



Global and regional stock market integration in Asia: A panel convergence approach[☆]

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ABSTRACT

This paper examines global and regional stock market integration in Asia at both the aggregate and disaggregate (industry) levels by applying the Phillips-Sul (2007) tests for panel and club convergence. Over both the whole sample (1998m12–2018m3) and the two sub-sample periods (i.e., pre- and post-2008 global financial crisis periods), the Asian stock markets appear to be integrated both globally (vis-à-vis the US) and regionally (vis-à-vis Asia) at the aggregate level, although the speed of convergence has decreased after the crisis. The industry level convergence tests reveals that, notwithstanding the aggregate convergence, there are 3 (i.e., Gas & Oil, Healthcare and Technology) out of 10 industries not exhibiting panel convergence in any sample period; further, no convergence is found for Basic Materials and Consumer Services in the pre-crisis period and Telecommunications and Utilities in the post-crisis period. The club convergence tests show this was due to the existence of convergence clubs, clubs in the turn-around phase, and divergent economies in these industries. Global and regional integration exhibited similar patterns in most cases, although the former appears to be stronger than the latter in the post-crisis period. We also find that trade linkages and stock market development promote Asia's regional stock market integration but not its global integration; real interest rate differentials and the recent financial crisis have slowed down both regional and global integration, while exchange rate risk and openness only affect the former.

1. Introduction

Cross-border financial integration is generally thought to bring benefits to an economy by lowering the costs of asset trading and offering more portfolio diversification opportunities. For these reasons many Asian countries, especially after the 1997 crisis, embarked upon regional financial deregulation programmes with the aim of removing the inefficiencies caused by the previous restrictions on capital flows and achieving welfare gains. Indeed, in the last couple of decades cross-border financial flows have increased significantly in most Asian economies (see [Park, 2013](#)). Regional initiatives boosting intra-regional trade have also stimulated financial integration as shown by changes in the composition of portfolio equity holdings (see [Lane, 2011](#)). There is also evidence that regional financial integration has been the main

funding source for domestic investment (see [Kim, Kim, & Park, 2011](#)). Subsequently, a number of studies have employed various indices to measure formally the extent of financial integration in Asia. Despite the fast growing cross-border financial activities within Asia, the majority of them suggest that Asia's global financial integration (e.g., the US) is still stronger than its regional integration, although the latter has also been growing.¹

The US has had a strong influence on Asian financial markets over time. However, regional financial integration might be an appealing alternative to globalised finance with its associated contagion risks: since the Asian region as a whole runs a large current account surplus, which means that regional saving exceeds regional investment, higher regional integration might be preferable to riskier global exposure to address the borrowing needs of individual Asian countries (see

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¹ See the Literature Review in [Section 2](#) for more detail on relevant studies.

Devereux, Lane, Park, & Wei, 2011). Analysing both global and regional integration of the Asian economies is also crucial from a policy perspective. Different degrees and patterns of financial integration have different implications for the stability of the domestic financial system and the ability of the domestic economy to absorb external shocks. Furthermore, the stage of financial integration achieved so far in emerging Asia has been far from uniform across individual economies and across different sectors (Park, 2013). Thus understanding the degree and pattern of integration across economies and sectors is important for policy makers to implement effectively policies aimed at greater regional cooperation and financial stability.

The present paper aims to provide up-to-date evidence on Asia's global and regional stock market integration across economies and industries. Its first motivation is the lack of studies analysing both aggregate and industrial level integration in the Asian stock markets and comparing Asia's regional and global integration. Our comprehensive analysis will not only reveal which industries are driving or holding back national stock market integration, but also provide industrial level explanations for the different extent of regional and global integration in the Asian stock markets. Second, the 2008 global financial crisis has sent shock waves throughout the Asian economies, and it is therefore crucial from a policy perspective to understand whether the post-crisis Asian stock markets have become more inward-looking (i.e., more integrated within the region), or whether instead investors in these markets have become more synchronised with their traditional leader, the US market. Hence analysing the pre- and post-2008 crisis separately is very important, yet very few studies have done so for the Asian stock markets and none at the industrial level; our analysis fills this gap. Third, our literature review suggests that previous studies on Asian stock market integration have mostly employed conventional correlation, cointegration, β - or σ -convergence analysis. Compared with these methods, the Phillips and Sul (2007) panel convergence procedure adopted here is able to detect sub-groups of converging markets as well as diverging economies in a panel whilst allowing for a wide range of possible time paths and individual heterogeneity. For any convergence group detected, the method can also provide information on the speed of convergence. Such properties make this panel procedure an ideal tool in the comparative context of regional versus global financial integration.

Therefore, in this paper we employ the Phillips and Sul (2007) panel convergence method to analyse the regional and global integration for the Asian stock markets at both national and industry levels, paying special attention to the pre- and post-2008 crisis period. Building on the relative transitional parameters obtained above, we then further investigate the role of economic and financial factors (in addition to the 2008 financial crisis) in explaining the integration process. Such a two-step approach links stock market integration with the underlying economic and financial conditions. More importantly, since the Phillips and Sul (2007) tests (see Section 4) suggest that integration has slowed down after the 2008 crisis, the results in the second step are informative about the effects of the crisis on the integration process taking into account various economic and financial factors.

The layout of the paper is as follows. Section 2 reviews the relevant literature. Section 3 outlines the empirical method used for the analysis, namely the Phillips and Sul (2007) convergence tests. Section 4 describes the data and discusses the empirical findings. Section 5 provides robustness checks using β -convergence tests and different data frequency. Section 6 examines the economic and financial factors driving convergence. Section 7 concludes and highlights the policy implications of the analysis.

