What does drive dynamic integration of stock markets in the Pacific basin region?: A quantile regression approach

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Abstract.
Using the novel methods of the conditional nonlinear quantile regression and pairwise realised moments, we aim to shed lights on its economic drivers on dynamic integration of stock markets in the Pacific basin for the full sample periods 1990-2012. We find empirical evidence that the recent integration of stock markets in the Pacific basin region have been significantly driven by the lower differences (i.e., higher similarities) of a variety of the economic performances between sample countries over the recent decades. In particular, this study suggests an interesting existence of nonlinearities for the effects of the economic drivers on the integration of stock markets in this region.

Keywords: Stock market integration; Macroeconomic performances, Realised correlations; Nonlinearity, Conditional quantile regression

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1. Introduction

In general, domestic investors can invest in foreign financial assets and foreign investors in domestic assets expect the same risk regardless of trading locations given that financial markets are integrated. It is also accepted in the theoretical literature that integration of international stock markets is fundamentally linked to economic growth, macroeconomic stability, and development of financial markets, through risk sharing benefits, and a reduction, spillover effects in volatility (Pagano, 1993; Devereux and Smith, 1994; Levine and Zervos, 1996; Osfeld, 1998; Bekaert, Harvey, and Lundblad, 2001a,b; Prasad et al., 2003 among others). Consequently, the concept of international equity market integration has been one of the central concerns in international finance and economics.

Following the Asian financial crisis in 1997-1998 that devastated the financial markets and economies in the East Asian region, ASEAN +3 finance ministers in the region have effectively put various regional initiatives such as the Chiang Mai Initiative (CMI), the Asian Bond Markets Initiatives (ABMI) to strengthen the financial cooperation and integration.[2] In addition, ideas of an Asian currency basket and Asian currency union for intra-regional exchange rate stability have been proposed as the mid-long term policy objective for the region (Institute for International Monetary Affairs, 2006). Apart from these initiatives, the region has significantly experienced a globalisation that makes financial markets in Asia more integrated through an increase in cross border trades and economic activities in the 1990s resulting in an increase in cross border financial activities. Actually, the importance of this region in the global economy has really increased over the decades. Specifically, the Asia-Pacific region makes up for about 37% of world GDP in a basis of the purchasing power

[2] The CMI, launched on May 2000, aims to create a network of bilateral swap arrangements among ASEAN +3 countries to address short term liquidity difficulties in the region and to supplement the existing international financial arrangements. The ABMI, launched on August 2003, aims to develop efficient and liquid bond markets in the region (see Yu et al., 2010 for further details for them)

parity. Furthermore, some of the most dynamic economies in the world are coming from this region (e.g., China, Malaysia, Taiwan, South Korea, etc.). The global growth of emerging Asia alone reached around 40% in 2007. Mature economies such as Australia or Japan, with GDP per capita of $42,000 and $4,000 (market rates) in a US dollar term in 2007, respectively, remain well ahead (ECB, 2008).

Despite its importance, studies on convergence of stock markets in this region are limited to few still, compared to a substantial body of the numerous studies on stock market integration in other regions (e.g., Europe, North America, etc.). Moreover, most studies are not fruitful for its drivers although they heavily devote to measuring an extent of integration across markets. If any, the existing literature mostly depends on a linear approach and so does not effectively account for nonlinearities for the effects of the drivers for integration of stock markets. Thus, this study aims to investigate nature of time varying integration of stock markets in the Pacific basin region including the East Asia zone and its drivers within a framework of a nonlinear approach. To this end, we employ the novel technique of the conditional nonlinear quantile regressions on pairwise realised moments (correlations), a proxy for integration of stock markets in the region. Focusing on the conditional median as well as different conditional quantiles, the nonlinear quantile regressions provide deeper insights than a classical linear OLS regression once a nonlinear relation between the realised correlations and its drivers substantially exists. The nonlinearities in financial markets may imply that market participants have different expectations about the future (prices) incomes of their assets from those suggested by the economic factors. From the economic point of view, this may run counter to the EMH (Efficient Market Hypothesis) assumption that all traders are rational and have homogenous expectation. To our knowledge, this study is the first to systematically capture nonlinearities between stock market integration in the Pacific basin region and its economic drivers by applying the conditional quantile regression and realised correlations. This paper also adds to the literature in that it is the first to explore the impacts of a variety of the distinctive global financial crises (e.g., 1997-Asian crisis, 2008-subprime crisis, 2010-European fiscal crisis) on the integration with the longest sample periods 1990-2012 among the literature.

Our principal findings are summarised as follows. The lower differentials of monetary performances such as inflation and interest rates among sample countries have crucially led to an increase in time-varying integration between stock markets in Pacific basin region. The growth differentials of industrial production among countries have made negative relations with the convergence of stock markets. The lower differentials of exchange rate volatility between pairwise countries are significantly associated with an increase in the integration. With respect to the impact of the market developments, the smaller differences of the stock market sizes proxied by the market capitalisation among them have contributed to an increase in integration of stock markets in this region. The 3month US-treasury bond returns proxied for a global risk free asset has made negative relationship with the market integration. In addition, this study find evidence that the recent three worldwide economic crises (i.e., Asian crisis in 1997, US subprime crisis in 2008, European fiscal crisis in 2010) made positive effects on dynamic convergence of stock markets in this region. In particular, we observe significant nonlinearities for the effects of the economic drivers on the integration.

The paper is organised as follows. Section 2 reviews the literature related to time varying integration of stock markets in the Pacific basin region. Section 3 presents the theoretical background and methodology issues for the study. Section 4 explains date issues. Section 5 discusses the empirical findings. Section 6 briefly concludes.

2. Literature review

The existing literature on the integration of Asian stock markets has reported mixed results. A substantial body of the existing depends on a (Johansen) cointegration technique for studying integration of Asian stock markets. For example, Chan, Gup, and Pan (1992) and DeFusco et al. (1996) report no cointegration between U.S. and 7 East Asian emerging stock markets in Hong Kong, Korea, Singapore, Taiwan, Malaysia, Thailand, and Philippines over the periods of 1980s and early 1990s. A recent study of Majid et al. (2008) also finds no cointegration relationship among five East Asian stock markets (i.e. Indonesia, Malaysia, Philippines, Singapore, and Thailand) for the pre-1997Asian crisis period. However they present long-run relationships for five ASEAN countries with the US and Japan only in the post-crisis period. Meanwhile, the empirical studies of Arshanapalli et al. (1995) and Masih and Masih (1997a, 1999, 2001) present only one cointegrating vector among several major East Asian emerging markets of Hong Kong, Korea, Singapore, Taiwan and major developed markets. Chung and Liu (1994) document two cointegrating vectors between the U.S. and these larger Asian-pacific stock markets.

