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2015

EGC Report No: 2015/05

HSS-04-86A
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On the integration of China's main stock exchange with the international financial market

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15 October 2015

This is a revision of the paper that earlier was entitled
"Hong Kong: A bridge connecting mainland China and the international market",
EGC Report No: 2014/06

Abstract

Extending published bivariate analyses on the revenues at the stock markets of New York and Shanghai by a tri-variate analysis, which also includes the Hong Kong stock market, we demonstrate that bivariate inferences on co-movement are highly fragile. In fact, rather common opinions like "China's stock market has become more and more integrated to the world market in the past twenty years" can easily be refuted. We do so also by demonstrating that the statistical findings from various earlier analyses are internally inconsistent. A rather straight-forward analysis based on standard and partial correlations over a running window, which does not pretend to unveil causality, indicates that although the Hong Kong market shows substantial though varying co-movement with both the New York and the Shanghai markets, an apparent systematically intensifying direct link between New York and Shanghai has not emerged yet.

Keywords: China, Co-movement, Globalization, Specification analysis, Stock markets.
JEL Classifications: C22, C32, C52, G14

1 Introduction

Mainland China joined the WTO at the end of 2001, which accelerated its progress of integration into the international markets of goods and services. As a consequence, cross-correlation or co-movement between stock markets of mainland China and international financial centres such as New York may have become

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increasingly apparent as well. For the integration of mainland China into the international markets, Hong Kong had and still plays an important role, due to its long-standing status as a commercial and financial centre. Hong Kong's importance was amplified after its political reversion to China in 1997, followed by a series of policies enhancing the economic integration between mainland China and Hong Kong. The purpose of this paper is to demonstrate that in the study of the co-movement of the price indices of stocks traded in Shanghai (representing mainland China) and at the New York Stock Exchange (representing the main international financial centres), the role of Hong Kong and of the dramatically changing political and institutional circumstances should not be omitted.

There is a vast literature on the relationships among various financial markets. We mention a few studies that focus on Asian markets. In a series of bivariate analyses Huang et al. (2000) claim to find unidirectional Granger-causality from the US to Hong Kong and no Granger-causality between Hong Kong and Shanghai, using daily data from 1992 to 1997. Li (2007) performs a multivariate VAR(1) analysis using the GARCH BEKK model for daily revenues from 2000 until 2005 and concludes to unidirectional volatility spillover from the stock market of Hong Kong to Shanghai while no direct linkage between Shanghai and the US could be established. Zhang et al. (2009) apply in a bivariate analysis the MVGARCH model to data from 1996 until 2008 and find return spillover from the preceding transaction day of Hong Kong to Shanghai, but not in reverse. Sun and Zhang (2009) use relatively short samples of daily data from the period 2005 until 2008 for China, Hong Kong and the US to examine the impact of the subprime financial crisis using both univariate and multivariate GARCH models that also allow for lagged feedbacks and further control variables to affect local revenues. Chow et al. (2011) use weekly data from 1992 until 2010 of the stock markets of Shanghai and New York to study co-movement of the two markets and employ three time-varying parameter methods to shed light on this issue, based on: (a) simple correlations over sub-samples, (b) dynamic regressions over sub-samples, and (c) state-space time-varying coefficient regressions. From their bivariate analyses they conclude that both the effect of current stock return of New York on Shanghai and of Shanghai on New York steadily increased after 1997 and turned significantly and persistently positive after 2002 when China entered the WTO.

So, we note that widely diverging methodologies are being used to address similar questions. Some use constant parameter models for bivariate relationships, whereas others include more than two markets and may also allow for parameter variation. Some researchers specify a (usually very simple) dynamic model for the mean and a more complex model for conditional heteroskedasticity and others adopt homoskedasticity and aim at establishing causality.