2. Literature review

There are three main types of measures of financial integration in the existing literature, based on prices, volume and regulatory or institutional factors respectively. The first is often embodied in interest

parities conditions in the money markets or in co-movements in assets returns in stock and bond markets. Studies employing volume-based measures often examine the saving-investment correlations pioneered by Feldstein and Horioka (1980), consumption correlations (e.g., Bayoumi, 1997; de Browuer, 1999) and capital flows (cross-border financial transactions) (e.g., Cavoli, Rajanb, & Siregarc, 2006). The third type is often based on the presence or not of capital controls and legal restrictions such as those on foreign equity holdings (e.g., Grilli & Milesi-Ferretti, 1995; Magud & Reinhart, 2006).²

Price-based measures have been most often employed to analyse Asian stock market integration. Both (time-varying) correlations and vector autoregression (VAR) (cointegration) models with impulse response analysis have been used in various papers (see Sharma & Seth, 2012). Some recent correlation studies include Loh (2013) (applying the wavelet coherence method), Abid, Kaabia, and Guesmi (2014) (using the multivariate general dynamic covariance-generalised autoregressive conditional heteroskedasticity (GARCH) model), Boubakri and Guillaumin (2015), Narayan, Srikanthakumar, and Islam (2014) (both using GARCH-dynamic conditional correlations), Dewandaru, Masih, and Masih (2015) (using wavelet decomposition techniques), Cao, Zhang, and Li (2017) (using volatility constrained multifractal detrended cross-correlation analysis) and Wang, Zhu, Yang, and Mul (2017) (using the coupling de-trended fluctuation analysis method).

In the context of VAR models, Huyghebaert and Wang (2010) and Wang (2014) examine both long- and short-term linkages in Asian stock markets using cointegration tests and impulse response analysis in turn. Gupta and Guidi (2012) and Chien, Lee, Hu, and Hu (2015) focus on India and China respectively within a cointegration framework. On the whole the available evidence suggests an increasing level of financial integration in Asian stock markets, which becomes stronger in response to shocks. Some recent studies have specifically examined whether this reflected global or regional integration (e.g., Jeon, Oh, & Yang, 2006; Hinojales & Park, 2011; Park & Lee, 2011; Kim, Kim, & Park, 2011; Kim & Lee, 2012). Typically these studies employ either correlation or VAR analysis. In general they find that financial integration with the rest of the world is greater than within the region, although regional integration is also growing.

The absence (existence) of integration at the aggregate stock market may conceal the existence (absence) of integration at the disaggregated industry level markets. Examining a large group of both developed and developing economies including a number of Asian countries, Apergis, Christou, and Miller (2014) and Tam and Tam (2012) find different patterns of convergence between aggregate and industry level stock markets. Focusing on Asian stock markets, Hinojales and Park (2011) provide industry level evidence for three industries (i.e., Industrials, Financials, and Technology, Media and IT) in addition to aggregate level analysis.

The 2008 global financial crisis had an immediate impact on the Asian stock markets as shown by the sharp decline in stock indices and their higher volatility during 2008–2009 (Figs. 1 and 2). Wu, Meng, and Xu (2015) examine the transmission of shocks (contagion) from the US, Japan, and Hong Kong to other Asian countries and find the US stock market was cointegrated with the Asian stock markets during the pre- and post-2008 financial crisis periods. Wang (2014) employs causality, cointegration and impulse response analysis and finds stronger stock markets linkages between the Asian economies during the crisis and

² Other measures include one based on the concept of international capital market completeness (Kearney & Lucey, 2004) and news-based measures that test whether returns on assets across countries are influenced by local or world-wide news as an indication of financial integration (e.g., Baele, Fernando, Hordahl, Krylova, & Monnet, 2004; Baltzer, Cappiello, & Santis, 2008). A recent price-based measure put forward by Volosovych (2011, 2013) and also employed in Donadelli and Paradiso (2014) is an integration index in the context of capital market integration obtained from a dynamic principal component analysis.

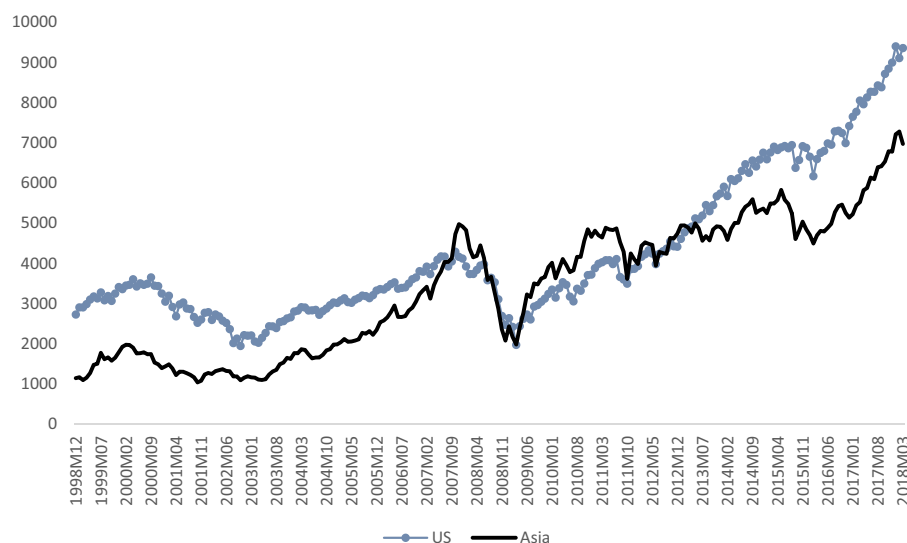


Fig. 1. US and Emerging Asia stock indices (total return) (1998m12–2018m3).

Note: The regional index of Morgan Stanley Capital International (MSCI) Asia (excluding Japan) includes the 12 Asian economies which are China (PRC), Hong Kong, India, Indonesia, Malaysia, Pakistan, Philippines, Singapore, South Korea, Sri Lanka, Taiwan, and Thailand.