Covering the periods of the 1997-1998 Asian financial crisis, Ghosh et al. (1999) address pairwise cointegration between a world bench market (e.g., US and Japan) and some Asia-pacific stock markets. Sheng and Tu (2000) also present evidence of one cointegrating vector between the U.S. and several Asian stock markets during the crisis. Using U.S. dollar denominated stock prices, Hung and Cheung (1995) find that five major Asia Pacific stock markets (i.e., Hong Kong, Korea, Malaysia, Singapore, and Taiwan) were cointegrated after but not before the 1987 stock crash. Hassapis et al. (1998) demonstrate that cointegration and causality inferences are strongly affected by the omission of an important causing variable in the econometrics system. Asian stock markets may or may not have been integrated with each other and with the world for various reasons (e.g., extensive stock market liberalization, an increase in economic integration within the region with the world, technological advances in communication, and stock market crashes, etc). In particular, the stock market crash in 1997 has been widely argued to strengthen major international as well as Asian stock market linkages. Along the similar vein, some recent studies also present evidence more than one cointegration vector among major Asian economies (e.g., India, Japan, Hong Kong, Korea, Malaysia, Singapore, Taiwan, etc.) with a significant increase in the number of cointegrating vectors in post-crisis periods (Awokuse et al., 2009; Mukherjee and Bose, 2008). By using the Kalman filter technique some studies examine nature of dynamic integration of East Asian stock markets. As an example, Khan and Park (2009) investigate bilateral time-varying correlations among stock markets in Thailand, Malaysia, Indonesia, Korea and Philippines. They provide empirical evidence of an increase in correlations among Asian economies during financial crisis periods and of a decrease in that during stable periods. Along a similar vein, Baur and Fry (2009) report that interdependencies across 11 Asian stock markets were substantially more important than contagion during the Asian crisis. Overall, the aforementioned studies indicate that stock markets in East Asian economies have significantly converged during or after the Asian financial crisis periods. The evidence of the regional market integration supports that a financial crisis significantly alters the relationship across stock markets in the region.

Several studies are devoted to discussing heavily the degree of integration of the stock markets. Specifically, financial integration in the East Asia region is still far behind that in Europe even prior to its unification in the 1990s (Danareksa Research Institute, 2004). Similarly, Kim et al. (2006) and Cavoli et al. (2004) also suggest that the East Asian financial markets are relatively less integrated with each other than to global markets, showing evidence of the limited extent of financial market integration. On the contrary, some studies report a high degree of financial integration in East Asia. First, Jeon et al. (2006) show that the degree of financial integration in East Asia has significantly increased due to the integration with the global market of the US market rather than regional counterparts. Kawai (2005) suggests that the rise in Asian newly industrialised economies' investment contributes to the integration of the East Asian economies through foreign direct investment (FDI) and FDI-driven trade. Chi et al. (2006) address empirical evidence that the level of integration of East Asian equity markets has significantly improved during the periods of 1991-2005. Based on the modified Feldstein–Horioka model, a recent study of Guillaumin (2009) also address a high degree of financial integration among some East Asian countries. More recently, Yu et al. (2010) provides a survey of high-frequency indicators to monitor the development of equity market integration in East Asia. They show that following slowing down between 2002 and 2006, the equity market integration process picked up again in 2007–08. Nevertheless, the process is not complete and the degrees of integration between mature and emerging equity markets are different. The divergence may be attributed to a difference in the political, economic and institutional aspects across jurisdictions in Asia.

Within the scope of integration among emerging stock markets, some studies try to explore a facet of integration of stock markets in the Pacific basin region (e.g., Bekaert and Harvey, 1995; Phylakis and Ravazzolo, 2002; Pretorius, 2002; Frinjns et al., 2012). Specifically, Bekaert and Harvey (1995) allow conditionally stock expected returns in a country to be affected by their covariance with a world benchmark portfolio when the market is perfectly integrated and by the variance of the country returns when it is completely segmented. So, the authors find evidence that stock market integration was substantial for the whole period not only for Malaysia where had less investment restrictions but also for Korea and Taiwan where had substantial foreign ownership restrictions. Phylakis and Ravazzolo (2002) examine real and financial links simultaneously at the regional and global level for a group of Pacific basin countries by analysing the covariance of excess returns on national stock markets. They report the overwhelming evidence at both levels that financial integration is accompanied by economic integration, suggesting that economic integration provides a channel for financial integration. Targeting 10 emerging stock markets in Asia, Latin America, Africa, and Europe, Pretorius (2002) provides findings that a substantial proportion of the interdependence among emerging stock markets could be explained by economic fundamentals of countries. This suggests that there is still scope for diversification among them. In favour of a positive impact of trade and financial liberalisation Beine and Candelon (2011) offer a strong support on the cross linkages of stock markets in 25 developing countries. An interesting study of Frijns et al. (2012) investigates the role of a variety of political crises in explaining the degree of stock market integration in 19 emerging markets in South and East Asia, Latin America, and Central and Eastern Europe over the period 1991−2006. They conclude that crises with certain characteristics generally reduce the level of stock market integration in these regions.

3. Methodology

3.1 Measuring time varying integration

In order to measure dynamic integration of stock markets in the Pacific basin region, we apply the concept of the realised correlation. The realised moments approach has been employed by outstanding authors in financial econometrics as a good alternative for the traditional parametric one such as the GARCH (family) models (e.g, Andersen et al., 2001, 2003; Barndorff-Nielsen and Shephard, 2002 among others). The empirical studies by Beine and Candelon (2011) and Cipollini et al. (2014) are the first to use the realised moments method to examine co-movements of emerging stock markets and integration of European sovereign bond markets, respectively.

The realised correlation approach allows us to facilitate a consistent estimate of low frequency correlations by summing the squares and cross-products of high frequency returns given the availability of higher frequency data. Correlations so constructed are model free and they also are, in theory, free from measurement error as the sampling frequency of the returns approaches infinity (Andersen et al., 2001a). This econometric merit of realised correlations motivates our use of this method. For instance, Andersen et al. (2003) use intra-daily data to measure daily realised correlations while Beine and Candelon (2011) and Cipollini et al. (2013) use daily observations to measure annual realised correlations. In this paper we follow the latter's method to compute annual estimates of the realised correlations using daily data of stock returns. Importantly note that we use the pairwise correlations of stock returns across sample countries to effectively overcome a synchronisation problem across markets. Daily stock returns are defined as $r_{i,t,d} = \ln(p_{i,t,d} / p_{i,t,d-1}) \times 100$ where $p_{i,t,d}$ is the value of stock index in country i in year t and the sub-index d indicates daily observation. First, the realised variance is measured by

$$\sigma_{t,i}^{2} = \sum_{d=1}^{D_t} [r_{i,t,d}]^2 \qquad (1)$$

where D_t is the total business days in the year t, and the total number of years is 23. In line with Andersen et al. (2003), our study assumes $E(r_{i,t,d} r_{i,t,d-1}) = 0$ that means that stock markets are efficient). Analogously, we can measure a realised covariance between the annual stock returns of country i and country j as

$$\sigma_{ij,t} = \sum_{d=1}^{D_t} [r_{i,t,d} \times r_{j,t,d}] \qquad (2)$$

The realised correlation $\rho_{ij,t}$ measure is then obtained as:

$$\rho_{ij,t} = \frac{\sigma_{ij,t}}{\sqrt{\sigma_{i,t}^{2} \times \sigma_{j,t}^{2}}} \qquad (3)$$

In line with Beine and Candelon (2011) and Cipollini et al. (2013), we use a Fisher-Z transformation of $\rho_{ij,t}$. This allows us to free the panel regression from bounds on the predicted realised correlations:

$$\overline{\rho_{ij,t}} = \ln(\frac{1 + \rho_{ij,t}}{1 - \rho_{ij,t}}) \qquad (4)$$

3.2 Theoretical background for drivers of stock market integration

In this subsection we briefly show how macroeconomic similarities (or differentials) between pairwise sample countries lead to higher stock return correlation between them using the factor model proposed by Ross (1976).