In most of these studies, the model assumptions that have to be adopted in order that the employed statistical techniques are sound have not very thoroughly been tested. We shall demonstrate this for the three approaches in Chow et al. (2011), which yield results that appear at odds with the model assumptions made. Moreover, their approaches (b) and (c) suffer from underidentification, implying that the produced inferences are void. However, demonstrating the shortcomings of earlier research is one thing; replacing them with firm and tenable alternative findings is another one. Given the overwhelming complexity of the interrelated financial markets, the fast changing circumstances under which they operated in particular in China, and because of the occasional occurence of crises, we believe that any attempt is doomed to failure which tries to model their relationships by a constant parameter specification over a longer period of time. This is especially so, when at the same time one abstains from the inclusion into the model of variables from the real economy, the political climate and institutional changes. So, what we will do here is simply demonstrate that by generalizing and refining the approach based on time-varying correlation coefficients earlier conclusions can be refuted and be replaced by other ones, which have to be supplemented by a range of reservations, because of the relative simplicity of the approach followed. It is simply based on the calculation and comparison of various series of simple and partial correlations between weekly stock market revenues over moving overlapping subsamples each covering a full year. This unpretentious method does certainly not allow inferences that can claim formal statistical significance on the actual (causal) direction that propels any co-movement between markets. However, it allows to falsify the image that was raised by a purely bivariate approach and replace it by a less naive one.

A partial-correlation coefficient quantifies the remaining correlation between two variables after taking out their correspondences with a third mediating variable. Baba et al. (2004) present a theoretical discussion of partial-correlation. Shapira et al. (2009) utilize partial-correlation to study the cohesive effects of the Dow Jones Industrial Average (DJIA), the Standard & Poor's (S&P) and the Tel Aviv Stock Exchange indices. Kenett et al. (2012) use partial-correlation to study the intra-correlations of individual stocks for the six most important world markets. Time-varying partial-correlations are useful in the interconnected fast-changing world to measure the pattern in the residual correlation between two variables and to reveal discrepancies between direct and indirect channels of market influence, without the pretension to explain all interactions. The use of short-term ordinary and partial-correlations can unveil whether substantial co-movement between the stock markets of mainland China and the US did emerge, and if so, whether it seems primarily through a direct channel or an indirect one.

In our empirical analysis we find that pronounced intensifying positive co-movement between Shanghai and New York is not apparent. In fact, it seems often negative, and did certainly not systematically increase after mainland China entered the WTO. We do establish increasing positive co-movement between Shanghai and Hong Kong since the latter's reversion to China, and also positive co-movement between New York and Hong Kong, which clearly has a longer history, and peaked during the recent financial crisis. However, extracting the co-movement with Hong Kong from both New York and Shanghai reveals that hardly any systematic direct linkage between Shanghai and New York has developed yet.

This paper is organized as follows. In Section 2 we re-examine the results in Chow et al. (2011) using the very same data. Section 3 applies to an extended data set partial-correlation analysis over moving windows in order to investigate the dynamics in any co-movement channels between the stock markets of Shanghai, Hong Kong and New York, and Section 4 concludes.

2 Verification of some earlier results

Let p_t^i denote the closing price index for week t at stock market i expressed in local currency. We do not convert to US dollar to avoid potential correlations due to common currency appreciation or depreciation patterns. From Yahoo finance we obtained the weekly data for the Shanghai Composite Index (sh), the NYSE Composite Index (ny) and the Hang Seng Index of Hong Kong (hk). The weekly return r_t^i is given by

$$r_t^i = \ln p_t^i - \ln p_{t-1}^i, \text{ for } i \in \{sh,\ ny,\ hk\}. \tag{1}$$

We use the same data and time frame as Chow et al. (2011) to replicate their results.

Method (b) of Chow et al. (2011) estimates the two simultaneous equations

$$\left.\begin{aligned} r_t^{ny} &= \beta_0 + \beta_1 r_t^{sh} + \beta_2 r_{t-1}^{ny} + \beta_3 r_{t-1}^{sh} + \varepsilon_t^{ny} \\ r_t^{sh} &= \gamma_0 + \gamma_1 r_t^{ny} + \gamma_2 r_{t-1}^{sh} + \gamma_3 r_{t-1}^{ny} + \varepsilon_t^{sh} \end{aligned}\right\} \tag{2}$$

over two subsamples, where ε_t^{ny} and ε_t^{sh} denote disturbance terms. Apparently, in order to obtain consistent estimators by ordinary least-squares for all the coefficients, these disturbances have been assumed to be such that

$$\left.\begin{aligned} E[\varepsilon_t^{ny}(1, r_t^{sh}, r_{t-1}^{ny}, r_{t-1}^{sh})] &= (0,0,0,0) \\ E[\varepsilon_t^{sh}(1, r_t^{ny}, r_{t-1}^{sh}, r_{t-1}^{ny})] &= (0,0,0,0) \end{aligned}\right\} \tag{3}$$