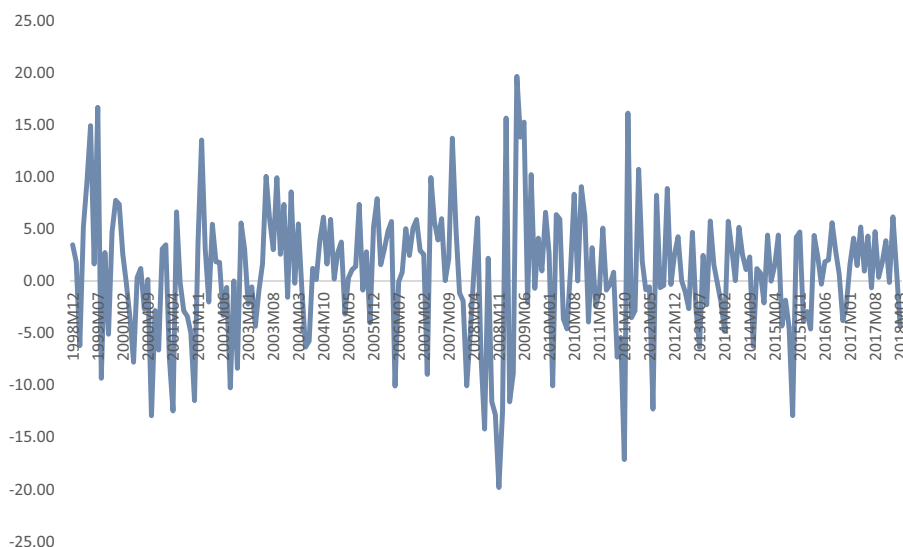


Fig. 2. Regional Stock Returns (%) of Emerging Asia (1998m12–2018m3).

also that these markets have become less responsive to shocks from the US after the crisis.

As for studies that have focused on convergence in stock market returns, [Park \(2013\)](#) examines global and regional integration in Asia by measuring both β - and σ -convergence (see [Barro & Sala-i-Martin, 1991, 1992](#)) in emerging Asia and some sub-groupings as a measure of financial market integration. Her results indicate an acceleration in the regional integration of financial markets in Asia's emerging economies in recent years, although these markets remain more integrated globally than regionally.

From the discussion above the following important points emerge. First, most previous studies employ national stock indices in Asia – very few of them have analysed industry level data to establish which industries are the driving force of Asian stock market integration, both globally and regionally. Although [Hinojales and Park \(2011\)](#) have done so, their analysis is restricted to three industries and based on correlations only; [Apergis et al. \(2014\)](#) and [Tam and Tam \(2012\)](#) cover more industries but the Asian countries are included in a large group of both developed and developing economies and neither analyse global versus regional integration in Asia. Second, none of these three studies specifically evaluates the impact of the 2008 global financial crisis on the integration process. The previously mentioned [Wu et al. \(2015\)](#) and

[Wang \(2014\)](#) analyse it but only at the aggregate level. The former focus on the transmission of shocks various markets to Asia and hence integration among Asian stock market themselves is not explained. Both studies are mainly based on cointegration analysis and no industry level evidence is presented. Third, all these studies use standard methods such as (time-varying) correlations and VAR (cointegration) models with impulse response analysis, but none examines the existence of convergence clubs and the speed of convergence as in the [Phillips and Sul \(P-S\) \(2007\)](#) panel convergence method. Given its club formation procedure, the P–S method is more powerful than the conventional β - and σ -convergence methods employed in [Park \(2013\)](#), yet it has rarely been applied to analyse global and regional stock market integration in Asia.³

Therefore, the present study aims to fill these gaps by investigating

³ Note that [Apergis et al. \(2014\)](#) and [Tam and Tam \(2012\)](#) also employed the P–S method for a panel of over 40 countries that include a number of Asian economies. However, neither paper analyses global versus regional integration of Asia, the former only covers the period up to 2008, and the latter does not consider either the impact of the recent global financial crisis nor club convergence (it uses stock valuation ratios such as earnings-, dividend-, and book-price ratios for the analysis).

global and regional integration in Asian stock markets at both the aggregate and industry level, employing the P-S (2007) panel convergence method. We also assess in particular the impact of 2008 global financial crisis on the integration process. Following Park (2013), we employ stock market returns to examine financial integration in Asia. To compare global and regional integration, convergence is estimated on stock return differentials between Asian economies and the US (as an indicator of global integration) and a regional index (as an indicator of regional integration). β -convergence method and alternative data frequency are also employed for robustness checks. Furthermore, following the Phillips and Sul (2007) panel convergence results, we estimate the influence of a number of economic and financial factors on the global and regional integration process, and specifically the impact of the 2008 global financial crisis.

3. The methodology – The Phillips and Sul panel convergence tests

Barro and Sala-i-Martin (1991, 1992) introduced the concepts of β - and σ -convergence, the former implying mean reversion for the panel units, whilst the latter is a reduction in overall cross-section dispersion. Islam (2003) highlighted some problems with standard convergence tests (see also Bernard & Durlauf, 1996; Durlauf & Quah, 1999): the implications of growth models for absolute convergence and convergence “clubs” are not clear; different tests do not have the same null hypothesis and therefore are not directly comparable; most tests are based on rather specific and restrictive assumptions about the underlying panel structures.

A new non-linear, time-varying coefficient factor model without such limitations has been developed by Phillips and Sul (2007), who proposed a regression-based test together with a clustering procedure. Their approach is not dependent on stationarity assumptions and allows for a wide variety of possible transition paths towards convergence (including sub-group convergence). Specifically, it is based on a time-varying factor model using common stochastic trends, which can accommodate long-term co-movement in aggregate behaviour outside the cointegration framework and allows for the modelling of transitional effects. Being based on such a time-varying factor model, the Phillips and Sul (2007) method is more powerful than the traditional β - and σ -convergence tests, and it provides estimates of the speed of convergence for both the full panel and sub-groups through its club formation procedure.

