,t}\mu_{A,t}, \quad \sigma^2_{A,t} = \gamma_{A,0} + \gamma_{A,1}\varepsilon^2_{A,t-1} + \omega_{A,1}\sigma^2_{A,t-1} \qquad (1)$$

$$R_{B,t} = \alpha_B + \beta_{BA} R_{A,t-1} + \beta_{BB} R_{B,t-1} + \varepsilon_{B,t}$$

$$\varepsilon_{B,t} = \sigma_{B,t}\mu_{B,t}, \quad \sigma^2_{B,t} = \gamma_{B,0} + \gamma_{B,1}\varepsilon^2_{B,t-1} + \omega_{B,1}\sigma^2_{B,t-1} \qquad (2)$$

Panel A: Beta Coefficients

Sample period	N	α_A ×100	β_{AB}	β_{AA}	$\gamma_{A,0}$ ×100	$\gamma_{A,1}$	$\omega_{A,1}$	α_B ×100	β_{BA}	β_{BB}	$\gamma_{B,0}$ ×100	$\gamma_{B,1}$	$\omega_{B,1}$
PRE-FEB	1475	0.084 (1.87)	0.029 (1.40)	0.029 (0.94)	0.001* (6.14)	0.096* (11.12)	0.892* (139.20)	-0.029 (-0.74)	0.046* (2.60)	0.166* (4.92)	0.003* (11.49)	0.276* (11.91)	0.687* (34.96)
POST-FEB	1122	-0.039 (-0.91)	-0.064 (-1.88)	0.154* (3.46)	0.001* (4.23)	0.123* (6.61)	0.838* (36.07)	-0.045 (-0.88)	-0.057 (-1.16)	0.147* (3.06)	0.002* (5.95)	0.124* (7.62)	0.827* (41.18)

Panel B: Beta Coefficients with the Series of First Differences

Sample period	N	α_A ×100	β_{AB}	β_{AA}	$\gamma_{A,0}$ ×100	$\gamma_{A,1}$	$\omega_{A,1}$	α_B ×100	β_{BA}	β_{BB}	$\gamma_{B,0}$ ×100	$\gamma_{B,1}$	$\omega_{B,1}$
PRE-FEB	1474	-0.047 (-0.98)	0.018 (0.77)	-0.518* (-19.55)	0.009* (11.27)	0.374* (9.52)	0.557* (18.64)	0.027 (0.64)	0.030* (2.50)	-0.428* (-16.04)	0.004* (10.54)	0.388* (11.73)	0.613* (25.75)
POST-FEB	1121	0.012 (0.27)	-0.065* (-2.31)	-0.377* (-9.90)	0.002* (4.64)	0.177* (6.23)	0.775* (27.04)	0.001 (0.02)	0.036 (0.76)	-0.492* (-11.01)	0.002* (5.99)	0.164* (7.66)	0.803* (43.58)

Panel C: Test Statistics for Structural Change

$H1_0$: $\beta_{BA-PRE-FEB} = \beta_{BA-POST-FEB}$

$H1_a$: $\beta_{BA-PRE-FEB} \neq \beta_{BA-POST-FEB}$

t-statistic=1.98

p-value=0.048

Table 4. Decomposition of A-share and B-share Portfolio Returns

$\nabla R_{A,t}$ and $\nabla R_{M,t}$ are the excess return on A-share portfolio and the market portfolio at time t, respectively, r_t is the return on a risk-free asset, β_A is the sensitivity of excess A-share portfolio return on the market portfolio return, α is the regression coefficient, and $\varepsilon'_{A,t}$ is the error term. Datastream China country price index and China time deposit are used as the poroxies for market portfolio and the risk-free asset, respectively. N is the number of observations of daily return. *t*-statistics are shown in the parentheses. * means different from zero at 5 percent level of significance.

Specification:

$$\nabla R_{A,t} = \alpha + \beta_A \nabla R_{M,t} + \varepsilon'_{A,t}$$
$$\varepsilon'_{A,t} \sim N(0, \phi_A^2)$$

Sample Period	N	α ×100	β_A	R^2
PRE-FEB	1476	0.02	0.896* (76.86)	0.808
POST-FEB	1123	-0.02	1.001* (52.25)	0.709

Table 5. The Effects of Portfolio-Specific and Market-Wide Information on the Cross-Autocorrelation

$R_{B,t}$ is the B-share portfolio return at time t, $\varepsilon'_{A,t}$ is the one-day lagged A-share portfolio-specific return, $R^{M}_{A,t-1}$ is the one-day lagged systematic return of A-share portfolio, α_B is the regression coefficient of the B-share portfolio return, β^{P}_{BA} and β^{M}_{BA} are the sensitivity of B-share portfolio return to one-day lagged A-share portfolio-specific and systematic return, respectively, and $\varepsilon_{B,t}$ is the error term of the B-share portfolio return. *N* is the number of observations of daily return. *t*-statistics are shown in the parentheses. * means different from zero at 5 percent level of significance. The Panel B reports the test statistics on betas.