This, however, cannot be the case. Substitution of the second into the first equation yields

$$(1-\beta_1\gamma_1)r_t^{ny} = \beta_0 + \beta_1\gamma_0 + (\beta_1\gamma_3 + \beta_2)r_{t-1}^{ny} + (\beta_1\gamma_2 + \beta_3)r_{t-1}^{sh} + \varepsilon_t^{ny} + \beta_1\varepsilon_t^{sh}.$$

Hence, provided $\beta_1\gamma_1 \neq 1$, this shows that r_t^{ny} is correlated with both disturbance terms, and so is the case for r_t^{sh}. More seriously, however, without further restrictions on the coefficients, these two equations form the prototypical example of an under-identified simultaneous system. Note that when $\beta_1 \neq 0$, the first equation implies

$$r_t^{sh} = -\beta_1^{-1}\beta_0 + \beta_1^{-1}r_t^{ny} - \beta_1^{-1}\beta_2 r_{t-1}^{ny} - \beta_1^{-1}\beta_3 r_{t-1}^{sh} - \beta_1^{-1}\varepsilon_t^{ny}, \tag{4}$$

which shows that the two equations are inherently indistinguishable. As can be formally proved, this result is also reflected by the equivalent t-ratios of the OLS coefficient estimates of β_1 and γ_1 (see Table 3 of Chow et al., 2011) for each of the three sample periods. The putative significance of these t-ratio's lead to the unjustified conclusion that r^{sh} is significantly determined by r^{ny} and vice versa. A meaningful interpretation of the model of method (b) would only be possible, if (i) some empirically unverifiable identification or exclusion restrictions would be adopted which annul the symmetry between the two equations, (ii) a consistent estimation technique would be used, for instance instrumental variables, and (iii) evidence would be provided that these bivariate dynamic equations do not suffer from underspecification due to the omission of further relevant explanatory variables.

Apparently in an attempt to cope with (iii) while sticking to a bivariate approach, method (c) of Chow et al. (2011) extends the two-equation simultaneous dynamic system by embedding it partly into a state-space model over the whole sample, upon allowing for time-varying coefficients of the current (with and without the lagged) effect of the other stock market, while imposing time-constancy for the intercept (with and without the lagged dependent variable). By applying maximum likelihood to the two equations separately, again the implied simultaneity is neglected, and too are the implications of the two equations for each other, being that all coefficients should in fact be taken as time-varying. Then again though, due to abstaining from identifying coefficient restrictions, a sensible interpretation of the estimated parameters is impossible.

So, neither approach (b) nor its extension (c) satisfy. That, despite its flexibility due to the allowed parameter variability, method (c) does not satisfy either as a coherent description of the observed stochastic data processes can be illustrated as follows. Adopting the simplest specification (as the more general ones involve insignificant additions, according to Chow et al., 2011) and using the same data span (running from early 1992 until end of 2010), so describing the return of market i in terms of the return of market j by

$$\left.\begin{array}{l} r_t^i = \alpha + \beta_t^i r_t^j + e_t^i,\ e_t^i \sim IIN\left(0, \sigma_{e^i}^2\right) \\ \beta_t^i = \beta_{t-1}^i + u_t^i,\ u_t^i \sim IIN\left(0, \sigma_{u^i}^2\right) \end{array}\right\} \tag{5}$$

where β_t^i is the time-varying coefficient and u_t^i its white-noise change $\Delta\beta_t^i$, we obtain by EViews (standard errors in parentheses):