Given that there are K factors $F_1, F_2, \cdots, F_K$ affecting the stock returns R_A and R_B for country A and country B, resepectively, then we can consider the following factor models by Ross (1976):

$$R_A = \alpha_A + \sum_{i=1}^{K} \beta_{Ai} F_i + \varepsilon_A \tag{5}$$

and

$$R_B = \alpha_B + \sum_{i=1}^{K} \beta_{Bi} F_i + \varepsilon_B \tag{6}$$

where $\forall i \neq j, Cov(F_i, F_j) = 0$, $\forall i, Cov(F_i, \varepsilon_A) = 0$, $\forall i, Cov(F_i, \varepsilon_B) = 0$, and $Cov(\varepsilon_A, \varepsilon_B) = 0$.

Then, we have

$$Cov(R_A, R_B) = \sum_{i=1}^{K} \beta_{Ai} \beta_{Bi} Var(F_i) \tag{7}$$

or

$$\rho_{A,B} = \sum_{i=1}^{K} \beta_{Ai} \beta_{Bi} \frac{\sigma_i^2}{\sigma_A \sigma_B} \tag{8}$$

where,

$$\sigma_i^2 = Var(F_i),$$

$$\sigma_A = \sqrt{Var(R_A)},$$

$$\sigma_B = \sqrt{Var(R_B)},$$

$$\rho_{A,B} = \frac{Cov(R_A, R_B)}{\sigma_A \sigma_B}.$$

Then, we have

$$\forall k \in \mathrm{N}_K, \frac{\partial \rho_{A,B}}{\partial \sigma_k} = \beta_{Ak}\beta_{Bk}\frac{2\sigma_k}{\sigma_A\sigma_B} = \begin{cases} >0, & if\ \ \beta_{Ak}\beta_{Bk} > 0; \\ <0, & if\ \ \beta_{Ak}\beta_{Bk} < 0. \end{cases} \tag{9}$$

We can see that the same change of the common risk (the future uncertainty of the common factor) can either increase or decrease the stock return correlation between the two countries depending on whether the common factor has similar or opposite effects on the stock returns of the two countries.

For example, assume that country A is an oil producer while country B is an oil consumer. Then, it is obvious that the oil price commonly affects the stock returns of the two countries in the opposite directions. That is, letting F_k be the oil price, we will obviously have $\beta_{Ak} > 0$ and $\beta_{Bk} < 0$. In that case, we will have

$$\frac{\partial \rho_{A,B}}{\partial \sigma_k} = \beta_{Ak}\beta_{Bk}\frac{2\sigma_k}{\sigma_A\sigma_B} < 0 \tag{10}$$

implying that the increasing volatility of the oil price will make the stock returns of the two countries diverge from each other.

Meanwhile, if both countries are exporting to the U.S. so that their stock returns are both influenced by the U.S. stock market return in a similar manner, then letting F_k be the U.S. stock market return, we will have $\beta_{Ak} > 0$ and $\beta_{Bk} > 0$. Then, we will have

$$\frac{\partial \rho_{A,B}}{\partial \sigma_k} = \beta_{Ak}\beta_{Bk}\frac{2\sigma_k}{\sigma_A\sigma_B} > 0 \tag{11}$$

implying that the US stock market risk increase can make the stock returns of the two countries converge to each other.

For further simplicity, let us assume single factor models for the two countries:

$$R_A = \alpha_A + \beta_{AM} R_M + \varepsilon_A \tag{12}$$

and

$$R_B = \alpha_B + \beta_{BM} R_M + \varepsilon_B \tag{13}$$

where $Cov(R_M, \varepsilon_A) = 0$, $Cov(R_M, \varepsilon_B) = 0$, and $Cov(\varepsilon_A, \varepsilon_B) = 0$. Then, we have

$$Cov(R_A, R_B) = \beta_{AM}\beta_{BM}Var(R_M) \tag{14}$$

or

$$\rho_{A,B} = \beta_{AM}\beta_{BM}\frac{\sigma_M^2}{\sigma_A\sigma_B} \tag{15}$$

where,

$$\sigma_M^2 = Var(R_M),$$

$$\sigma_A = \sqrt{Var(R_A)},$$

$$\sigma_B = \sqrt{Var(R_B)},$$

$$\rho_{A,B} = \frac{Cov(R_A, R_B)}{\sigma_A\sigma_B}.$$

Then, we have

$$\frac{\partial\rho_{A,B}}{\partial\sigma_M} = \beta_{AM}\beta_{BM}\frac{2\sigma_M}{\sigma_A\sigma_B} = \begin{cases} > 0, & if\ \beta_{AM}\beta_{BM} > 0; \\ < 0, & if\ \beta_{AM}\beta_{BM} < 0 \end{cases} \tag{16}$$

implying that in the case σ_M increases due to a global financial crisis, the stock market correlation $\rho_{A,B}$ between the two countries increases if both of them are affected by the global financial market in the same direction and it decreases otherwise.

Of course, these models are only based on factor models for stock returns. Since there may be some additional factors influencing only the covariance or the correlation of the two different stock returns not influencing the corresponding individual stock returns, we can build up our regression model as follows:

$$Cov(R_A, R_B) = \alpha_{AB} + \sum_{i=1}^{K}\beta_{Ai}\beta_{Bi}Var(F_i) + \sum_{j=1}^{L}\beta_j G_j + \varepsilon_{AB} \tag{17}$$

or

$$\rho_{A,B} = \frac{\alpha_{AB}}{\sigma_A\sigma_B} + \sum_{i=1}^{K}\beta_{Ai}\beta_{Bi}\frac{\sigma_i^2}{\sigma_A\sigma_B} + \sum_{j=1}^{L}\beta_j\frac{G_j}{\sigma_A\sigma_B} + \frac{\varepsilon_{AB}}{\sigma_A\sigma_B} \quad (18)$$

where,

$$\sigma_i^2 = Var(F_i),$$

$$\sigma_A = \sqrt{Var(R_A)},$$

$$\sigma_B = \sqrt{Var(R_B)},$$

$$\rho_{A,B} = \frac{Cov(R_A, R_B)}{\sigma_A\sigma_B}.$$

Here, the G_j s represents those additional factors influencing only the covariance of the two different stock returns other than the $Var(F_i)$s.

The problem is that we do not exactly know what those common international risk factors are. And even if we know those factors F_i s correctly, we cannot easily measure their future uncertainty σ_i due to data availability. Actually, we at least need to have weekly data for those (assumed-to-be-known) risk factors to calculate the annual σ_i s.