The Phillips and Sul method is also more suitable to examine Asian financial integration than other techniques such as the dynamic copulas and asymmetric dynamic conditional correlation models that study cross-market financial linkages (e.g., Cappiello, Engle, and Sheppard (2006), Patton (2006), Jondeau and Rockinger (2006), Bartram, Taylor, and Wang (2007), Okimoto (2008), Kenourgios, Samitas, and Paltalidis (2010)).⁴ These two alternative types of methods often focus on pairwise interdependence, or linkages between one market and all others. In contrast, the PS method has the advantage of considering the behaviour of all members as a panel yet allowing for a wide range of possible time paths and individual heterogeneity, making it an ideal tool to investigate the financial integration of a group of Asian economies. In addition, while it is important to recognise hiked correlations during crisis period (as observed in the above mentioned studies), a stronger correlation during such a period does not necessarily imply the same for the subsequent period. Thus information on the post-crisis convergence process obtained through the Phillips and Sul method can provide valuable information to national authorities and investors for

designing their policies and investment strategies respectively.⁵ This method is explained in detail below.

3.1. Relative transition

Phillips and Sul (2007) (P–S) proposed the new time-varying loading factor representation for the panel variable X_{it} :

$$X_{it} = \delta_{it}\mu_t, \quad (1)$$

where μ_t is a single common component and δ_{it} is a time-varying factor-loading coefficient that measures the idiosyncratic distance between the common trend components μ_t and X_{it} .

To obtain information about the time-varying factor loading δ_{it} , Phillips and Sul (2007) employed the relative version of δ_{it} , the relative loading factor or the relative transition parameter, as follows:

$$h_{it} = \frac{X_{it}}{\frac{1}{N} \sum_{i=1}^N X_{it}} = \frac{\delta_{it}}{\frac{1}{N} \sum_{i=1}^N \delta_{it}}, \quad (2)$$

where h_{it} is the relative transition parameter that measures δ_{it} in relation to the panel average at time t and therefore describes the transition path for country or area i relative to the panel average. If δ_{it} converge to δ , then the relative transition parameters h_{it} converge to unity. In this case, the cross-sectional variance of h_{it} , H_t , converges to zero in the long run:

$$H_t = \frac{1}{N} \sum_{i=1}^N (h_{it} - 1)^2 \rightarrow 0 \text{ as } t \rightarrow \infty. \quad (3)$$

3.2. The log t convergence test

P–S proposed a simple regression-based testing procedure to examine the null of convergence, $H_0: \delta_i = \delta$ and $\alpha \geq 0$, against the alternative of $H_A: \delta_i \neq \delta$ or $\alpha < 0$. The procedure involves three steps. First, the cross-sectional variance ratio H_1/H_t is calculated, given that $H_t = \frac{1}{N} \sum_{i=1}^N (h_{it} - 1)^2$. Second, the following ordinary least squares regression is run, and a conventional robust t statistics, $t_{\hat{\alpha}}$, is calculated for the coefficient $\hat{\alpha}$ using the estimate of the long-run variance of the regression residuals:

$$\log\left(\frac{H_1}{H_t}\right) - 2\log L(t) = \hat{\alpha} + \hat{\beta} \log t + \hat{u}_t, \quad (4)$$

for $t = [rT], [rT] + 1, \dots, T$ with some $r > 0$. P–S recommended $r = 0.3$ on the basis of their simulations. Other settings of the regression include $L(t) = \log(t + 1)$ and the fitted coefficient of $\log t$ is $\hat{\alpha} = 2\hat{\alpha}$, where $\hat{\alpha}$ is the estimate of α under the null. A one-sided t test of null $\alpha \geq 0$ using $\hat{\alpha}$ is then performed and the null of convergence is rejected at a 5% significance level if $t_{\hat{\alpha}} < -1.65$.

Note that $\hat{\alpha} \geq 1$ and, accordingly, $\hat{\alpha} \geq 2$ implies level (i.e., absolute) convergence and that $1 > \hat{\alpha} \geq 0$ and therefore $2 > \hat{\alpha} \geq 0$ implies rate (i.e., conditional) convergence.

3.3. Club convergence and clustering

Rejection of the null of full-panel convergence does not imply that there is no convergence. There may be one or more convergent clusters as well as divergent units in the panel. P–S provided a four-step algorithm to detect such units of clusters that is based on repeated log t

⁴ Compared with copula and the asymmetric dynamic conditional correlation models that have the capacity to measure and test asymmetry in the tail dependence, the standard non-parametric measures of tail dependence have poor finite-sample properties and generally reject such asymmetry (Jondeau, 2016).

⁵ Both dynamic copulas and dynamic conditional correlation models could be extended to account for asymmetry in the tail dependence (see Kenourgios et al. (2010) for an example). Although the Phillips and Sul method does not specifically address such asymmetry from the joint distribution perspective, it can accommodate asymmetries in the convergence process in the sense that it allows for heterogeneity in the speed of convergence and transition effects over time for the panel members.

regressions and involves the following steps:

- (i) Order the panel units X_{it} according to the last observation, X_{iT} .
- (ii) Select the first k highest panel units ($N > k \geq 2$) and calculate $t_{\hat{\beta}}(k)$ for each k . The core group size k^* is chosen according to $k^* = \arg\max_k \{t_{\hat{\beta}}(k)\}$ subject to $\min\{t_{\hat{\beta}}(k)\} > -1.65$. If $k^* = N$, there is full-panel convergence. If $\min\{t_{\hat{\beta}}(k)\} > -1.65$ does not hold for $k = 2$, drop the first unit and perform the same procedure for the remaining units. If $\min\{t_{\hat{\beta}}(k)\} > -1.65$ does not hold for every subsequent pair of units, there are no convergent clusters in the panel.
- (iii) Add one remaining unit at a time to the core group and perform the $\log t$ test. If the corresponding t statistic from this regression, \hat{t} , exceeds a chosen critical value, c ,⁶ then include the unit in the current subgroup. The $\log t$ test is run for this sub-group, and if $t_{\hat{\beta}} > -1.65$, the formation of the sub-group is completed. Otherwise, increase the critical value c and repeat the procedure.
- (iv) A subgroup of the units is formed for which $\hat{t} < c$ in (iii). Run the $\log t$ test for this subgroup, and if $t_{\hat{\beta}} > -1.65$, this cluster converges, and there are two convergent sub-groups in the panel. Otherwise, repeat (i)–(iii) on this sub-group to determine whether a smaller convergent sub-group exists. If there is no k in (ii) for which $t_{\hat{\beta}}(k) > -1.65$, the remaining units diverge.