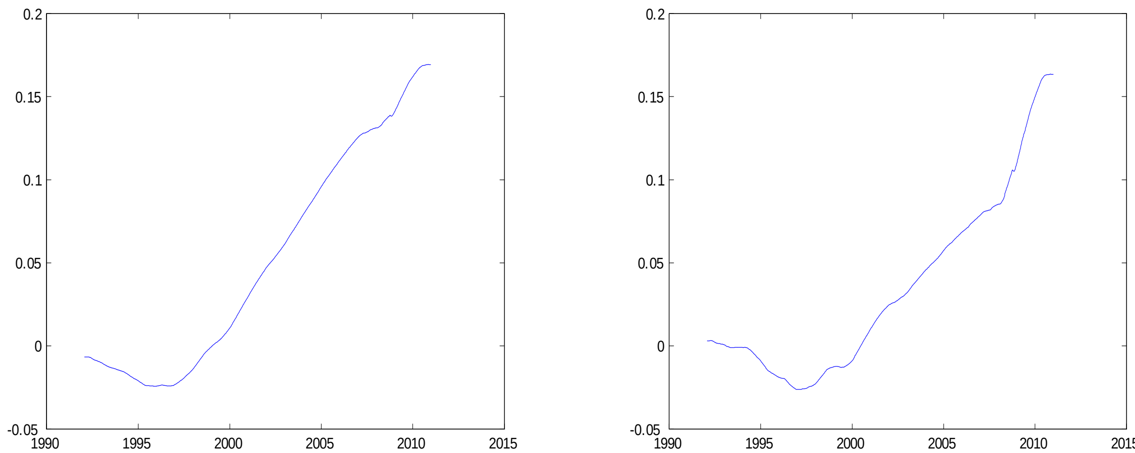
$$\begin{array}{rcccccc} r_t^{sh} = & \underset{(0.002)}{0.002} & + & \hat{\beta}_t^{ny} r_t^{ny} & + & \hat{e}_t^{sh}, \\ r_t^{ny} = & \underset{(0.001)}{0.001} & + & \hat{\beta}_t^{sh} r_t^{sh} & + & \hat{e}_t^{ny}. \end{array} \tag{6}$$

The series of estimates $\hat{\beta}_t^{ny}$ and $\hat{\beta}_t^{sh}$ are plotted in Figure 1. Although their magnitudes are clearly different from those plotted in Fig. 1 of Chow et al. (2011), they do exhibit a similar rising pattern for both β_t^{ny} and β_t^{sh}, which in that study is interpreted as: the mutual influence between Shanghai and New York enhanced over time.

However, these time-varying regressions become suspicious when we examine the estimated increments of their time-varying coefficients (the state disturbances)

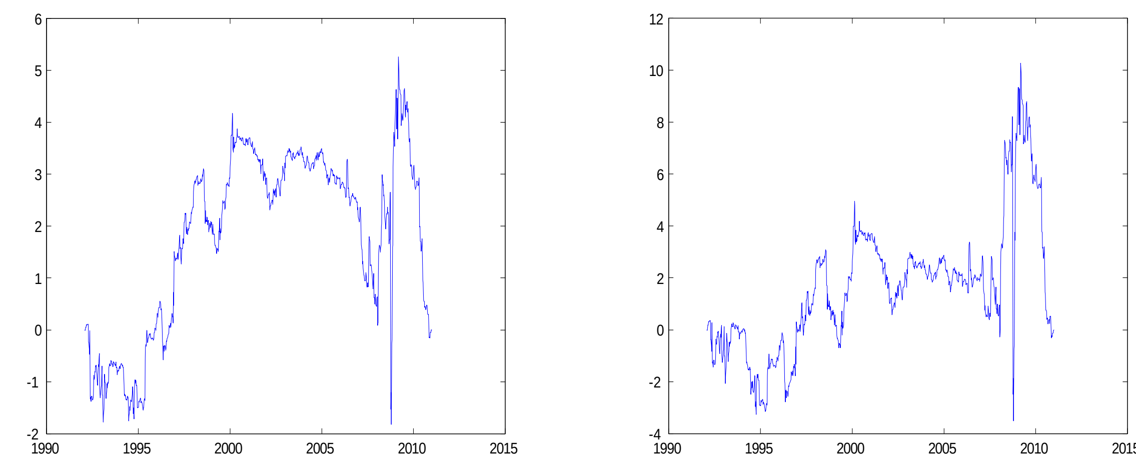
$$\hat{u}_t^i = \hat{\beta}_t^i - \hat{\beta}_{t-1}^i,\ i \in \{ny, sh\}, \tag{7}$$

plotted in Figure 2. From these it is obvious that it is hard to believe that they correspond to series u_t^i, which were assumed to establish zero mean normal white-noise processes. Formal (asymptotic) statistical tests confirm their non-zero means, non-normal distributions and serious serial correlation. Hence, these time-varying coefficient regressions do not pass basic diagnostic tests.



$\hat{\beta}_t^{ny}$ $\hat{\beta}_t^{sh}$

Figure 1: Estimated time-varying coefficients



$\widehat{u}_t^{ny} \times 10^4$ $\widehat{u}_t^{sh} \times 10^4$

Figure 2: Estimated state disturbances

3 Findings from (partial) correlations over running windows

Correlation analysis based on a running window is a common technique in investigating the dynamic relationship between two variables in financial markets. Aslanidis and Christiansen (2014) use a running window to calculate stock-bond correlations in order to study effects from the macroeconomy. Forbes and Rigobon (2002) also make use of running average correlations to investigate the co-movement, i.e. the interdependence, of stock markets at crises periods.