But fortunately, it is highly probable that if the two countries have similar economic structures, then they will have a higher chance to be affected by those unknown common international risk factors' future uncertainty in a similar manner. That is, if country A and country B have similar industrial structures consuming massive oil, then both of them will be affected by the future uncertainty of the international oil price (a common risk factor) in the same direction. Then, the rise of the future oil price uncertainty will increase the stock return correlation. This implies that similar macroeconomic variables of two countries will result in higher stock return correlation between the two. So our research will focus on similarity of which macroeconomic variables between any two countries in Pacific basin region will influence the stock return correlation between them.

3.3 The Conditional nonlinear quantile regression

For examining drivers for comovements among stock markets in the Pacific basin region, this study employs the conditional nonlinear quantile regression developed by Koenker and Basset (1978) based on a median value approach and the linear OLS regression for a comparison. One of the merits of the conditional quantile regression is that it traces the entire distribution of dependent variable conditional on a set of explanatory variables. Then, this merit provides researchers with more robust and informative outputs even when the data include a large heterogeneity with extreme outliers.

Given that the sample date contain large and non-normal disturbances applying the conditional mean estimators to the main equation might not be suitable because these estimators are not robust to departure from normality. Hence, the OLS estimation is likely to produce inefficient and biased estimates. By contrast, the quantile regression on the conditional median approach is robust to departure from normality and skewed tails (Mata et al., 1996, Fattouh et al., 2005).

We briefly describe the estimation procedure of the quantile regression and some properties of the estimator. Given any real-valued random variable X may be characterised by its distribution function as

$$F(x) = \Pr(X \le x) \tag{19}$$

The τ^{th} quantile, for $0 < \tau < 1$, is defined as

$$Q(\tau) = \inf\{x : F(X) \ge \tau\} \tag{20}$$

Let $(y_i, x_i), i = 1,2,3,..., n,$ be a sample from some population, where y_i is a dependent variable of interest and x_i is a vector of regressors. Assuming that the τ^{th} quantile of the conditional distribution of y_i is linear in x_i, we can write the conditional quantile regression model as follows:

$$y_i = x_i^{'}\beta_\tau + u_{\tau i} \quad (21)$$

$$Quant_\tau(y_i \mid x_i) \equiv \inf\{y : F_i(y \mid x)\tau\} = x_i^{'}\beta_\tau \quad (22)$$

$$Quant_\tau(u_{\tau i} \mid x_i) = 0 \quad (23)$$

where $Quant_\tau(y_i \mid x_i)$ denotes the τ^{th} conditional quantile of y_i on the regressor vector x_i, β_τ is unknown vectors of parameters to be estimated for different values of $\tau \in (0,1)$, u_τ is the error term which is assumed to have a continuously differentiable c.d.f. $F_{u\tau}$ and a density function $f_{u\tau}(.\mid x).F_i(.\mid x)$ denotes the conditional distribution function of y. By varying the value of τ from 0 to 1 we trace the entire distribution of y conditional on x. Thus the quantile regression estimator for β_τ is obtained as the solution to the following minimisation problem:

$$\min \sum_{i}^{n} \rho_\tau(y_i - x_i^{'}\beta_\tau) \quad (24)$$

where

$$\rho_\tau(u) = \begin{cases} \tau u & if, u \geq 0 \\ (\tau - 1)u & if, u < 0 \end{cases} \quad (25)$$

The estimator does not have an explicit form, but the resulting minimisation problem can be solved by linear programming techniques. (Koenker et al., 1978, Koenker et al., 2001). In this paper, we employ the design matrix bootstrap method to obtain estimates of the standard errors for the coefficients in quantile regressions. To employ the bootstrap method based on fundamentally different assumptions about the form of the asymptotic covariance matrix of β_τ, there are two alternative approaches of the design matrix bootstrap technique and the error bootstrap technique. The design matrix bootstrap method provides a consistent estimator of the asymptotic matrix under more general conditions whereas the error bootstrap method yields a consistent estimator only under an independence assumption. See Buchinsky (1995, 1998) for its more details.

3.4 The conditional quantile regression specified for its drivers

Our conditional quantile regression with panel data of realised correlations between stock market returns in the Pacific basin region is specified like

$$
\begin{aligned}
&Quant_{\tau}(Y_{it}(=\overline{\rho_{ij,t}}) \mid X_{it}) = \alpha_{\tau 0} + \beta_{\tau 1} InfDif_{ij,t-1} + \beta_{\tau 2} IntDif_{ij,t-1} + \beta_{\tau 3} IP\_Dif_{ij,t-1} \\
&+ \beta_{\tau 4} FX\_VolDif_{ij,t-1} + \beta_{\tau 5} MarkCapDif_{ij,t-1} + +\beta_{\tau 6} USBill + \beta_{\tau 7} 1997\,Dummy \\
&+ \beta_{\tau 8} 2008\,Dummy + \beta_{\tau 9} 2010\,Dummy + \varepsilon_{it}
\end{aligned}
\tag{26}
$$

where $Quant_{\tau}(Y_{it}(=\overline{\rho_{sb,t}}) \mid X_{it})$ denotes the τ^{th} conditional quantile of $Y_{it}(=\overline{\rho_{sb,t}})$, the realised correlations between returns of stock markets at year (t). The parameter $\alpha_{0\tau}$ is a overall constant for each of the quantile regression. $InfDif_{ij,t-1}$, $IntDif_{ij,t-1}$, $IP\_Dif_{ij,t-1}$, $FX\_VolDif_{ij,t-1}$, $MarkCapDif_{ij,t-1}$, and $USBill_{t-1}$ denote the exogenous economic variables chosen for explaining the integration of stock markets. $1997Dummy$, $2008Dummy$, and $2010Dummy$ denote intercept dummies to examine the effects of a variety of the regional and global financial crises from East Asia, US, and Europe, respectively, on the integration. ε_{it} is the error terms for cross-sectional units.

For our empirical model with the panel data of the pairwise realised correlations, the cross-section dimension (N) equals $36\,(=\frac{9\times 8}{2})$. Given that we have annual observations of the realised correlations among stock market returns in the region over the whole period, the panel time series dimension (T) is 23 (years). Therefore, the final panel dataset size of realised correlation between stock market returns is 828.

4. Data Issues

4.1 Stock returns

For measuring annual realised correlations between stock market returns in the Pacific basin region we use daily stock returns in this region countries over the full sample periods of 1st January 1990 to the end of December 2012. Our sample countries in this study include the nine economies in the Pacific basin region; Australia, China, Hong Kong, Japan, Korea, Malaysia, Philipines, Singapore, and Thailand.[3] All the daily stock indices are available from the Datastream International. The paper uses US dollars as the reference currency. The daily stock returns (continuously compounded) are computed as the log first difference of the closing index levels from one trading day to the next such that $r_{i,t,d} = \ln(p_{i,t,d} / p_{i,t,d-1}) \times 100$ for stock (i), where p are daily stock indices.