The Phillips and Sul (2007) method has been employed for a range of developed stock markets. For instance, Caporale, Erdogan, and Kuzin (2015) apply it to test for convergence in the stock returns of five EU countries (Germany, France, the Netherlands, Ireland and the UK) as well as the US between 1973 and 2008, for both sectors and individual industries within sectors. In the context of global and regional financial integration in Asia, it has been applied to the money and bond market by Rughoo and You (2016).

4. Empirical analysis

4.1. Data – the stock return differentials

The Asian economies included in our study are China (PRC), Hong Kong, India, Indonesia, Malaysia, Pakistan, Philippines, Singapore, South Korea, Sri Lanka, Taiwan, and Thailand. These markets are chosen following the Morgan Stanley Capital International's (MSCI) classification of the Asian economies (excluding Japan). Japan is not in the sample as it is widely regarded as a highly developed country compared with other economies in the Asian region.

Following Park (2013), we employ stock market returns to examine global and regional financial integration in Asia. Specifically, convergence is estimated on stock return differentials between the Asian economies and the US (as an indicator of global integration) and a regional index (as an indicator of regional integration). A similar way of measuring global and regional integration in Asia has also been employed by Rughoo and You (2016) on money and bond markets.

The data source is Datastream and the frequency is monthly. Stock market returns are calculated as monthly log first differences. The sample covers the period 1998M12–2018M3. Then two sets of return differentials are constructed vis-à-vis the US and Asia. Note that the latter is the regional index of MSCI Asia (excluding Japan) which includes the 12 Asian economies mentioned above. The MSCI index is a market capitalisation weighted index created by combining individual market indices.⁷ If the Asian stock markets are integrated with the US

market, then return differentials using the US as the benchmark should converge. If these markets are integrated regionally, convergence should be found when regional index is used as a benchmark.

We employ data at both the aggregate and industry level. The following ten sectors are included in the analysis: 1) Basic Materials, 2) Consumer Goods, 3) Consumer Services, 4) Financials, 5) Healthcare, 6) Industrials, 7) Oil & Gas, 8) Technology, 9) Telecommunications, and 10) Utilities. Return differentials at industry level are calculated in the same way as the aggregate data discussed above.

The descriptive statistics of the monthly return series are presented in Table 1. For the whole sample period, the average stock market returns are positive for most economies except China, Taiwan and Singapore (vis-à-vis Asia only). As for the two sub-sample periods, all markets performed on average better than the US in the pre-crisis period but 7 out of 12 countries lost this momentum after the crisis. At the regional level, China, Taiwan and Singapore have performed consistently worse on average than the region in both sub-periods. Other poorly performing economies include HK, Philippine and Thailand in the pre-crisis period and Malaysia and South Korea in the post-crisis one. China and Pakistan are the most volatile markets regardless of the period considered, with Sri Lanka also becoming relatively volatile in the post-crisis period. For most markets the skewness coefficients are positive and imply that the return distributions are skewed to the right. However, India and Pakistan exhibit negative skewness coefficients in both the whole and the pre-crisis periods, and Indonesia, Taiwan and South Korea in the post-crisis period. The Kurtosis values are below three in most instances, which suggests that the series are platykurtic.

4.2. Logt test results

Following Phillips and Sul's (2007) recommendation, we apply the Hodrick and Prescott (1997) filter⁸ to remove the cycle component of each series prior to carrying out the convergence test on the return differentials. The first step is to examine full-panel convergence applying the logt test. The test results for the whole sample period (1998m12–2018m3) are displayed in Panel A of Table 2.

At the aggregate level, the null of convergence cannot be rejected at the 5% level for both cases, suggesting both global and regional integration. Indeed the corresponding relative transition parameters (see Figs. 3–4) show that the Asian economies are moving closer to the panel mean over time. Given that $2 > \hat{b} \geq 0$, there is conditional convergence (convergence in rates) in both sets of return differentials. In terms of the speed of convergence, \hat{b} is slightly higher for differentials relative to Asia than to the US, which suggests that regional convergence is marginally faster than the global one.

As discussed earlier, convergence at the aggregate level may reflect convergence at industry level but it may also conceal the existence of non-convergent industries. Given that investors may more easily arbitrage profitable opportunities away at the industry level rather than the market level (Poterba & Summers, 1998), we investigate further the sector level results. As shown in Panel A of Table 2, the null of convergence cannot be rejected in for 7 out of 10 sectors. The three exceptions are Oil & Gas, Healthcare, and Technology. Although convergence is absent in these three sectors, convergence in the other 7 sectors leads to convergence at the aggregate level. This is the case for both sets of return differentials.

(footnote continued)
1882b4470059.

⁸ The HP filter is chosen as it is an optimal filter when the goal is to analyse the behaviour of a variable across series as opposed to relying on it purely as a detrending method. The HP filter can remove more information on the data than may be desirable but it is a suitable filter if the objective is to measure long term equilibria (see Rughoo & You, 2016). The smoothing parameter is set to 14,400 because the data frequency is monthly.

⁶ Note that, following Phillips and Sul (2009), we set $c = 0$, as the number of observation is not particularly large.

⁷ More information on the MSCI Global Investable Market Indexes Methodology can be found at: https://www.msci.com/documents/10199/7366222/MSCI_GIMIMethodology_Jun2019.pdf/5dc8116b-6d0f-bdd2-7f51-

Table 1
Descriptive statistics of stock returns differentials.