To determine any co-movement between the Shanghai and New York stock markets and the degree of market opening and integration, we make a running window analysis for both the pair-wise simple correlations and the partial correlations between the observed weekly returns at the Shanghai, New York and Hong Kong stock markets using data from 1992-01-27 till 2015-08-31. Unit root tests for these time-series indicate that all three considered return series are non-integrated.[1] However, their pattern is such that they certainly do not seem covariance stationary, and therefore we employ a running window analysis. We allow for varying parameters also because we realize that a tri-variate analysis suffers from the omission of important explanatory variables. Therefore we just aim to describe co-movement patterns and cannot claim to model the structural causal relationships between these three variables.

We use a window width of 52 weeks, hence of one full year, where the first window covers weeks 1 through 52, the second one weeks 2 through 53, and so on. Assuming that the returns at the stock markets i and j are available for the weeks $t = 1, 2, ..., T$, where $T \gg 52$, their simple sample correlations are calculated over the moving windows $w = 1, 2, ..., T - 51$ by Pearson's correlation coefficient according to

$$\hat{\rho}_w(i,j) = \frac{1}{51\left|\hat{\sigma}_w^i \hat{\sigma}_w^j\right|} \sum_{s=1}^{52} (r_{w+s-1}^i - \bar{r}_w^i)(r_{w+s-1}^j - \bar{r}_w^j), \tag{8}$$

where

$$\bar{r}_w^i = \frac{1}{52} \sum_{s=1}^{52} r_{w+s-1}^i, \;\; \hat{\sigma}_w^i = \sqrt{\frac{1}{51} \sum_{s=1}^{52} (r_{w+s-1}^i - \bar{r}_w^i)^2}.$$

The sample partial correlation for the moving window w between the markets i and j, excluding their correlations with market k, is given by

$$\hat{\rho}_w(i,j;k) = \frac{\hat{\rho}_w(i,j) - \hat{\rho}_w(i,k)\hat{\rho}_w(j,k)}{\sqrt{[1 - \hat{\rho}_w^2(i,k)][1 - \hat{\rho}_w^2(j,k)]}}. \tag{9}$$

In an inter-connected financial world, markets may be linked through direct connections or also by indirect ones via other markets. Existence of a positive indirect connection during weeks $t \in \{t_1, ..., t_2\}$ between the markets i and j, which stems from market k, should in principle give rise to a partial-correlation

[1] The unit root tests have been conducted with different settings for intercept and linear trend. To detect potential structural breaks, we also divided the sample period into two subsamples separated at the end of 2007. In all cases, the three return time series appeared stationary. These findings are consistent with results reported in Glick and Hutchison (2013) and Wang (2014).

$\hat{\rho}_w(i, j; k)$ which is smaller than the simple correlation $\hat{\rho}_w(i, j)$ over the windows $w \in \{t_1, ..., t_2\}$ or a subset of these. Positive simple sample correlations indicate co-movement, while positive sample partial-correlations reveal a certain degree of more direct market integration. The reason to include Hong Kong in our analysis is that Hong Kong has played a distinct role for mainland China as a corridor to connect with the external world, helped by its established status as a commercial and financial centre. The pair-wise concurrent simple and partial correlations between the three markets are plotted in the Figures 3 through 5.

