Linkage between American, Chinese, and Indian Stock Markets

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Qikun Wu, Dejun Xie*
South University of Science and Technology of China
wuqk@mail.sustc.edu.cn, xie.dj@sustc.edu.cn

Bianxia Sun
South University of Science and Technology of China
sun.bx@sustc.edu.cn

ABSTRACT

This paper presents a structural VAR model to examine the contemporaneous interaction between US, China, and India Stock Markets. By analyzing the market data from January 2004 to December 2013 we find an increasing trend of interaction between these markets. Before the financial crisis, China market's effect on US market is modest; whereas after financial crisis, the effect is significant. The US market is also more substantially affected by the performance of Indian market. Increasing integrations across these major markets are established by this study.

Keywords: SVAR model, contemporaneous interaction, stock market, linkage across markets

INTRODUCTION

The financial linkage between China and the rest of the world is becoming more and more stronger. But previous works on market interactions did not pay enough attention to this since most of these studies have focused on the comovement between US, UK and Japan. The study from Campbell and Hamao (1992) suggests the integration across US and Japan by the evidence of common movement in expected excess returns. Bae and Andrew Karolyi (1994) demonstrated the magnitude and persistence of shock transmission between Nikkei Average and the Standard and Poor's 500 stock Index. Engsted and Tanggaard (2004) found news component is important in explaining the comovement of US and UK stock market. The interrelation among Asian countries also has long been a topic of discussion. Mukherjee and Mishra (2007) found a significant contemporaneous flow of information among India and 20 other foreign countries, with higher integration in the same region than in the different regions. Ng (2000) found significant spillovers from the region to many of the Pacific-Basin countries. Ranpura et al. (2011) find high correlation between India and other Asian stock market. Chow et al. (2013) have

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traced the increased integration from 1980 to 2011 among the NIEs of Korea, Hong Kong, Taiwan and Singapore.

The purpose of this paper is to focus on the relationship of Chinese, Indian and American stock markets. India, as the country with second highest population, is in some ways similar to China: they both have long history, and both are emerging countries in BRICS. Chiang et al. (2013) found geographic proximity an important role in explaining the correlation in markets performance among China and other regions. Lucey and Zhang (2010) found higher financial linkage usually exists between country-pairs if they have smaller cultural distance. This paper will inspect on the market performance of the China, US and India markets with the contemporaneous effect being focused. Second, this paper provides a comparison of their interaction before and after financial crisis, which may help investors diversify their investment risk. Third, such comparison and study will help policy makers to better understand the pattern of market development.

This paper is organized as follows. Data description and preliminary analysis is presented in Section 2. The methodology and model of SVAR is explained in Section 3 and the empirical results are in Section 4. Section 5 gives a conclusion.

DATA

Our sample includes daily closing price indices from three stocks from China, US and India: *SSE 50* (China), Dow Jones Industrial Average (*DJI*,US) and S&P *CNX nifty* (India). The range of the data is from January 2004 to December 2013, in total 2249 samples after deleting the samples in which some indices are not open (the reason to choose January 2004 is that it is when SSE 50 appears in the market). The daily returns are calculated by $r_{t,i} = \Delta \ln p_{it}$ (in the table shown below, $r_{t,i}$ will also be expressed as index_R, where, index is the name of the stock market, for instance SSE50_R) , where Δ is the first difference operator and p_{it} the closing index of i th index at time t.

