Co-movements of Shanghai and New York Stock prices by time-varying regressions

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Abstract

We estimate a time-varying regression model to study the relationship between returns in the Shanghai and New York stock markets, with possible inclusion of lagged returns. The parameters of the regressions reveal that the effect of the current stock return for New York on that for Shanghai steadily increases after the 1997 Asian financial crisis and turns significantly and persistently positive after 2002, when China entered WTO. The effect of the current return for Shanghai on New York also becomes significantly positive and increasing after 2002. The upward trend has been interrupted during the recent global financial crisis, but reaches the level of about 0.4 to 0.5 in 2010 for both markets. Our results show that China's stock market has become more and more integrated into the world market in the past twenty years, with interruptions occurring during the recent global economic downturn.

Jel classification: C29; C58; G14; P43

Keywords: China; Globalization; Rate of Return; Stock Markets; Time-varying parameter regression.

1. Introduction

The purpose of this paper is to study the co-movement of price indices for stocks traded in the Shanghai and New York stock exchanges using time-varying regressions. The parameters of the regressions will show the extent to which these two markets are becoming integrated in the course of time. The estimates of the parameters are also measures of China's economic globalization, i.e., the extent to which China's financial markets are affected by the US markets and US markets by the Chinese markets.

Globalization consists of flows among nations of goods, capital, people, and the accompanying information and technology. Since China opened up to the outside world in 1978, its economy has been gradually integrating into the rest of the world via international trade and foreign direct investment. This process has accelerated since China joined the WTO at the end of 2001. The flow of financial capital is an important component of globalization. China’s capital market has experienced twenty years of rapid development since the Shanghai Stock Exchange was established in December 1990 and the Shenzhen Stock Exchange was founded one year later. As of the end of 2009, China's A-share market has become the world's second-largest after the United States, with a market value of 24.27 trillion RMB yuan ($3.57 trillion). However, the extent to which China’s financial market is integrated into the world markets remains an open question that has not been adequately measured. For China, the flows of both physical capital, in the form of direct foreign investment, and financial capital are regulated by the government. There was a distinction between stocks traded in China: only Chinese citizens can purchase A shares whereas B shares are reserved for foreigners.

Various papers have investigated the linkages among stock markets in and around China, such as Zhu et al. (2004), Groenewold et al. (2004) and Zhang et al.(2009), or the relationship between Chinese and other stock markets, such as Ghosh et al. (1999), Chow and Lawler (2003), Cheng and Glascock (2005) and Li (2007). Among the first group, Zhu et al. (2004) reject a causal relationship and cointegration between market returns in Shanghai, Shenzhen and Hong Kong; Groenewold et al. (2004) support cointegration between Shanghai and Shenzhen, but reject it between mainland markets and Hong Kong and Taiwan. Zhang et al. (2009) find weak return linkage and no volatility spillover between Shanghai and Hong Kong, but volatility linkage in both tails. Among the second group of papers, in which international linkages are studied, Chow and Lawler (2003) find no correlation between Shanghai and New York stock returns and negative correlation between their volatilities, using weekly data from 1992 to 2002. They characterize the negative correlation in volatility as spurious and driven by macroeconomic fundamentals in the United States and China, as indicated by negative correlation between the rates of change in their GDPs while their capital markets were not integrated. Li (2007) finds evidence of spillover between Hong Kong and China's stock market, employing multivariate GARCH and daily data from January 2000 to August 2005, but no spillover between China and US markets; other papers generally also reject cointegration and spillover between China and the US market. The studies of spillover effects in volatility among different foreign exchange rates by Engle, Ito and Lin (1990) and Ito, Engle and Lin (1992) also employ vector autoregression as in Chow and Lawler (2003).

In this paper we use time-varying regression to model the relationship between returns in the Shanghai and New York stock markets, with the possible inclusion of lagged returns. The parameters of the regressions reveal the extent to which these two markets are integrated over time. Our econometric model implies a nonstationary relationship between the variables for China and for the outside world. Under such circumstances, a cointegration test assuming long run equilibrium is inappropriate for finding the trend of integration. Likewise, by assuming the existence of an unconditional covariance matrix of returns, multivariate GARCH models and stochastic volatility models assume stationarity and tend to emphasize high frequency changes in volatility and covolatility but ignore the underlying smooth structural change modeled in this paper. In spite of the institutional restrictions in China's financial market, we find robust evidence of a steady increase of integration between the Shanghai and New York stock markets, with the integration strengthening after China joined the WTO. The process was disturbed during the recent financial crisis, but the trend was restored in 2010.