An inspection of Figure 1 below, where the pairwise (Z Fisher transformed) realised correlations are plotted, exhibits overall an upward trend, especially since the second half of 1990s, showing a peak around the subprime mortgage crisis from the US in 2008-009. This suggests that stock markets in this region have significantly converged after the Asian turmoil in 1997. In particular, showing the highest realised correlation, the two stock markets between China and Hong Kong have been significantly converged after Hong Kong returned to the Chinese government on 1st July 1997.

Figure 1 around here

[3] In this study Taiwan, one of major countries in the region, is exclusive due to unavailability for the full data of the whole macroeconomic performance over the full sample periods.

4.2 Exogenous economic variables for its drivers

This subsection describes the exogenous economics variables considered in this study in more detail. The exogenous variables to explain dynamic integration of stock markets in the region are mostly related to macroeconomic performance differences and differences of capital markets between pairwise countries. These are commonly used in the literature on stock market integration (e.g., Pretorius, 2002; Kim et al., 2005; Beine and Candelon, 2011 among others). First, marcoeconomic performance differences denoted by $InfDif_{ij,t-1}$, $IntDif_{ij,t-1}$, $IP\_Dif_{ij,t-1}$ and $FX\_VolDif_{ij,t-1}$ represent the 1st lagged values of inflation differentials, 3 month-short term interest rate differentials, industrial production differentials, exchange rate volatility differentials between pairwise countries, respectively. Here, note that the lagged inflation differentials ($InfDif_{ij,t-1}$) is computed as differences of CPI (consumer price index) between pairwise counries. The variable, $MarkCapDif_{ij,t-1}$, to examine the effects of differences of capital market development across countries on integration are computed by the 1st lagged value of market capitalisation differentials across them. A 1st lagged short term interest rate of 3 month-US treasury bill denoted by $USBill_{t-1}$ is for a proxy for a global risk free return. The whole variable is based on the annual frequency for purpose of matching the frequency of the dependent variable of annual estimates of realised correlations among stock markets. The specific data for them are gathered from the Datastream international as well.

4.3 Crisis dummies for global risks

Lastly we use the three intercept dummies of the 1997dummy, the 2008dummy, the 2010dummy to examine each effect of a variety of the regional and global financial crises from East Asia, US, and Europe, respectively. The three kinds of dummies take value 1 for 1997, 2008, and 2010, 0 otherwise, respectively.

Table 1 presents the descriptive statistics for the exogenous variables over the full sample period. Most variables show positive skewness value but the US 3 month treasury bill rate does negative one. Kurtosis shows, overall, high values between 13.827 and 4.578 except the 3month-US treasury bill rate. So, we need to focus on the median rather the mean. Compared to the other macro economic performance differences between pairwise countries, the interest rate difference is substantially larger since the interest rate differential shows high median value. Market capitalization differential also shows high value at 0.231 and suggests an existence of substantial differences between pairwise countries with respect to the degree of stock market development.

Table 1 around here

5. Empirical results

In this section, we analyse the specific results for the OLS and quantile regressions at seven conditional quantiles (τ) of the distribution; 5th, 10th , 25th, 50th , 75th , 90th, and 95th quantiles, using the exogenous variables on realised correlations between stock market returns in the Pacific Basin region.

Prior to our actual regression analysis Table 2 presents the correlation matrix across the variables in this study. Overall, the low correlation estimates across the variables suggest that there is no serious correlation problem even when they are simultaneously inclusive in the regression models.

[Table 2 around here]

Table 3 presents the results of estimating Eq. (12) by using quantile regressions at the seven conditional quantiles (τ) of the distributions of the realised correlations between the stock market returns over the full sample period. For comparison the OLS estimates focusing only on a single measure of the central tendency of the distribution are also reported in column 1 of Table.

[Table 3 around here]

First of all, for the inflation differentials (*InflDif*), one of monetary performances between sample countries, the OLS specification estimates a significantly negative coefficient at -0.816. This result suggests that lower price differences (i.e., higher similarities) between two countries contribute to an increase in convergence among stock markets in the Pacific basin region. Meanwhile, the conditional quantile regressions for this have significantly bigger negative coefficients at -1.102 and -1.564 on the middle (τ_{50}) and higher (τ_{75}) quantiles of the realised correlation distribution only. This implies evidence that price differences between them make greater negative impact on convergence of the stock markets at the middle and high quantiles of distribution of the realised correlations. For the other monetary performance variable proxied by the (short term) interest rate differentials (*InterDif*), the OLS regression has also a significant negative estimate at -0.034. Along the same vein, this result suggests that lower interest rate differences (higher similarities) lead to an increase in integration of stock markets in the Pacific basin region. As for its nonlinearity, all the quantile regressions estimate overall significantly bigger negative coefficients at standard levels. In particular, we observe bigger negative values at higher quantiles with the biggest value (-0.041) at the quantile of τ_{90}. This suggests evidence of nonlinearity that this driver makes differentiated effects on the τ^{th} conditional quantiles of the realised correlations between returns of stock markets. Through these results for the two monetary variables we suggest that higher convergence of monetary performances among sample countries is associated with an increase in integration of stock markets in the region.

In association with the effect of growth differences between pairwise countries, the industrial production differentials (*IP_Dif*) between them also show significant negative coefficient (-0.141) in the OLS model. This result reflects that the lower IP differences between two countries are associated with an increase in the market integration. The conditional quantile regressions estimate significant bigger negative coefficients at high quantiles of the distributions of the realised correlations except for one quantile τ_{75}. These also imply evidence of nonlinear effects of which make differentiated effects conditional on the degree of integration. For examining the effect of exchange rate volatility on the market integration, the exchange rate volatility differentials (*FX_VolDiff*) among sample countries have significantly negative estimates for the OLS and most quantile regressions as expected. In particular, except for the quantile τ_{75} showing an insignificant coefficient, most of the quantile regressions estimate significantly greater negative values as one goes up upper quantiles. The results also reflect an existence of nonlinearity that makes different effects of this driver conditional on the distributions of the realised correlations among stock markets in the region. For the effects of a market size, the stock market size difference proxied by market capitalisation differentials between pairwise countries make negative relationship with the integration as the OLS regression estimate significant negative coefficient for this variable. With respect to the nonlinearity of this driver conditional on the distribution of realised correlations, the quantile regressions estimate greater increasing negative coefficients between the quantiles $\tau_{25} - \tau_{75}$ but insignificant ones at the high quantiles $\tau_{90} - \tau_{95}$ of the distribution. This result suggests that the market size differentials have a differentiated (negative) effect on the market integration across various quantiles of the distribution of realised correlations. This also goes with our theoretical expectation. Overall, the so far discussed empirical findings related to macroeconomic performance differences between sample countries far firmly support our theoretical perspective (Eq. 9) that economic similarities between them contribute to an increase in integration of stock markets. The 3 month-US treasury bill rate (*USBill*) proxied for a worldwide risk free return also makes negative impacts on the market integration as the OLS and the whole quantile regression estimate highly significant negative coefficients at the 1% level, respectively, for this variable. Like the aforementioned variables above, the results of showing greater negative coefficients at the higher quantiles for the risk free asset return also suggest the nonlinear effects conditional on the distribution of realised correlations.