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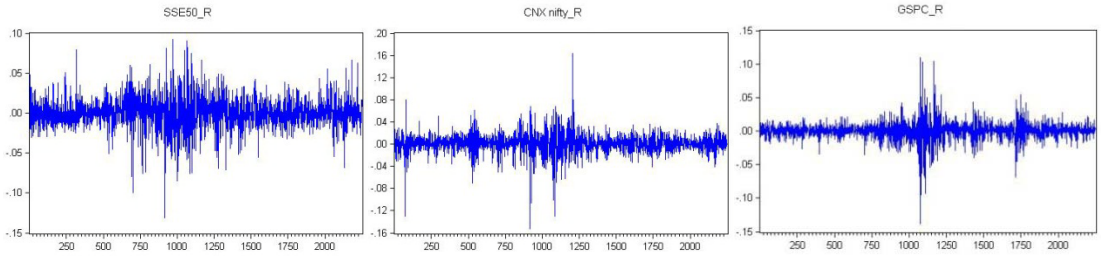
FIGURE 2_1: Plot of daily revenue



To further investigate the data, we split the period into two periods, where the break point is the bankruptcy of Lehman Brothers:

- period 1(P1): January 5, 2004-September 15, 2008
- period 2(P2): September 16, 2008-December 31, 2013

TABLE 2_1: Descriptive Statistics of Period 1

	Mean(%)	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Prob.
period 1									
DJI_R	-0.0578	0.0003	0.0314	-0.0335	0.009	-0.4771	4.6004	153.8	0
SSE50_R	-0.0052	-0.0002	0.0812	-0.1315	0.0198	-0.5722	7.6214	1003.9	0
CNX_NIFTY_R	0.1036	0.0023	0.0797	-0.1523	0.0184	-1.2154	12.3528	4136.1	0
period 2									
DJI_R	0.0689	0.0008	0.1033	-0.0912	0.0132	0.165	14.9181	7024.6	0
SSE50_R	0.0311	0.0001	0.0923	-0.0853	0.0189	0.1436	6.1572	496.7	0
CNX_NIFTY_R	0.0294	0.0009	0.1633	-0.1305	0.0198	-1.0043	16.0105	8564.2	0

METHODOLOGY

We will specify a Structural Vector Autoregressive (SVAR) model to test the co-movement among two emerging countries and US. Gianni and Giannini (1997) mentioned three kinds of SVAR model under the short run relationship: AB-model, C-model and K-model. In the following, we will use short run relationship since we focus on the comovement on several consecutive days instead of months. Also,

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compare to C and K model, AB-model can fully reflects the information of SVAR. The AB-model is presented as:

$$\mathbf{AA}(L)X_t = \mathbf{A}\varepsilon_t$$
$$\mathbf{A}\varepsilon_t = \mathbf{B}e_t$$
$$E(e_t) = 0$$
$$E(e_t e_t') = I_n$$

Where $\varepsilon_t \sim VGW(0,\Omega)$ (vector Gaussian white noise), $E(\varepsilon_t \varepsilon_t') = \Omega$, L is the lag operator $\mathbf{A}(L) = I_n - \mathbf{A}_1 L - \mathbf{A}_2 L^2 - \cdots - \mathbf{A}_p L^p$. The matrix $\mathbf{A}$ and $\mathbf{B}$ is called orthogonal factorization matrices. Note that the C-model is the case where $\mathbf{A} = I_n$ (exclude the contemporaneous correlation) and the K-model is the case where $\mathbf{B} = I_n$.

According to Watson (1994), the relationship between the coefficient in the AB-model should be identified by the corresponding internal relation of X_t and there will be no use discussing a model whose relationship of the coefficient is unjustified. We know that in the reduced VAR(p) model, there are in total pn^2 elements in the coefficient matrices $\mathbf{A}_i, i = 1 \ldots p$ and $\frac{n(n+1)}{2}$ elements in the variance-covariance matrix of ε_t. However, the number of coefficients in the corresponding SVAR(p) (AB-model) is different. In the coefficient matrices $AA_i, i = 0 \ldots p, A_0 = I_n, B$, there are in total $(p+2)n^2$ elements, while there are also $\frac{n(n+1)}{2}$ elements in the variance-covariance matrix of ε_t. Thus we know that there are extra $2n^2$ coefficients that needs to be determined in the SVAR(p) (AB-model) comparing to the reduced VAR(p) model.