The rest of this paper is organized as follows. We first present in section 2 a comparison of regressions of the rate of return and of volatility of stocks traded in the Shanghai Stock Exchange on the corresponding variables for the New York Stock exchange in the two periods 1992-2002 and 2002-2010. In section 3 we present three specifications of models of regression with time-varying parameters to study the co-movement between the rates of return for stocks traded in the Shanghai and New York stock markets. The results from estimating these models, presented in section 4, show that regression with time-varying parameters nicely depicts the co-movement of stock prices in the two markets. These results agree with the history of China's globalization and the recent world economic downturn during the period studied. Section 5 concludes.

2. Co-movement of prices of stocks traded in the Shanghai and New York stock exchanges in two sample periods

Stocks were first traded on the Shanghai stock market in December 1990, before the Chinese economy was integrated with the world economy. Chow and Lawler (2003) studied the co-movements of prices of stocks traded on the Shanghai Stock Market and the New York Stock Market, using weekly data from the start of 1992 to February 2002. Daily movements were not used because of the time difference between Shanghai and New York, with trading in Shanghai preceding that in New York. Monthly intervals are too long and miss the co-variation in the prices of stocks traded in the two markets. Chow and Lawler (2003) used two variables to measure the weekly movement of prices of stocks in the two markets. The first is the rate of return, r_t, which is the rate of change in weekly prices, calculated as the log difference in price: $\ln(P_t) - \ln(P_t)$. The second is volatility, measured by the absolute value of the rate of return $|r_t|$. The study showed no co-movement in the prices in these two markets and predicted that the co-movement would increase in the course of time following integration of the Chinese economy into the world economy.

In this section we examine weekly returns on Shanghai and New York stocks for two subsamples. The first is from 1992-01-27 to 2002-02-25, as in Chow and Lawler (2003), and the second is from 2002-03-04 to 2010-12-27, with 511 and 455 observations respectively, after excluding holidays at either market as well as missing data. For the entire sample the start of 2002 is a reasonable break point. The two stock price indices used in Chow and Lawler (2003) and in this paper are the Shanghai Composite Index and the NYSE Composite Index, as reported in Datastream International. The two subsamples divide the sample roughly into halves. At the end of 2001 China joined WTO, which promotes the economic and financial integration of China's financial market into the world financial market.

For the whole sample and each subsample, Table 1 presents summary statistics of returns and volatilities (measured by absolute return) in Table 1. Table 2 compares correlations of the two measures between the two markets.

Table 1. Rate of Return and Volatility in Full Sample and Two Sub-samples

	Shanghai Rate of Return			New York Rate of Return		
	Full Sample	Before Feb.2002	After Feb. 2002	Full Sample	Before Feb.2002	After Feb. 2002
Mean	0.002308	0.003095	0.001405	0.001245	0.001846	0.000554
Variance	0.0037	0.075292	0.038073	0.000630	0.019708	0.030129
	Shanghai Volatility			New York Volatility		
	Full Sample	Before Feb.2002	After Feb. 2002	Full Sample	Before Feb.2002	After Feb. 2002
Mean	0.035455	0.041297	0.028748	0.016823	0.014644	0.019326
Variance	0.002449	0.063005	0.024964	0.000348	0.013303	0.023103

Table 2. Correlation of Rate of Return and Volatility

Rate of Return

	Full sample	Before Feb. 2002	After Feb. 2002
Correlation	0.041632	-0.022727	0.151953

Volatility

	Full sample	Before Feb. 2002	After Feb. 2002

Correlation	0.000598	-0.120583	0.257922

From the above two tables, three observations are in order.