For the three kinds of dummies to test for each effect of a variety of worldwide financial and economic crises on integration of stock markets in the region, the OLS regressions estimate significant positive coefficients at 0.205, 0.471, 0.182), respectively. This suggests that all the economic crises from Asia, US, and Europe lead to an increase in the integration. Shortly, the findings suggesting positive impacts of the global crises for integration supports our theoretical expectation discussed in Eq. (18) that the stock market correlation between two countries increases if both are affected by the global crisies in the same direction.

Even if so, all the conditional quantile regressions for the three dummies make a variety of features across the distributions of quantiles of realised correlations. That is, in the case of the 1997Dummy, the quantile regressions estimate significant positive values 0.296, 0.275, 0.301, 0.235 at the bottom and middle quantiles (i.e., τ_5, $\tau_{10}, \tau_{25}, \tau_{50}$) but do insignificant values at the other (high) quantiles at all. For the 2008Dummy of the US subprime mortgage crisis in 2008, the regressions estimate highly significant positive coefficients exclusively at the quantiles of τ_5, $\tau_{10}, \tau_{25}, \tau_{50}, \tau_{75}$, which are smaller at higher quantiles of the distribution. The results suggest a bigger impact of the 2008 crisis from the USA on the stock market integration at lower quantiles of distribution of realised correlations among sample stock markets. Lastly, regarding the effect of EU fiscal crisis in 2010, we see significant bigger positive estimates only at the three quantiles of $\tau_{10}, \tau_{25}, \tau_{75}$ than the linear OLS regression estimate (0.182) for the 2010Dummy. This reflects the different impacts of this crisis on the stock market integration across quantiles of the realised correlations. Shortly, these results for the three dummies imply their nonlinear effects that make different impacts across quantiles of realised correlations for integration among stock markets in the Pacific basin region.

The nonlinearities on relations between the integration and the determinants may arise due to an existence of different groups of investors having heterogenous expectations about future prices and dividends of their assets with the determinants. For instance, one group might be fundamentalists who believe asset prices return to their fundamental equilibrium while the other group might be chartists who extrapolating patterns of past prices. Based on the results so far, overall, the nonlinearities of the whole exogenous variables and the three crisis dummies for integration of stock markets support the necessity for use of the quantile regressions for an accurate study on stock market integration in this region.

Extending the bootstrap procedure to construct a joint distribution, we conduct the F test to test for the equality of coefficients at various pairs of quantiles. We use the bootstrapped standard errors from 1000 replications. (see Arias et al., 2001, Fattouh et al., 2005 and 2008, Miller et al., 2008 for a similar application). Table 4 shows the F statistics and the associated values for the equality of the estimated coefficients for various quantile pairs over the full sample period.

[Table 4 around here]

The F statistics for most pairs, except for little pairs (i.e., $\tau_5 - \tau_{10}$, $\tau_{10} - \tau_{25}$, $\tau_{25} - \tau_{50}$, $\tau_{25} - \tau_{75}$, $\tau_{75} - \tau_{90}$, $\tau_{90} - \tau_{95}$) significantly reject the null of homogenous coefficients at the standard levels. This suggests a different impact of the whole variable at most of the pairs. Moreover, the homogeneity F statistic (5.94) on them across all quantiles of the distribution strongly rejects the null of homogenous coefficients of the variables across all the quantiles. Then this suggests different impacts of the variables across all the quantiles. Suggesting that results derived from only the linear OLS estimates are not solid, the nonlinearities of all the variables across the conditional quantiles of the distribution in Table 3 justify our use of the quantile regression technique for this study.

Figure 2 depicts variations in coefficient estimates for the linear OLS and the conditional quantile regressions over the full sample periods. In Figure 2, coefficient variations on the exogenous variables considered in this study seem clear mostly across majority of the quantiles of the distribution.

[Figure 2 around here]

6. Summary and concluding remarks

This paper aims to investigate economic drivers for dynamic integration of stock markets in the Pacific basin region. To this end we employ the conditional quantile regression technique which allows us to trace the entire distribution of realised correlations of stock markets and so to capture nonlinearities in the distribution and the liner OLS regression for compare.

Principal findings from our study are as follows. First, the lower differentials (high similarities) of monetary performances such as inflation and interest rates between sample countries are associated with an increase in time-varying integration between stock markets in this region. The growth differentials of industrial production among countries have made a negative relation with convergence of stock markets. We also find evidence that the high similarities (lower differentials) of exchange rate volatility between pairwise countries contribute to an increase in the integration. With respect to the impact of the market developments, the smaller differences of stock market sizes proxied by the market capitalisation among them lead to an increase in integration of stock markets in this region. The 3 month-US treasury bill rate proxied for a global risk free asset makes a negative effect with the market integration. Shortly, these results suggest that the (lower) differences of the economic performances across sample countries have been key factors not only for integration of stock markets but also pricing stocks in this region. In addition, our study suggests that the recent three worldwide economic crises (i.e., Asian crisis in 1997, US subprime crisis in 2008, European fiscal crisis in 2010) made positive effects on the time varying integration of stock markets in the Pacific basin region. In addition, in this study, the worldwide-economic crises as global risk factors on the (realised) correlations of two different stock returns make the positive impacts. Importantly, we observe interesting facets of nonlinearities whereby the economic drivers considered in this study make different effects conditional on the distribution of quantiles of realised correlations measured for integration of stock market integration in this region.

Our study has invaluable implications for international investors and academics. That is, integration dynamics between stock markets in the Pacific basin region is an important concern for the efficient portfolio diversification of global investors. In particular, a desirable understanding of drivers behind the stock market interdependence in this region could provide a better grasp of the functioning of the global stock markets. This also allows international investors and policy makers to be sensitive to the concerned economic performances of each country for investing and pricing stocks in this region. We need to mention limits of this study. Our study is effective for building up a theoretical framework for linear impacts of a variety of the economic drivers on integration of stock markets in the Pacific basin region but is not for their nonlinearities captured in our empirical devices. This challengeable work would be a really meaningful room for a more rigorous study for integration of stock markets in this region. It would be interesting to explore convergence of stock market integration in this region in firm and industry levels, respectively, but is beyond the scope of this study. So this is also a meaningful avenue for a future study.