From the model specification $\mathbf{A}\varepsilon_t = \mathbf{B}e_t$ and $E(e_t e_t') = I_n$ we have

$$(\mathbf{A}\varepsilon_t)(\mathbf{A}\varepsilon_t)' = \mathbf{BB}'$$

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And this relation will add $\frac{n(n+1)}{2}$ nonlinear constrain. Thus we now need $2n^2 - \frac{n(n+1)}{2}$ additional constrain. We now find this additional constrains by looking at the open and close prices of the stock markets

By inspection, we can give the corresponding hypothesis of X_t as:

H_{01} : $r_{t,SSE50}$ and $r_{t,CNX\ nifty}$ may affect $r_{t,DJI}$;

H_{02} : $r_{t,DJI}$ may affect $r_{t,SSE50}$ and $r_{t,CNX\ nifty}$;

H_{03} :there may be interaction between $r_{t,SSE50}$ and $r_{t,CNX\ nifty}$.

Also, here we will arrange the position in the SVAR(p) model as:

$$X_t = \begin{pmatrix} r_{t,DJI} \\ r_{t,SSE50} \\ r_{t,CNX\ nifty} \end{pmatrix} \text{ (first group)}$$

$$X_t = \begin{pmatrix} r_{t,GSPC} \\ r_{t,SHCOMP} \\ r_{t,CNX\ 500} \end{pmatrix} \text{(second group) (}\textit{will be used to test robustness}\text{)}$$

Correspond to the order of our group and assumption, here we will use the AB-model and the expression of matrices $\mathbf{A}$ and $\mathbf{B}$ is given as:

$$\mathbf{A} = \begin{pmatrix} 1 & C_{C\to U} & C_{I\to U} \\ 0 & 1 & 0 \\ 0 & C_{C\to I} & 1 \end{pmatrix}, \mathbf{B} = \begin{pmatrix} C_U & 0 & 0 \\ 0 & C_C & 0 \\ 0 & 0 & C_I \end{pmatrix}$$

Where $C_{C\to U}$ represents the influence from Chines to American stock markets, $C_{C\to I}$ represents the influence from Chinese to Indian stock markets and $C_{I\to U}$ represents the influence from Indian to American stock markets. C_U , C_C and C_I represents the variance of the contemporaneous shocks of American, Chinese and Indian stock market. Correspondingly, if a SVAR(p) model only includes two indices, we can

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construct the AB-model using the same assumption. For instance:

$$X_t = \begin{pmatrix} r_{t,DJI} \\ r_{t,CNX\ nifty} \end{pmatrix}, \mathbf{A} = \begin{pmatrix} 1 & C_{I\to U} \\ 0 & 1 \end{pmatrix}, \mathbf{B} = \begin{pmatrix} C_U & 0 \\ 0 & C_I \end{pmatrix}$$

Where $C_{I\to U}$ represents the influence from Indian to American stock markets, C_U and C_I represents the relative size of the shock of American and Indian stock market.

EMPIRIAL RESULT

4.1 Unit Root test

To confirm the stationarity of all series, ADF test (Dickey and Fuller (1979)) and PP test (Phillips and Perron (1988)) are used. All these tests, in Table 4_1 , reject the null hypothesis of the existence of a unit root, implying the stationarity of the series.

TABLE4_1: Test of Stationarity

	ADF	PP
CNX_NIFTY_R	-45.86**	-45.84**
DJI_R	-53.30**	-53.74**
SSE50_R	-48.61**	-48.59**

Note:
ADF test with lag selected by SIC
PP test with Bandwidth selected by Newey-West
** Statistically significant at 1% level

4.2 Results in SVAR model

Period P1 (January 5, 2004-September 15, 2008)

We first focus on the period 1 (P1), which is the period before the financial crisis. Some characteristic of the stock markets can be observed. First, American market has effect on both Chinese and Indian stock market, while Chinese and Indian market virtually have no effect on American market. Second, the effect mentioned above is more significant in the Indian market than that in Chinese.