1. Overall, the mean and variance of the Shanghai Stock return are higher.
2. In the first subsample, up before Feb. 2002, the Shanghai stock return experienced a highly volatile period due to its early developmental stage and the 1997 Asian crisis. During the recent financial crisis in 2007-2008, the New York stock return experienced a surge in volatility; the Shanghai stock volatility was affected to some extent, but the change in volatility is not as drastic as for the New York counterpart.
3. The correlation of returns between the two markets turns from negative before 2002 to positive after. This happens both in terms of return and its absolute value, a proxy for volatility. The negative correlation before 2002 was explained in Chow and Lawler (2003) as driven by macro fundamentals, which were different in the two countries. The positive correlation after 2002 reflects economic and financial integration through time.

In what follows, we regress rate of return in one market on its own lag term and on the current and lagged returns of the other market. For Shanghai the lag terms are selected first by AIC for the first subsample in order to be comparable to the Chow and Lawler (2003) subsample. Then we run the same regression for the full sample and the other subsample in order to see the difference between different periods. In Table 3, the first column displays variable names, where “S” stands for Shanghai and “N” for New York, and the numbers 0 and 1 denote lag orders.
For each coefficient, we report the associated t-statistics.

Table 3. Regressions of Rate of Return for Shanghai and New York Stock Indices

	Shanghai			New York		
	All Data (obs. 955)	Before 02.2002 (obs. 510)	After 02.2002 (obs. 444)	All Data (obs. 955)	Before 02.2002 (obs. 510)	After 02.2002 (obs. 444)
Lag	Coef. (t-stats.)	Coef. (t-stats.)	Coef. (t-stats.)	Coef. (t-stats.)	Coef. (t-stats.)	Coef. (t-stats.)
S0				.0225 (1.68)	-.0057 (-0.49)	.1368 (3.63*)
S1	.1090 (3.38*)	.1235 (2.80*)	.0337 (0.72)	-.0260 (-1.94)	-.0036 (-0.31)	-.1172 (-3.16*)
N0	.1318 (1.68)	-.0828 (-0.49)	.2131 (3.63*)			
N1	.1675 (2.14*)	-.0259 (-0.15)	.2614 (4.46*)	-.0880 (-2.73*)	-.1240 (-2.80*)	-.0845 (-1.77)
Cons.	.0017 (0.85)	.0029 (0.86)	.0009 (0.52)	.0014 (1.70)	.0021 (2.43*)	.0006 (0.40)
R^2	.0189	.0158	.0684	.0138	.0159	.0546
RMSE	.0604	.0750	.0367	.0250	.0196	.0294

From the multivariate regressions in Table 3 for returns, it is evident that after 2002, the interaction between markets is stronger. A star indicates that the return on the foreign market has a significant effect. It can be seen that not only do the lagged and current values of returns from the New York market affect the corresponding variables in Shanghai, but the effects also run from Shanghai to New York.

3. Specification of time-varying coefficient regressions for co-movement between stock returns in Shanghai and New York

As revealed by the statistics and linear regressions presented in the last section, there have been significant structural changes in the co-movement of returns on the Shanghai and New York stock markets. In this section we specify three time-varying coefficient regressions of the rate of return for one market on the return for the other market. In a bivariate distribution there are two regressions. Movements in the New York Stock Exchange represent a larger part of the global financial activities than movements in the Shanghai Stock Exchange. To reflect possible asymmetric effects between these two markets, we run the regressions in both directions. In each specification, the time-varying coefficient of the current foreign market return is modeled as a random walk process. The random walk model is appropriate because an autoregression coefficient of less than unity would imply a stationary process with the parameter converging to a constant.

For robustness, we consider three specifications of the regressions for co-movement between the Shanghai and New York stock returns. The first specification is the simplest one where return on domestic market is regressed only on the foreign return, with a constant intercept and time-varying coefficient.

Model I:

$$r_t = \alpha + \beta_t r_t^* + e_t, \qquad e_t \sim N(0, \sigma_e^2),$$

$$\beta_t = \beta_{t-1} + u_t, \qquad u_t \sim N(0, \sigma_u^2)$$

The second specification adds one lagged domestic return with constant coefficient to the first specification. The third specification adds to the second specification one lagged foreign return as an additional regressor with time-varying coefficient. This choice of a time-varying coefficient reflects the subsample comparison in Table 3 of Section 2 for those coefficients which change signs and are significant for the second subsample.