National aggregate returns (vis-à-vis the US)												
Whole sample period				Post-2008 crisis				Post-2008 crisis				
(1998M12–2018M3)				(1998M12–2009M5)				(2009m6–2018m3)				
Mean (%)	S.D. (%)	Skewness	Kurtosis	Mean (%)	S.D. (%)	Skewness	Kurtosis	Mean (%)	S.D. (%)	Skewness	Kurtosis	
China	−0.10	8.65	0.46	1.18	0.52	9.80	0.49	0.39	−0.83	7.03	0.03	2.41
India	0.68	6.70	−0.25	1.67	1.38	7.97	−0.62	0.75	−0.16	4.68	1.01	5.65
HK	0.21	4.55	0.31	1.84	0.63	4.88	0.56	1.15	−0.29	4.09	−0.34	2.73
Indonesia	0.62	6.72	0.21	3.14	0.98	8.07	0.13	2.10	0.20	4.64	0.05	1.31
Malaysia	0.31	5.25	0.71	2.85	0.89	6.51	0.45	1.30	−0.37	3.06	0.41	0.22
Philippine	0.27	5.56	0.39	2.09	0.37	6.57	0.32	1.21	0.14	4.05	0.45	2.24
Singapore	0.11	4.02	0.70	2.23	0.56	4.69	0.42	1.35	−0.42	2.99	1.05	2.94
Thailand	0.34	6.84	0.69	3.97	0.43	8.22	0.72	2.73	0.23	4.74	−0.04	2.52
Taiwan	−0.12	5.44	0.19	3.94	0.16	6.80	0.10	2.15	−0.44	3.13	−0.18	0.41
S. Korea	0.39	5.41	0.63	1.71	1.16	6.57	0.39	0.59	−0.54	3.40	0.04	−0.18
Pakistan	1.00	8.13	−0.91	8.75	1.46	10.08	−1.01	6.37	0.44	4.87	0.23	0.03
Sri Lanka	0.72	7.06	0.28	0.86	1.21	7.84	0.13	0.79	0.12	5.98	0.44	0.26

National aggregate returns (vis-à-vis Asia)												
Whole sample period				Post-2008 crisis				Post-2008 crisis				
(1998M12–2018M3)				(1998M12–2009M5)				(2009m6–2018m3)				
Mean (%)	S.D. (%)	Skewness	Kurtosis	Mean (%)	S.D. (%)	Skewness	Kurtosis	Mean (%)	S.D. (%)	Skewness	Kurtosis	
China	−0.34	8.31	0.40	1.10	−0.21	9.33	0.47	0.46	−0.50	6.95	0.13	2.25
India	0.43	5.05	−0.16	1.95	0.66	6.09	−0.32	1.01	0.17	3.45	0.49	2.01
HK	−0.03	2.60	0.17	1.52	−0.09	3.09	0.19	0.95	0.04	1.89	0.15	−0.07
Indonesia	0.38	5.56	−0.37	2.02	0.25	6.73	−0.29	0.96	0.53	3.73	−0.34	1.67
Malaysia	0.07	4.72	0.17	0.55	0.16	5.50	0.11	0.02	−0.04	3.60	0.26	0.68
Philippine	0.02	5.12	−0.03	0.64	−0.36	5.99	0.05	0.20	0.47	3.82	0.15	−0.12
Singapore	−0.13	2.95	0.06	0.42	−0.17	3.29	0.07	0.16	−0.09	2.48	0.08	0.43
Thailand	0.09	5.68	0.04	2.39	−0.30	6.90	0.15	1.39	0.56	3.73	0.16	0.34
Taiwan	−0.36	4.52	0.15	1.45	−0.57	5.31	0.27	0.84	−0.11	3.37	−0.14	1.38
S. Korea	0.14	4.56	0.95	5.18	0.44	5.40	1.04	3.64	−0.21	3.30	−0.41	5.02
Pakistan	0.75	8.82	−1.51	10.55	0.73	10.54	−1.66	9.01	0.77	6.22	0.17	1.51
Sri Lanka	0.47	7.69	0.06	1.03	0.49	8.71	0.07	0.79	0.45	6.31	0.01	0.44

Table 2
Log *t* convergence tests for the whole sample (1998M12–2018M3) (Panel A), pre- (1998M12–2009M5) (Panel B) and post-crisis period (2009m6–2018m3) (Panel C).

Aggregate/sectors	Panel A: whole sample (1998M12–2018M3)				Panel B: pre-crisis period (1998M12–2009M5)				Panel C: post-crisis period (2009m6–2018m3)			
	Stock return differentials vis-à-vis the US		Stock return differentials vis-à-vis regional index of Asia		Stock return differentials vis-à-vis the US		Stock return differentials vis-à-vis regional index of Asia		Stock return differentials vis-à-vis the US		Stock return differentials vis-à-vis regional index of Asia	
	b	<i>t</i> -Stat	b	<i>t</i> -Stat	b	<i>t</i> -Stat	b	<i>t</i> -Stat	b	<i>t</i> -Stat	b	<i>t</i> -Stat
Aggregate stock market indices	0.749*	36.769	0.800*	40.432	1.105*	7.195	1.120*	7.28	0.723*	2.721	0.678*	2.529
Oil & Gas	−0.856	−7.377	−0.864	−6.791	−0.557 ^T	−1.534	−0.507 ^T	−1.364	−0.468 ^T	−1.516	−0.587	−1.864
Basic Materials	1.027*	17.573	1.085*	16.869	−0.078	−2.362	−0.076	−2.313	0.530*	1.933	0.433*	1.587
Industrials	0.117*	2.233	0.192*	3.682	0.367*	0.940	0.372*	0.960	1.542*	20.959	1.526*	21.048
Consumer Goods	0.445*	6.214	0.492*	6.292	0.634*	12.614	0.650*	12.315	0.591*	1.429	0.514*	1.220
Healthcare	−1.189	−6.947	−1.155	−6.281	−0.809	−2.658	−0.799	−2.522	−0.762	−2.035	−0.814	−2.117
Consumer Services	0.665*	6.331	0.722*	7.859	−1.132	−17.587	−1.110	−16.163	0.715*	2.583	0.664*	2.319
Telecommunications	0.205*	0.542	1.619*	52.140	0.063*	0.362	0.068*	0.438	−0.816	−7.850	−0.800	−7.802
Utilities	0.246*	2.491	0.282*	2.680	0.271*	0.659	0.265*	0.637	−0.211 ^T	−0.733	−0.232 ^T	−0.790
Financials	1.196*	56.119	1.266*	54.636	0.663*	3.847	0.596*	3.419	0.420*	1.874	0.375*	1.646
Technology	−0.081	−2.324	−0.074	−2.066	−0.317	−6.333	−0.306	−5.291	−2.026	−3.766	−2.010	−3.721