We also construct a SVAR model on these markets (whose corresponding VAR model is with lag four), the X_t is specified in each model. The result is shown as follows:

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TABLE 4_2: SVAR coefficient estimation in period1 (1)

$$X_t = \begin{pmatrix} r_{t,DJI} \\ r_{t,SSE50} \\ r_{t,CNX\ nifty} \end{pmatrix}, \mathbf{A} = \begin{pmatrix} 1 & C_{C\to U} & C_{I\to U} \\ 0 & 1 & 0 \\ 0 & C_{C\to I} & 1 \end{pmatrix}, \mathbf{B} = \begin{pmatrix} C_U & 0 & 0 \\ 0 & C_C & 0 \\ 0 & 0 & C_I \end{pmatrix}$$

	Coefficient	Std. Error	z-Statistic	Prob.
$C_{C\to U}$	0.0011	0.0139	0.08	0.94
$C_{C\to I}$	-0.1596	0.0262	-6.08	0.00
$C_{I\to U}$	-0.0876	0.0161	-5.46	0.00
C_U	0.0088	0.0002	46.02	0.00
C_C	0.0197	0.0004	46.02	0.00
C_I	0.0168	0.0004	46.02	0.00

TABLE 4_3: SVAR coefficient estimation in period1 (2)

$$X_t = \begin{pmatrix} r_{t,DJI} \\ r_{t,CNX\ nifty} \end{pmatrix}, \mathbf{A} = \begin{pmatrix} 1 & C_{I\to U} \\ 0 & 1 \end{pmatrix}, \mathbf{B} = \begin{pmatrix} C_U & 0 \\ 0 & C_I \end{pmatrix}$$

	Coefficient	Std. Error	z-Statistic	Prob.
$C_{I\to U}$	-0.0872	0.0158	-5.50	0.000
C_U	0.0088	0.0002	46.02	0.000
C_I	0.0171	0.0004	46.02	0.000

TABLE 4_4: SVAR coefficient estimation in period1 (3)

$$X_t = \begin{pmatrix} r_{t,DJI} \\ r_{t,SSE50} \end{pmatrix}, \mathbf{A} = \begin{pmatrix} 1 & C_{C\to U} \\ 0 & 1 \end{pmatrix}, \mathbf{B} = \begin{pmatrix} C_U & 0 \\ 0 & C_C \end{pmatrix}$$

	Coefficient	Std. Error	z-Statistic	Prob.

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$C_{C\to U}$	-0.0125	0.0139	-0.90	0.368
C_U	0.0089	0.0002	46.02	0.000
C_C	0.0197	0.0004	46.02	0.000

TABLE 4_5: SVAR coefficient estimation in period1 (3)

$$X_t = \begin{pmatrix} r_{t,SSE50} \\ r_{t,CNX\ nifty} \end{pmatrix}, \mathbf{A} = \begin{pmatrix} 1 & 0 \\ C_{C\to I} & 1 \end{pmatrix}, \mathbf{B} = \begin{pmatrix} C_C & 0 \\ 0 & C_I \end{pmatrix}$$

	Coefficient	Std. Error	z-Statistic	Prob.
$C_{C\to I}$	-0.2048	0.0270	-7.57	0.000
C_C	0.0200	0.0004	46.10	0.000
C_I	0.0177	0.0004	46.10	0.000

Note: the lag of corresponding reduced VAR model is 0 as suggested by AIC, which means we construct this SVAR model just to examine the contemporaneous relationship.