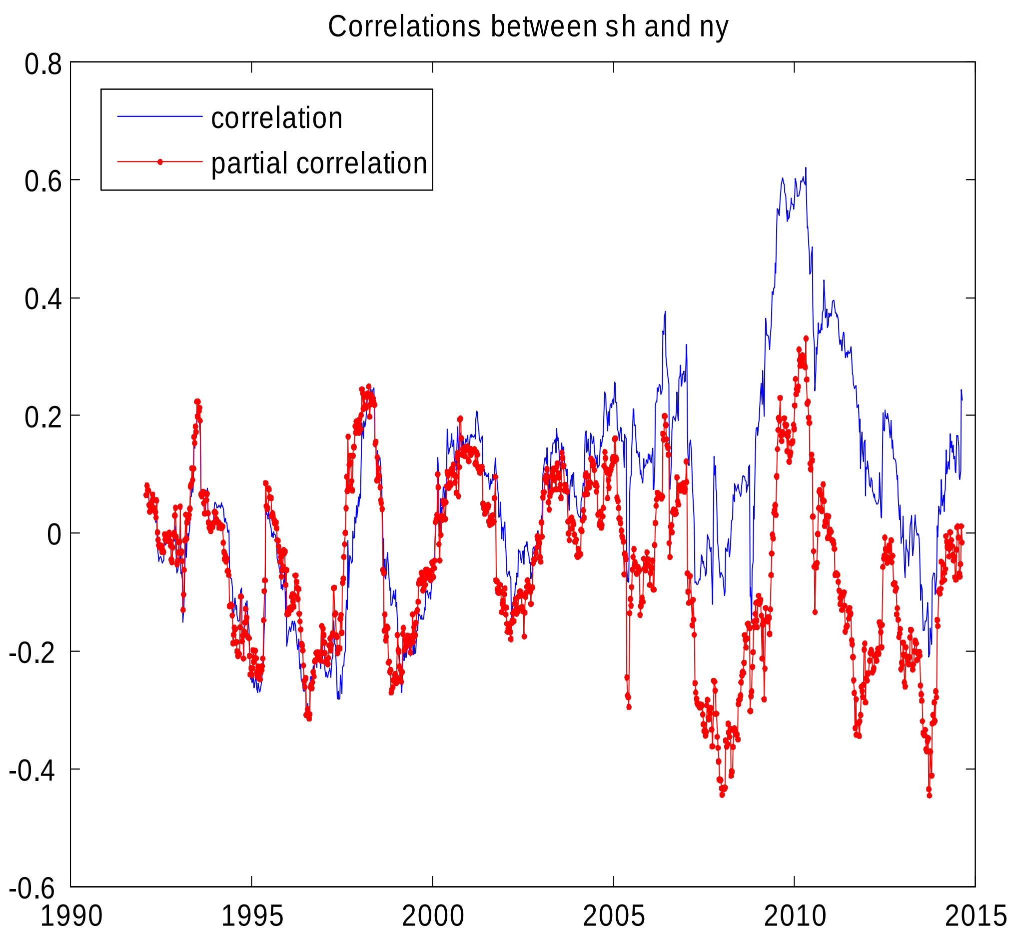


Figure 3: Correlation and partial correlation: Shanghai and New York

From Figure 3 we note that the partial correlation between the markets of Shanghai and New York, partialling out their co-movement with Hong Kong, has fluctuated around zero. In fact, it has been negative most of the time, and is systematically so since 2010. Since 2005 there is a substantial positive discrepancy between the short-term ordinary and partial correlations. Before we interpret this, we first examine the other two figures. From Figure 4 we observe that before 2000 the sign of the co-movement between Shanghai and Hong Kong fluctuated, but from early in the new millennium on it gradually increased and now seems to fluctuate around 0.4. The discrepancies between the ordinary and partial correlations are generally small in Figure 4, they change sign, and are most prominent over about a four or five year period since the most recent global financial crisis in 2007. Figure 5 shows that a positive though fluctuating co-movement between Hong Kong and New York exists since about 1994. It peaked immediately after the outbreak of the financial crisis of 2007. Very recently both correlation coefficients dropped substantially to a level of about 0.4, which it also had on average from 1995 until 2007.

Note, that most of the time, all six depicted correlation series are far away from unity, and thus at each of all three markets the pattern of their revenue series has been driven as well by components not shared by any of the other two markets.