Specification:

$$R_{B,t} = \alpha_B + \beta^{P}_{BA}\varepsilon'_{A,t-1} + \beta^{M}_{BA}R^{M}_{A,t-1} + \beta_{BB}R_{B,t-1} + \varepsilon_{B,t}$$

$$\varepsilon_{B,t} = \sigma_{B,t}\mu_{B,t}\,, \quad \sigma^2_{B,t} = \gamma_{B,0} + \gamma_{B,1}\varepsilon^2_{B,t-1} + \omega_{B,1}\sigma^2_{B,t-1}$$

Panel A: Beta Coefficients

Sample Period	*N*	α_B ×100	β^{P}_{BA}	β^{M}_{BA}	β_{BB}	$\gamma_{B,0}$ ×100	$\gamma_{B,1}$	$\omega_{B,1}$
PRE-FEB	1475	-0.040 (-0.73)	0.040 (1.23)	0.047* (2.17)	0.166* (4.90)	0.003* (11.49)	0.276* (11.80)	0.687* (34.70)
POST-FEB	1122	-0.051 (-1.01)	0.019 (0.30)	-0.116* (-2.16)	0.165* (3.47)	0.002* (5.97)	0.126* (7.53)	0.826* (41.00)

Panel B: Test Statistics for Structural Change

H2$_0$: $\beta^{P}_{BA-PRE-FEB} = \beta^{P}_{BA-POST-FEB}$
H2$_a$: $\beta^{P}_{BA-PRE-FEB} \neq \beta^{P}_{BA-POST-FEB}$
t-statistic =0.29
p-value=0.772

H3$_0$: $\beta^{M}_{BA-PRE-FEB} = \beta^{M}_{BA-POST-FEB}$
H3$_a$: $\beta^{M}_{BA-PRE-FEB} \neq \beta^{M}_{BA-POST-FEB}$
t-statistic =2.81
p-value=0.005

Table 6. Directional Asymmetric Cross-Autocorrelation Pattern

$R_{B,t}$ is the B-share portfolio return at time t, $R_{A,t-1}^{M,u}$ ($R_{A,t-1}^{M,d}$) is the one-day lagged upward (downward) returns of A-share portfolio, α_B is the regression coefficient of the B-share portfolio return, β_{BA}^{u} (β_{BA}^{d}) is the sensitivity of B-share portfolio return to one-day lagged upward (downward) returns of A-share portfolio, and $\varepsilon_{B,t}$ is the error term. *N* is the number of observations of daily return. *t*-statistics are shown in the parentheses. * means different from zero at 5 percent level of significance. The Panel B reports the test statistics on betas.

Specification:

$$R_{B,t} = \alpha_B + \beta_{BA}^{P}\varepsilon'_{A,t-1} + \beta_{BA}^{u}R_{A,t-1}^{M,u} + \beta_{BA}^{d}R_{A,t-1}^{M,d} + \beta_{BB}R_{B,t-1} + \varepsilon_{B,t}$$

$$\varepsilon_{B,t} = \sigma_{B,t}\mu_{B,t}\,, \quad \sigma_{B,t}^{2} = \gamma_{B,0} + \gamma_{B,1}\varepsilon_{B,t-1}^{2} + \omega_{B,1}\sigma_{B,t-1}^{2}$$

Panel A: Beta Coefficients

Sample Period	*N*	α_B ×100	β_{BA}^{P}	β_{BA}^{u}	β_{BA}^{d}	β_{BB}	$\gamma_{B,0}$ ×100	$\gamma_{B,1}$	$\omega_{B,1}$
PRE-FEB	1475	-0.022 (-0.53)	0.040 (1.20)	0.041 (1.41)	0.055 (1.66)	0.166* (4.87)	0.003* (11.40)	0.277* (11.69)	0.686* (34.40)
POST-FEB	1122	-0.104 (-1.82)	0.027 (0.41)	-0.041 (-0.55)	-0.207* (-2.87)	0.164* (3.42)	0.002* (5.96)	0.129* (7.36)	0.821* (38.90)

Panel B: Test Statistics for Structural Change

$H4_0$: $\beta_{BA-PRE-FEB}^{u} = \beta_{BA-POST-FEB}^{u}$	$H5_0$: $\beta_{BA-PRE-FEB}^{d} = \beta_{BA-POST-FEB}^{d}$
$H4_a$: $\beta_{BA-PRE-FEB}^{u} > \beta_{BA-POST-FEB}^{u}$	$H5_a$: $\beta_{BA-PRE-FEB}^{d} > \beta_{BA-POST-FEB}^{d}$
t-statistic=1.03	t-statistic=3.30
p-value=0.302	p-value=0.001