In table 4_2, $C_{C\to U}$ represents the contemporaneous effect of SSE 50 to DJI, $C_{C\to U}$ the contemporaneous effect of CNX nifty to DJI and $C_{C\to I}$ the contemporaneous effect of SSE 50 to CNX nifty. Note that $C_{C\to U}$ is relatively small comparing to $C_{I\to U}$ and $C_{C\to I}$. Also, by comparing the coefficient of $C_{I\to U}$ (representing the effect of Indian to US stock market) in TABLE 4_3 and $C_{C\to U}$ (representing the effect of Chinese to US stock market) in TABLE 4_4, we can find that India had a larger contemporaneous effect on American stock market than China before financial crisis.

We now focus on $C_{C\to I}$ in table 4_2, which represents the contemporaneous effect of

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SSE 50 to CNX nifty. Note that the magnitude of $C_{C\to I}$ (-0.1596) is bigger than $C_{C\to U}$ (0.0011) and $C_{I\to U}$ (-0.0876). This suggests the influence of Chinese stock market may be regional and the effect from Chinese to US stock market is minor comparing to that from Indian market to American market. Also, in TABLE 4_5, we use a pairwise SVAR model in which the lag of reduced VAR model is 0 (this suggest that there may be no lag relationship between Indian and Chinese stock market). The coefficient which reflects the contemporaneous effect, $C_{C\to I}$ (-0.2048) is bigger than that in the full SVAR model with three countries (-0.1596).

Also, the $C_{I\to U}$ in TABLE 4_2(-0.0876) and TABLE 4_3(-0.0872) is virtually the same. Note that while the former coefficient is put into a SVAR model with three stock markets, the latter is in the SVAR model only contains Indian and American stock market. This result suggests that the Chinese stock market, before the financial crisis, have minor effect on the relationship between the Indian and American stock market, which in other words the Chinese market is 'isolated' outside the system of Indian and American market.

By combining the two points above, we know that the effect from Chinese stock market to American stock market is minor since the effect of Chinese stock market is regional rather than global.

Period P2 (September 16, 2008-December 31, 2013)

Similar as in P1, we first construct the corresponding VAR(p) (p is determined by AIC), and construct the SVAR model.

TABLE 4_6: SVAR coefficient estimation in period2 (1)

$$X_t = \begin{pmatrix} r_{t,DJI} \\ r_{t,SSE50} \\ r_{t,CNX\ nifty} \end{pmatrix}, \mathbf{A} = \begin{pmatrix} 1 & C_{C\to U} & C_{I\to U} \\ 0 & 1 & 0 \\ 0 & C_{C\to I} & 1 \end{pmatrix}, \mathbf{B} = \begin{pmatrix} C_U & 0 & 0 \\ 0 & C_C & 0 \\ 0 & 0 & C_I \end{pmatrix}$$

	Coefficient	Std. Error	z-Statistic	Prob.
$C_{C\to U}$	-0.0691	0.0227	-3.05	0.002
$C_{C\to I}$	-0.2783	0.0254	-10.97	0.000

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$C_{I\to U}$	-0.3833	0.0247	-15.50	0.000
C_U	0.0132	0.0003	48.70	0.000
C_C	0.0177	0.0004	48.70	0.000
C_I	0.0155	0.0003	48.70	0.000

TABLE 4_7: SVAR coefficient estimation in period2 (2)

$$X_t = \begin{pmatrix} r_{t,DJI} \\ r_{t,CNX\ nifty} \end{pmatrix}, \mathbf{A} = \begin{pmatrix} 1 & C_{I\to U} \\ 0 & 1 \end{pmatrix}, \mathbf{B} = \begin{pmatrix} C_U & 0 \\ 0 & C_I \end{pmatrix}$$

	Coefficient	Std. Error	z-Statistic	Prob.
$C_{I\to U}$	-0.4043	0.0236	-17.11	0.000
C_U	0.0133	0.0003	48.70	0.000
C_I	0.0163	0.0003	48.70	0.000