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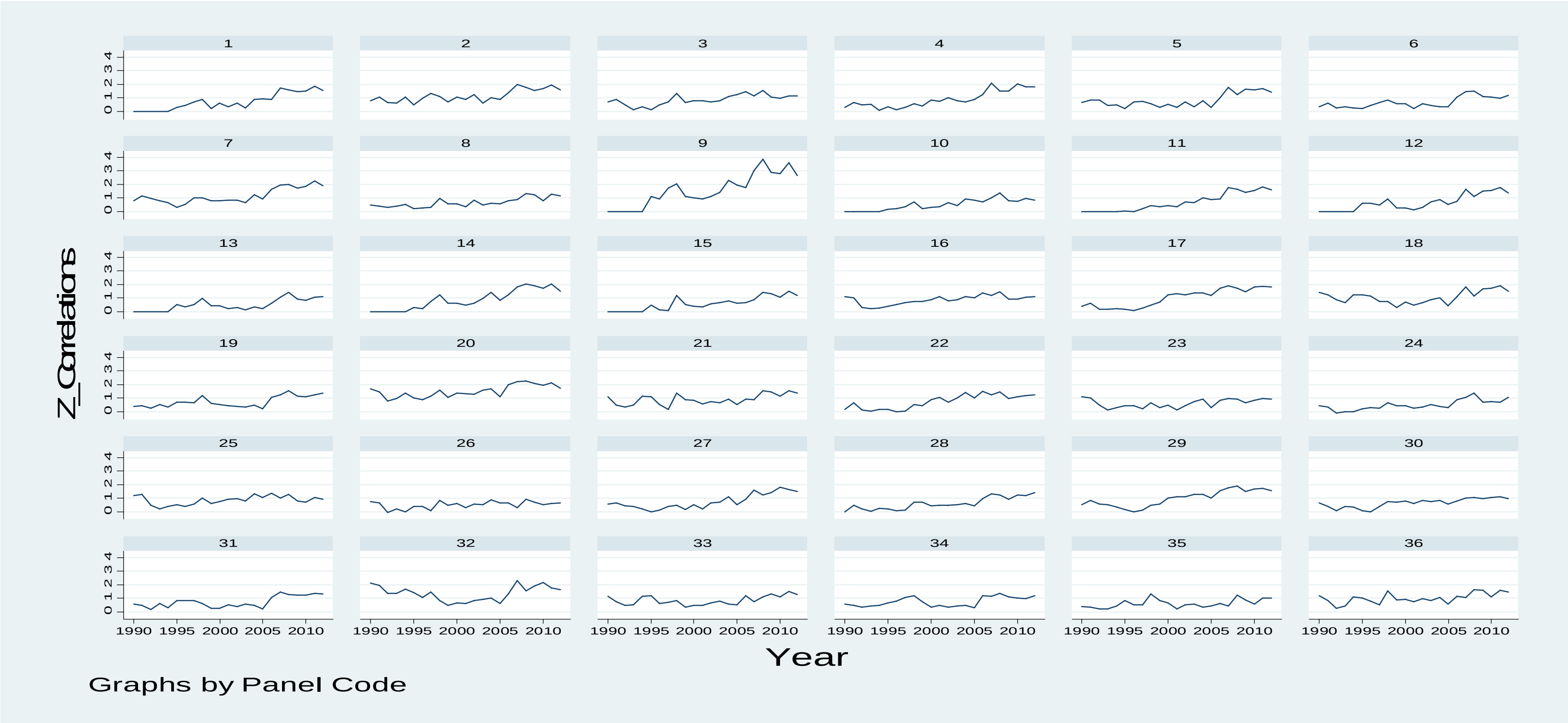
Figure 1. Time varying (Z- Fisher transform) realised correlations between stock market returns in the Pacific basin region



Note.

Panel Code: 1. Australia-China, 2. Australia-Hong Kong, 3. Australia-Japan 4. Australia-Korea, 5. Australia-Malaysia, 6. Australia-Philipines, 7. Australia-Singapore, 8. Australia-Thailand, 9. China-Hong Kong, 10. China-Japan, 11. China-Korea, 12. China-Malaysia, 13. China-Philipines, 14. China-Singapore, 15. China.-Thailand, 16. Hong Kong-Japan, 17 Hong Kong-Korea, 18. Hong Kong-Malaysia, 19. Hong Kong-Philipines, 20. Hong Kong-Singapore, 21. Hong Kong-Thailand, 22. Japan-Korea, 23. Japan-Malaysia, 24. Japan-Philipines, 25. Japan-Singapore, 26. Japan-Thailand, 27. Korea-Malaysia, 28. Korea-Philipines, 29. Korea-Singapore, 30. Korea-Thailand, 31. Malaysia-Philipines, 32. Malaysia-Singapore, 33. Malaysia-Thailand, 34. Philipines-Singapore, 35. Philipines-Thailand, 36. Singapore-Thailand.

Table 1. The descriptive statistics for the exogenous variables

Variables	Mean	Std. Dev.	Median	Min	Max	Skewness	Kurtosis	Obs
InflDif	0.033	0.032	0.024	0	0.270	2.520	13.060	828
InterDif	3.649	3.0440	2.838	0	15.632	1.256	4.285	828
IP_Dif	828	0.231	0.429	0	2.111	3.007	11.328	828
FX_VolDif	0.088	0.103	0.057	0	0.698	2.549	10.951	828
MarkCapDif	0.327	0.332	0.231	0	2.451	2.260	10.447	828
USBill	3.098	2.153	3.22	0.010	6.741	-0.161	1.647	828

Table 2. Correlation matrices across the exogenous variables

Variable	*InflDiff*	*InterDiff*	*IP_Diff*	*FX_VolDiff*	*MarCapDiff*	*USBill*
InflDif	1					
InterDif	0.355	1				
IP_Dif	0.133	0.217	1			
FX_VolDif	0.151	0.222	-0.005	1		
MarkCapDif	0.135	0.180	0.079	0.287	1	
USBill	0.308	0.345	-0.065	0.171	0.132	1

Table 3. Quantile regression results for the realisd correlations between stock market returns

(Obs. = 828)	OLS	Quantile regressions						
Variables		τ_5	τ_{10}	τ_{25}	τ_{50}	τ_{75}	τ_{90}	τ_{95}
Intercept	1.310[a]	0.502[a]	0.615[a]	0.915[a]	1.197[a]	1.635[a]	1.977[a]	2.164[a]
	(0.064)	(0064)	(0.060)	(0.054)	(0.049)	(0.054)	(0.056)	(0.091)
InflDif	-0.816[c]	0.546	-0.058	-0.592	-1.102[b]	-1.564[c]	-2.053	-1.938
	(0.475)	(0.519)	(0.362)	(0.434)	(0.512)	(0.938)	(1.351)	(1.772)
InterDif	-0.034[a]	-0.014[a]	-0.017[a]	-0.027[a]	-0.036[a]	-0.031[c]	-0.041[a]	-0.030[c]
	(0.005)	(0.005)	(0.005)	(0.007)	(0.006)	(0.011)	(0.010)	(0.016)
IP_Dif	-0.141[a]	-0.121 [a]	-0.090[c]	-0.099[c]	-0.058	-0.154[a]	-0.230[a]	-0.353[a]
	(0.029)	(0.045)	(0.050)	(0.053)	(0.040)	(0.035)	(0.035)	(0.049)
FX_VolDif	-0.636[a]	-0.440[a]	-0.558[a]	-0.578[a]	-0.630[b]	-0.385	-0.667[c]	-1.077[a]
	(0.178)	(0.157)	(0.124)	(0.175)	(0.321)	(0.393)	(0.387)	(0.394)
MarkCapDif	-0.131[b]	-0.106[a]	-0.149[a]	-0.168[b]	-0.177[b]	-0.185[c]	-0.058	-0.001
	(0.058)	(0.031)	(0.028)	(0.059)	(0.076)	(0.115)	(0.117)	(0.152)
USBill	-0.076[a]	-0.063[a]	-0.059[a]	-0.073[a]	-0.056[a]	-0.078[a]	-0.079[a]	-0.076[a]
	(0.009)	(0.015)	(0.012)	(0.012)	(0.011)	(0.013)	(0.016)	(0.022)
1997Dummy	0.205[a]	0.296[a]	0.275[a]	0.301[a]	0.235[b]	0.027	0.166	0.069
	(0.078)	(0.094)	(0.077)	(0.094)	(0.114)	(0.137)	(0.151)	(0.185)
2008Dummy	0.471[a]	0.569[a]	0.647[a]	0.515[a]	0.478[a]	0.392[a]	0.336	0.281
	(0.099)	(0.094)	(0.108)	(0.072)	(0.098)	(0.157)	(0.221)	(0.657)
2010Dummy	0.182[b]	0.179	0.256[b]	0.256[a]	0.177	0.266[b]	0.099	0.151
	(0.089)	(0.119)	(0.122)	(0.098)	(0.148)	(0.122)	(0.174)	(0.313)