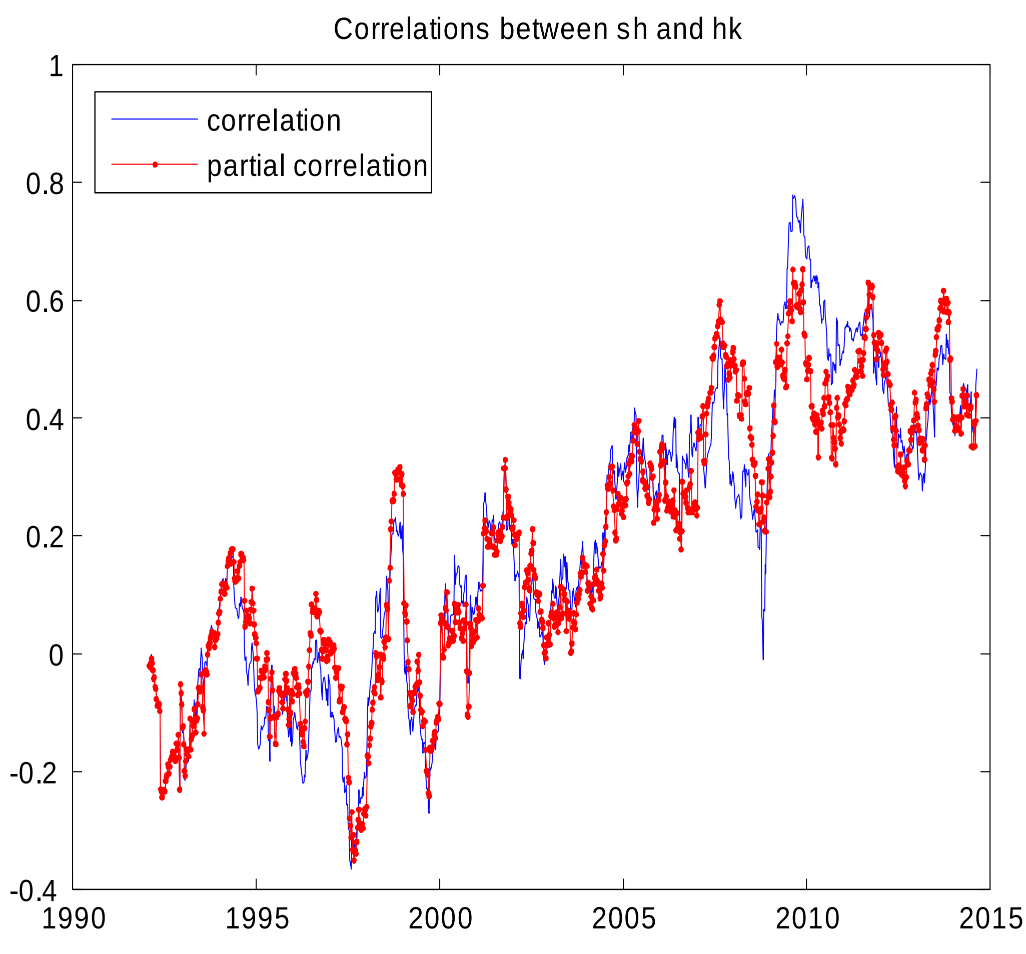


Figure 4: Correlation and partial correlation: Shanghai and Hong Kong

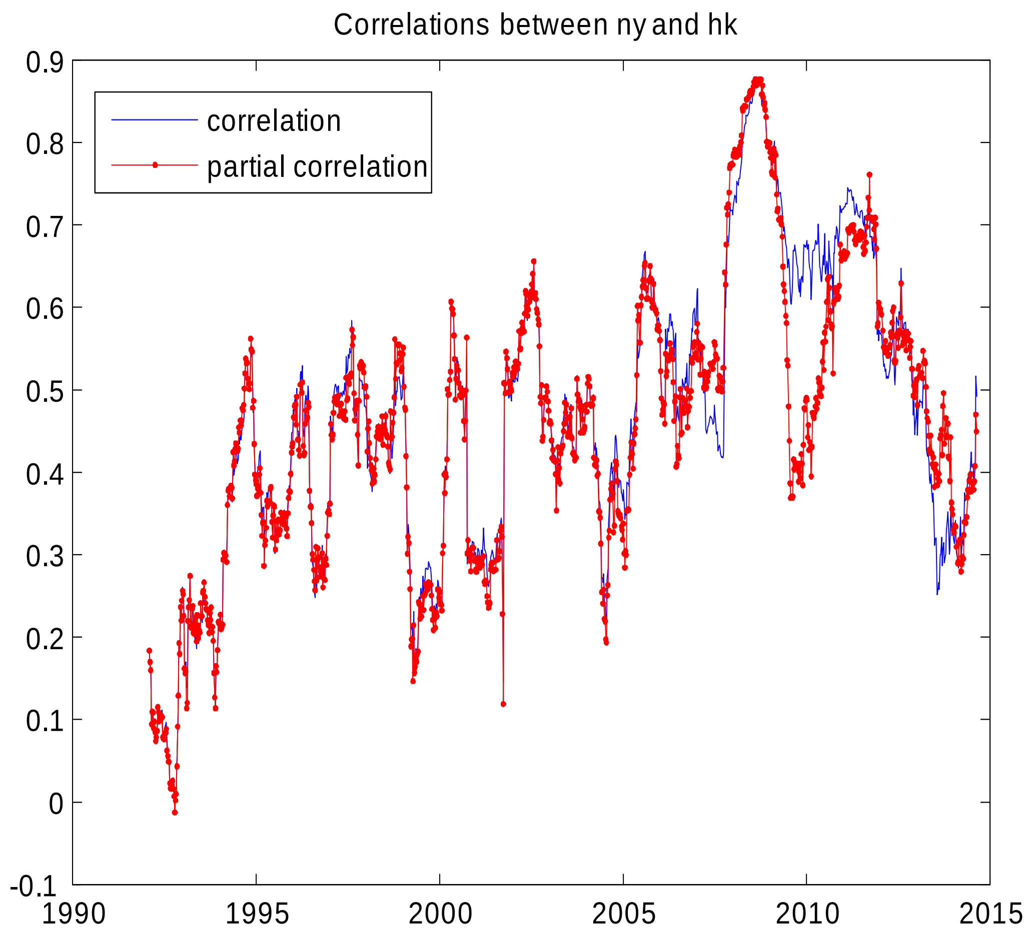


Figure 5: Correlation and partial correlation: New York and Hong Kong

It seems noteworthy that all three figures show substantial periods where the two correlations move very closely together. This indicates that over those periods both markets have almost similar or possibly no co-movement with the third market. Differences between the ordinary and the partial correlations occur in Figure 5 roughly around 2007 (negative) and from 2009 until 2011 (positive), in Figure 4 from 2007 until 2012 (with a similar change in sign around 2009), and in Figure 3 from 2005 until 2015 (uniformly positive). A plausible explanation for this is the following. Since about 2005 there is obvious co-movement between Shanghai and Hong Kong, which fluctuates but developed from zero to around a correlation of about 0.4. This also manifests itself with an apparent positive counter effect on the often negative net (partialling out Hong Kong) co-movement between Shanghai and New York, which was even strongly negative especially when the recent global financial crisis broke out. During a few years after the crisis a positive co-movement component between Shanghai and New York, beyond the New York component shared with Hong Kong, established a prominent overall positive co-movement between Shanghai and New York, especially around 2010. However, this had completely disappeared again in 2014. That from 2007 until 2012 New York had some separate direct co-movement with Shanghai, in addition to the linkage channeled by Hong Kong, can also be seen from both Figures 4 and 5. This separate component changed sign half-way. Initially it mitigated the movements of Shanghai with New York in comparison to Hong Kong and later enforced them, leading to all six graphs having peaks shortly before 2010. The above interpretation of the data refutes often expressed statements on the gradually increased integration of Chinese stock markets into the global market over the last two decades. Also, our characterization of the changes in the mutual relationships between the three stock markets is not in conflict with the conclusions drawn in Sun and Zhang (2009), which only concern the years shortly before and just after 2007.