TABLE 4_8: SVAR coefficient estimation in period2 (2)

$$X_t = \begin{pmatrix} r_{t,DJI} \\ r_{t,SSE50} \end{pmatrix}, \mathbf{AB} = \begin{pmatrix} 1 & C_{C\to U} \\ 0 & 1 \end{pmatrix}, \quad = \begin{pmatrix} C_U & 0 \\ 0 & C_C \end{pmatrix}$$

	Coefficient	Std. Error	z-Statistic	Prob.
$C_{C\to U}$	-0.1685	0.0236	-7.13	0.000
C_U	0.0145	0.0003	48.70	0.000
C_C	0.0179	0.0004	48.70	0.000

TABLE 4_9: SVAR coefficient estimation in period2 (2)

$$X_t = \begin{pmatrix} r_{t,SSE50} \\ r_{t,CNX\ nifty} \end{pmatrix}, \mathbf{A} = \begin{pmatrix} 1 & C_{I\to U} \\ 0 & 1 \end{pmatrix}, \mathbf{B} = \begin{pmatrix} C_U & 0 \\ 0 & C_I \end{pmatrix}$$

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	Coefficient	Std. Error	z-Statistic	Prob.
$C_{C\to I}$	-0.3032	0.0256	-11.84	0.000
C_U	0.0180	0.0004	48.70	0.000
C_C	0.0159	0.0003	48.70	0.000

TABLE 4_6 to TABLE 4_9 shows the estimated results for SVAR model for all three markets and SVAR model with all pairs. For the period P2, there are also a few observations.

First, in the SVAR model for three market (TABLE 4_6), we can see the magnitude of $C_{C\to U}$, $C_{C\to I}$ and $C_{I\to U}$ is both bigger than that before financial crisis (TABLE 4_2), which shows stronger connection between these three markets. Also, the magnitude of the coefficients in the pairwise SVAR model is bigger than that in the full SVAR model with three countries, which suggests the interaction of these markets. From $C_{I\to U}$ (TABLE 4_2 and TABLE 4_3) in period one, we know that the interaction between Indian and American market is of little relationship with Chinese market since $C_{I\to U}$ virtually does not change. But in period two, $C_{I\to U}$ change by 5% when Chinese market is taken into consideration.

Second, $C_{C\to U}$ is much bigger and more significant than that before financial crisis (TABLE 4_2), which shows that the influence of Chinese stock market to American stock market is higher than before.

Third, $C_{C\to I}$ in TABLE 4_9 shows stronger evidence in the influence of Chinese stock market to Indian. Before the financial crisis (P1), the lag of corresponding VAR(p) model for Chinese and Indian stock market is 0, which means the lagged variable of these two markets before the financial crisis is not so significant, and this indirectly substantiate the relatively small influence of Chinese stock market to Indian stock market. However, after financial crisis, the corresponding VAR(p) model can be constructed with lag one suggested by AIC show that the lagged variable did play a role in the VAR model.

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CONCLUSION AND DISCUSSION

In this paper we study the contemporaneous linkage between American, Chinese and Indian stock markets. A pairwise SVAR model helps us to investigate their relation in a more specific way and conclusions are be deducted by fitting the SVAR models with the three stocks. Before the financial crisis, Chinese stock market did not affect American stock market. Instead, Indian stock market had much closer link with American stock market. After the financial crisis, the effect from Chinese to American stock market emerged and the interrelationship of these three stock markets increased.

The reason of increasing interrelation between three markets can be explained in some way. First the financial crisis in US and the following Eurozone crisis made hot money (which also includes the surplus capital produced by Quantitative Easing) seek for safer and more profitable investment. The emerging markets, as well as a place for portfolio diversification, become the destination of such hot money. Since the flow of hot money is extremely fast, the markets around the world thus become more connected by the flow of capital.

Further research of the topic can include other Asian countries, Europe countries or emerging markets. Also, data from import and export can be introduced and treated as exogenous variables. These exogenous variables can be used to indicate the influence of fundamental factors to the performance of the stock market.

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