Model II:

$$r_t = \alpha + \beta_t r_t^* + \gamma r_{t-1} + e_t, \qquad e_t \sim N(0, \sigma_e^2),$$

$$\beta_t = \beta_{t-1} + u_t, \qquad u_t \sim N(0, \sigma_u^2)$$

Model III:

$$r_t = \alpha + \beta_{1,t}\, r_t^* + \gamma\, r_{t-1} + \beta_{2,t} r_{t-1}^* + e_t, \qquad e_t \sim N(0, \sigma_e^2),$$

$$\beta_{1,t} = \beta_{1,t-1} + u_{1t}, \qquad u_{1t} \sim N(0, \sigma_{u1}^2)$$

$$\beta_{2,t} = \beta_{2,t-1} + u_{2t}, \qquad u_{2t} \sim N(0, \sigma_{u2}^2)$$

These time-varying coefficient models fit naturally into the state-space framework. The states here are the time-varying parameters. Given the constant coefficients, the time-varying latent states can be estimated by a Kalman filter. For the estimation of the constant coefficients and the latent states together, we use Bayesian inference with a Gibbs sampler. The prior distributions of autoregressive coefficients such as α, γ are normal, which produces posterior normal distributions. The prior distributions of parameters such as $\sigma_\epsilon^2, \sigma_{u1}^2, \sigma_{u2}^2$ are inverse Gamma, which produces posterior inverse Gamma distributions. These parameters can be taken in random draws directly. The Kalman filter step for the latent states is embedded in the Gibbs sampler, and we use the algorithm of DeJong and Shephard (1995) to draw from the posterior distribution of time-varying parameters. The hyperparameters of prior distribution for time-varying latent states are set at relatively large values, which allows the time-varying coefficients to change substantively over time.

4. Estimation results

In this section, we present the parameter estimates for each model for both market returns. For the constant coefficients, we report the estimates in the equation and show the standard deviation in parentheses; for time-varying coefficients, we plot the estimated process in a figure.

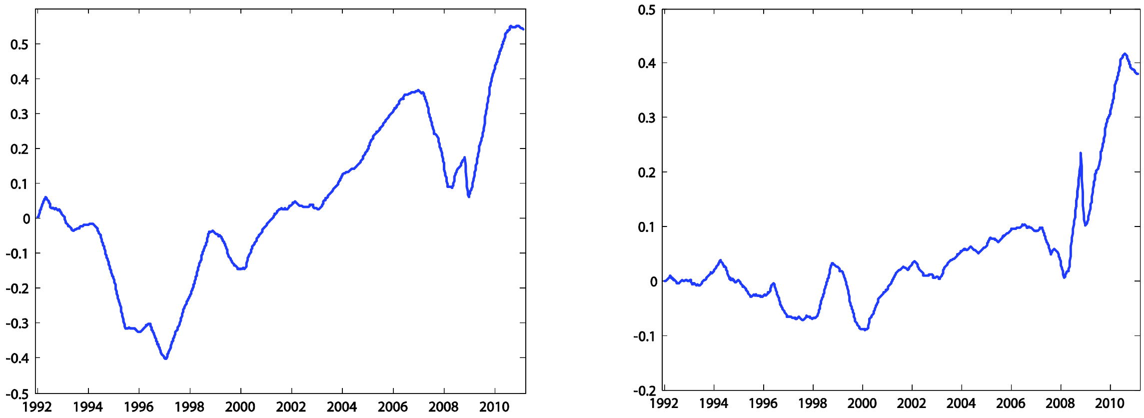
Model I:

$$r_t^{sh} = 0.0026(0.002487) + \beta_t r_t^{ny} + e_t$$

$$r_t^{ny} = 0.0012(0.001285) + \beta_t r_t^{sh} + e_t$$

Figure 1. Plot of β_t

Shanghai New York



From the first equation and the first plot we observe how the New York market influences the Shanghai market. In this simplest specification, the effect of the current stock return for New York on Shanghai, measured by β_t, steadily increases after the 1997 Asian crisis. The impact turns significantly and persistently positive after 2002, when China entered WTO. The upward trend was interrupted during the recent financial crisis, but in 2010 it returned to the pre-crisis level as the markets gradually recovered from the financial and economic turmoil.