Note: For the Aggregate Stock Market Indices, Consumer Goods, Financials and Industrials Sectors, all 12 Asian economies are included. Due to data limitation, Singapore and Sri Lanka are not included for Basic Materials sector; Indonesia for Consumer Services sector; Hong Kong, Malaysia, Philippine, Taiwan, and Sri Lanka for Healthcare sector, Indonesia and Taiwan for Oil & Gas sector; Indonesia, Malaysia, Philippines, Pakistan, and Sri Lanka for Technology sector, Taiwan and Sri Lanka for Telecommunications sector; Indonesia, Singapore, Taiwan and Sri Lanka for Utilities sector. Same applies to Tables 3, 4 and 6.

* Indicates rejection of the null hypothesis of convergence at the 5% significance level.

^T Indicates transitional divergence and turn-around phase.

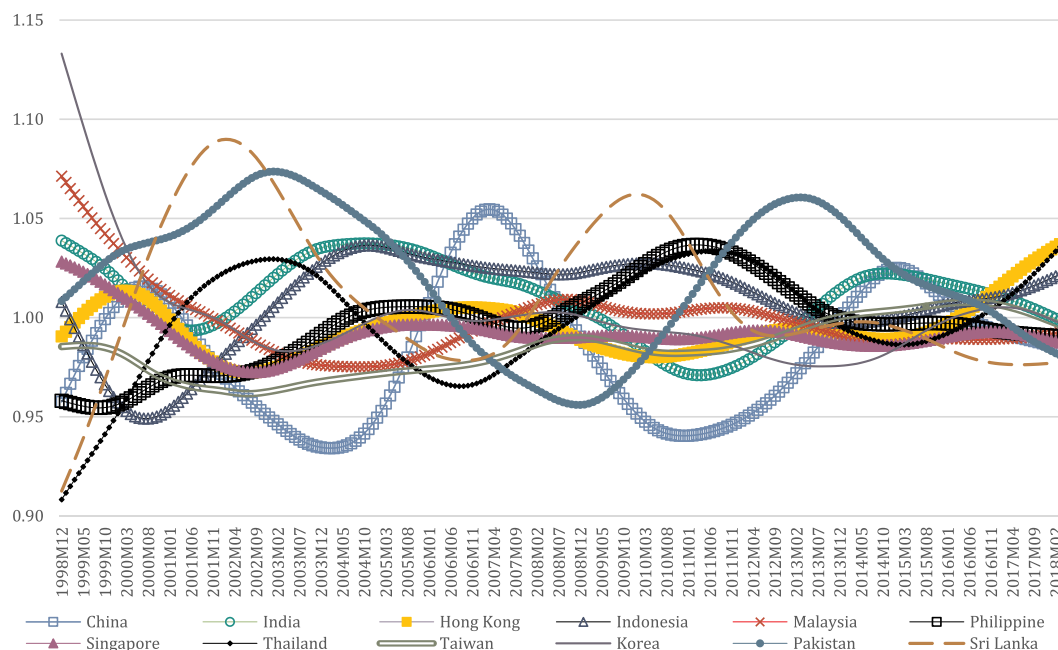


Fig. 3. Relative Transition Parameters: Return differentials vis-à-vis the US (Aggregate Indices, 1998m12–2018m3).

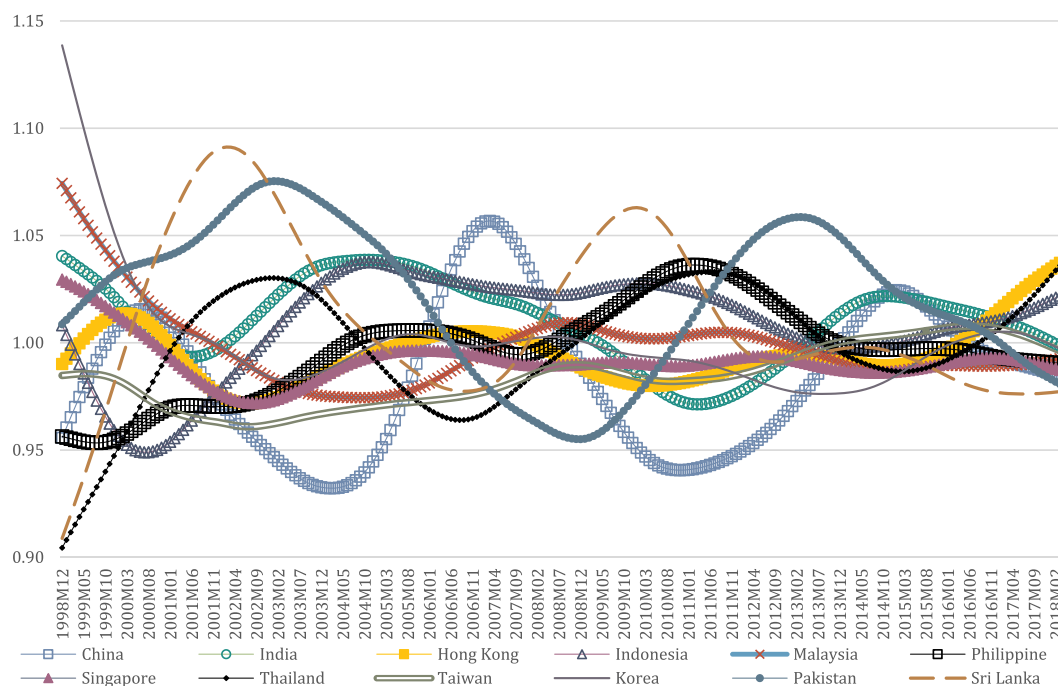


Fig. 4. Relative Transition Parameters: Return differentials vis-à-vis Asia (Aggregate Indices, 1998m12–2018m3).