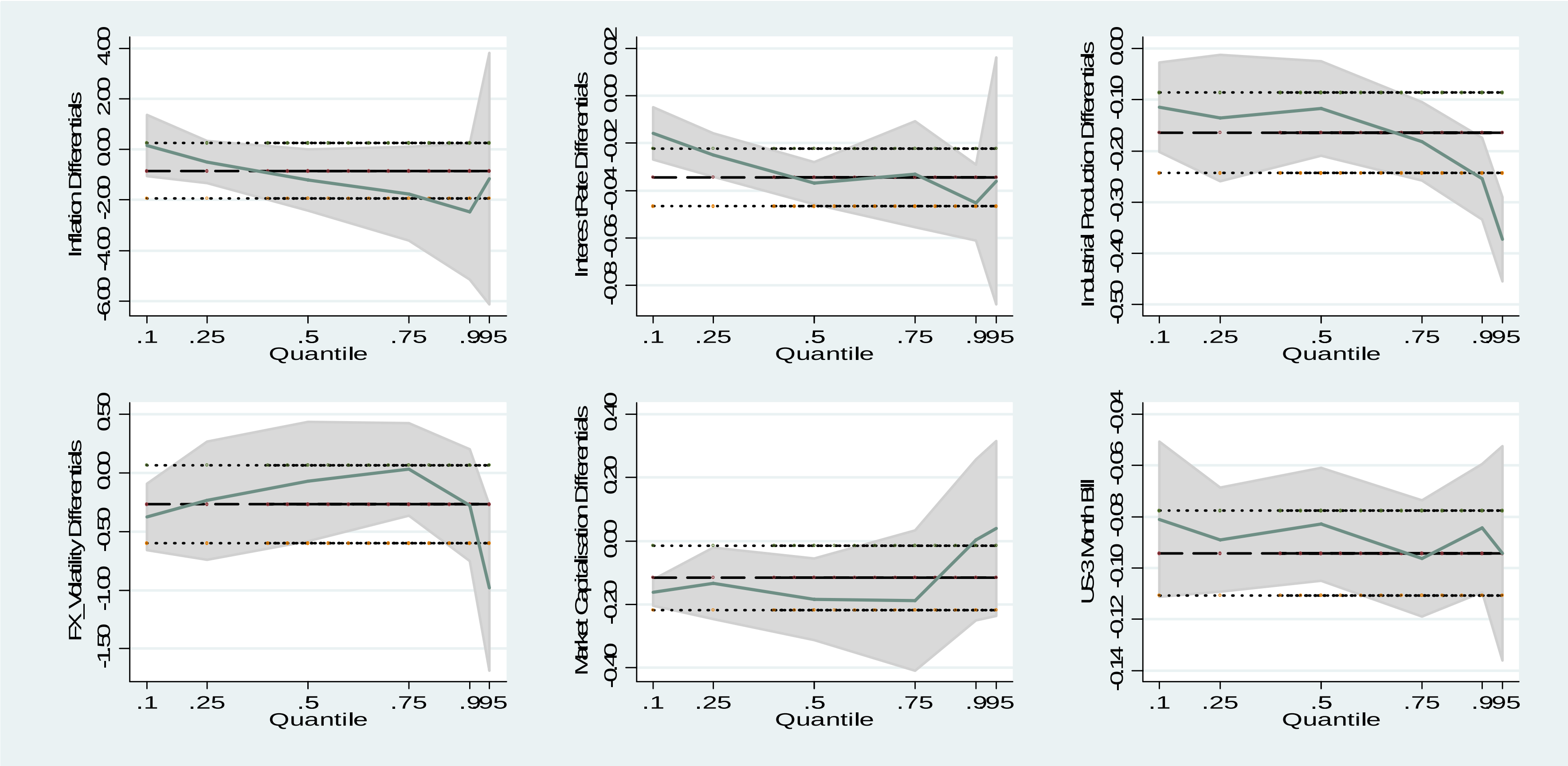
Notes. Standard errors in parentheses for the OLS estimators are robust standard errors while those in parentheses for the quantile regressions are bootstrapped standard errors obtained using 1000 replications. [a] , [b] , [c] indicate significance at the 1%,5%, 10% levels respectively.

Table 4. F statistics for coefficients on the exogenous variables across the conditional quantile regressions

	τ_5	τ_{10}	τ_{25}	τ_{50}	τ_{75}	τ_{90}
τ_{10}	0.88					
	(0.542)					
τ_{25}	2.08^{**}	1.35				
	(0.029)	(0.207)				
τ_{50}	2.87^{***}	2.22^{**}	0.87			
	(0.002)	(0.019)	(0.549)			
τ_{75}	2.80^{***}	2.22^{**}	1.08	1.61^{*}		
	(0.003)	(0.019)	(0.377)	(0.107)		
τ_{90}	3.68	3.35^{***}	1.87^{**}	2.51^{***}	1.20	
	(0.002) ***	(0.000)	(0.053)	(0.007)	(0.292)	
τ_{95}	4.52^{***}	4.39^{***}	2.93^{***}	3.70^{***}	2.31^{**}	1.17
	(0.000)	(0.00)	(0.002)	(0.000)	(0.014)	(0.312)
Homogeniety F statistic on the variables across all the quantiles: 5.94^{***}(0.000)						

Notes. p-values in parentheses are based on the bootstrap method of 1000 simulations. ***,** , and * indicate significance at the 1%,5%, and 10% levels respectively.

Figure 2. Variations in coefficient estimates for the exogenous variables



Notes. The conditional quantiles (on the x-axis) of the realised correlations distribution conditional on the first lagged exogenous variables and the intercept range from 0 (for the lowest realised correlation) to 1 (for the highest realised correlations). 95% confidence intervals (bootstrapped) extend to 2 standard errors in either direction. Horizontal lines represent the OLS estimators with 95% confidence intervals. All graphs made using the 'grqreg' stata module (Azevedo (2004).