From the second equation and the second plot we observe how the Shanghai market influences the New York market. The effect of Shanghai on New York is weaker (as expected) and is close to zero before 2002. The impact becomes positive and increases after 2002, but it reverses direction during the financial crisis, and then increases rapidly in 2009 and 2010.

Overall, it is clear that the co-movement between Shanghai and New York stock returns have become positively related and stronger in the past decade, with interruptions associated with the global financial market turmoil.

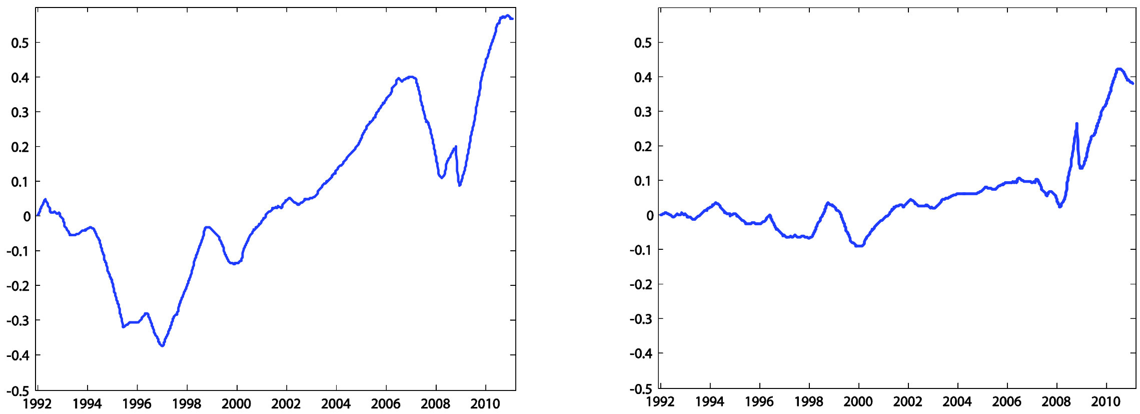
Model II:

$$r_t^{sh} = 0.0021(0.001935) + \beta_t r_t^{ny} + 0.0975(0.2784) r_{t-1}^{sh} + e_t$$

$$r_t^{ny} = 0.0014(\ 0.001396) + \beta_t r_t^{sh} + 0.0843(0.1513) r_{t-1}^{ny} + e_t$$

Figure 2. Plot of β_t

Shanghai　　　　　　　　　　New York



From the results for the second model, where an autoregressive part is added to explain the domestic return, the paths of the time-varying coefficients for the two markets are fairly similar to the paths of the first model. The effect of the New York market on the Shanghai market has been stronger than the effect in the opposite direction. Both coefficients turn persistently positive after 2002. After the financial crisis, the coefficient resumes a high value of about 0.4-0.5.

Model III:

$$r_t^{sh} = 0.0026(0.002200) + \beta_{1,t}\, r_t^{ny} - 0.0103(0.03481)\, r_{t-1}^{sh} + \beta_{2,t} r_{t-1}^{ny} + e_t$$

$$r_t^{ny} = 0.0013(0.0099) + \beta_{1,t}\, r_t^{sh} - 0.0378(0.04755)\, r_{t-1}^{ny} + \beta_{2,t} r_{t-1}^{sh} + e_t$$