4 Conclusion

We have argued and illustrated above that various types of bivariate analysis of the mutual connections between the revenues at the stock markets of Shanghai and New York lead to misleading inferences. Not all problems can be solved by simply generalizing to a tri-variate analysis, which incorporates Hong Kong as well. Although obvious common sense arguments for this inclusion are abundant, at the same time one should realize that more individual stock markets in Asia and Europe may play serious roles here. Moreover, institutional and further financial and economic factors will have had effects on the interrelationships between these stock markets too. Therefore, a tri-variate analysis can at best be purely descriptive (and thus not reveal causality), and any description can only be temporal, if the direct effects of the ever changing determining external circumstances are left out of the analysis. This inspires to use correlations and partial correlations in a tri-variate analysis for the description of their interlinkages, and to calculate these over so-called running windows in order to allow for the changing external circumstances.

Adding five series of moving window (partial) correlations to the simple bivariate one for Shanghai and New York allows to make various interesting observations. The most important one is that there is no evidence for a systematically increasing positive linkage between Shanghai and New York. Such a linkage, beyond the indirect linkage via Hong Kong, may have existed just during a short period a few years after the financial crisis of 2007. But on the whole, a separate and independent linkage between Shanghai and New York is not apparent, whereas clearly much more prominent, though numerically still rather limited, positive linkages between Shanghai and Hong Kong and between Hong Kong and New York are manifest.

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