Figure 3. Plot of β_{1t}

Shanghai New York

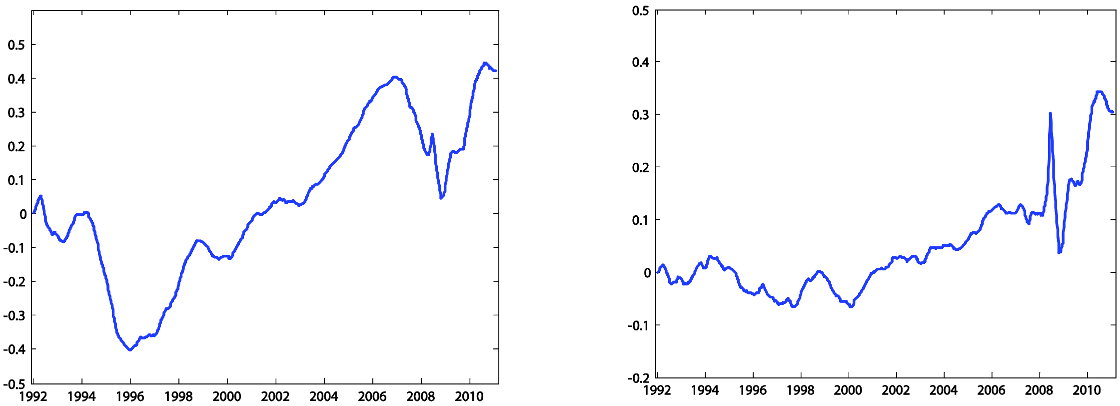
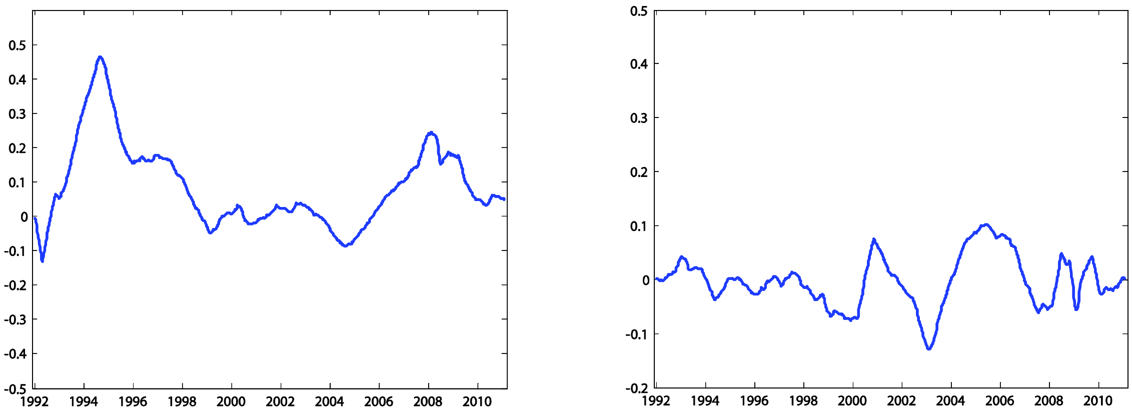


Figure 4. Plot of β_{2t}

Shanghai New York



To further check the robustness of the time-varying coefficients of current returns of the foreign market, we add one lagged foreign market return also with a time-varying coefficient. This specification is motivated by the results of estimation presented in Section 2, where we have found the coefficient of the lagged foreign return becoming statistically insignificant in the latter subsample.

The results show that:

1) The coefficients of the current foreign returns remain robust in the presence of the lag variable, with paths similar in shape to those based on Models I and II .
2) Conditional on the impact of current foreign returns, the effects of the lagged foreign returns are less important. For Shanghai, lagged New York return seems to have positive effects around 1994 while the effect of current return is zero or negative, indicating that the information on the New York return may affect Shanghai stock prices with a time lag. But with β_{1t} turning significantly positive after 2002, β_{2t} moves closer to zero while remaining positive most of the time.
3) For New York, conditional on the presence of β_{1t}, β_{2t} is not significantly different from zero, showing the weak lagged effect of the Shanghai market.

5. Conclusions

By using time-varying regressions, this paper has provided estimates of the degrees of dependence of the Shanghai stock market on the New York market and the dependence in the opposite direction. Weekly estimates are provided from January 1992 to December 2010. The time-varying coefficients obtained by regressing current returns of Shanghai (New York) on New York (Shanghai) are fairly robust over alternative specifications.

As Figure 1 shows, the effect of current stock return for New York on Shanghai steadily increases after the 1997 Asian crisis and turns significantly and persistently positive after 2002, when China entered WTO. For New York, it is also the case that the effect of current return for Shanghai becomes significantly positive and increasing after 2002. The upward trend has been disturbed during the recent financial crisis, but reaches the level of about 0.4-0.5 in 2010 for both markets. China's stock market has become more and more integrated into the world market over the past twenty years. Our results provide measures of this integration.

It remains the task of future research to build models to explain the process of economic globalization itself, with China and the US playing important roles.

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