Therefore, it appears that there is both global and regional integration at the aggregate level in 7 out of 10 industries. There is stronger evidence of regional than global integration at both the aggregate and sector level since the speed of convergence (\hat{b}) is consistently faster (though by a small amount) in the former case. This is in contrast to the studies by Jeon et al. (2005), Hinojales and Park (2011), Park and Lee (2011), Kim, Kim, and Park (2011), Kim and Lee (2012), where global integration is found to be stronger. While these studies focus mainly on pre-2008 financial crisis period, our analysis covers a longer time span including the post-crisis period. This confirms that financial integration has become stronger in Asia over the years through a rapid expansion of Asian markets and various cooperation

mechanisms (Rillo & dela Cruz, 2016).

4.3. Club convergence results

As argued by Phillips and Sul (2007), a rejection of full-panel convergence on the basis of the logt test does not rule out the possibility of club convergence and the presence of divergent members. Hence our next step is to apply the P–S clustering algorithm to the above identified three sectors for which full panel convergence is rejected. The results are presented in Table 3.

4.3.1. Oil & gas sector

For this sector, in the case of return differentials vis-à-vis the US,

Table 3

Club convergence tests for Oil & Gas, Healthcare, and Technology sectors (1998M12–2018M3).

Sectors	Stock return differentials vis-à-vis the US				Stock return differentials vis-à-vis regional index of Asia			
			b	t-Stat			b	t-Stat
Oil & Gas	Club 1	Hong Kong Korea	−0.644 ^T	−0.541	Club 1	Hong Kong Korea	−0.650 ^T	−0.522
	Club 2	India Thailand	−2.050 ^T	−1.462	Club 2	India Thailand	−1.955 ^T	−1.436
	Club 3	China Malaysia Philippines Singapore Pakistan Sri Lanka	0.061 [*]	2.122	Club 3	China Malaysia Philippines Singapore Pakistan Sri Lanka	0.058 [*]	2.103
Healthcare	Club 1	China Korea	−0.585 ^T	−0.327	Club 1	China Singapore Korea	0.004 [*]	0.037
	Club 2	Singapore Thailand	−1.629 ^T	−0.650	Club 2	India Indonesia Thailand	−0.899 ^T	−1.138
	Club 3	India Indonesia Pakistan	−0.227 ^T	−1.530	Club 3	Divergent	Pakistan	
Technology	Club 1	Hong Kong Korea	−3.790 ^T	−1.588	Club 1	Hong Kong Korea	−3.781 ^T	−1.578
	Club 2	China India Singapore Thailand Taiwan	1.037 [*]	22.185	Club 2	China India Singapore Thailand Taiwan	1.048 [*]	23.025

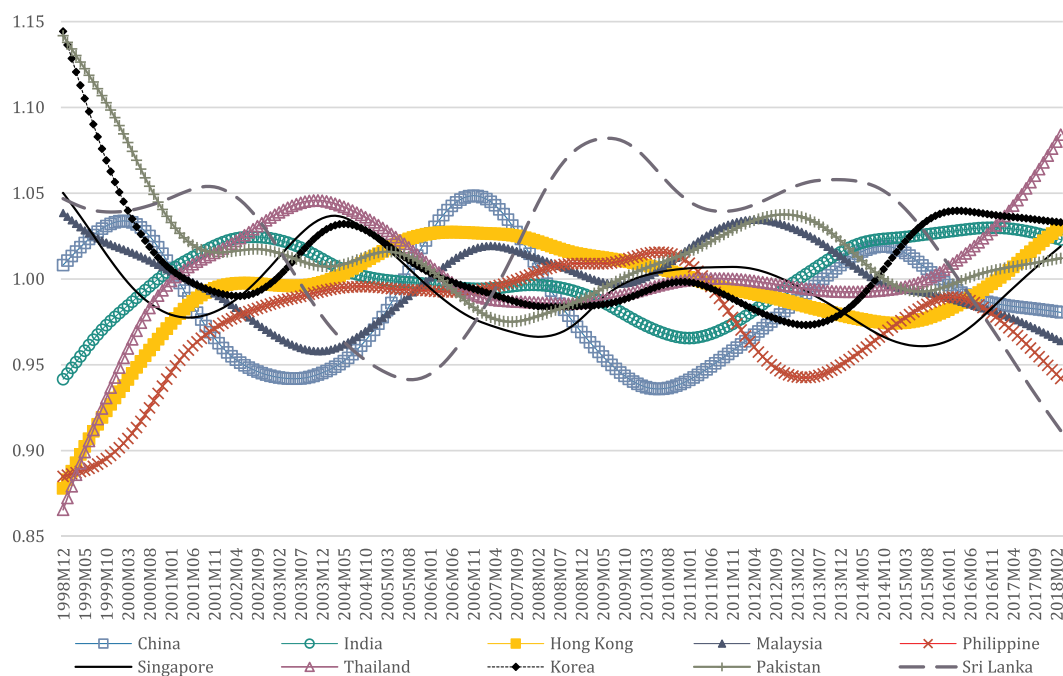
* Indicates rejection of the null hypothesis of convergence at the 5% significance level.

^T Indicates transitional divergence and turn-around phase.

three clubs are identified including Hong Kong and Korea (Club 1), China, India, Malaysia, Philippines, Thailand (Club 2), and Pakistan, Singapore and Sri Lanka (Club 3). For all three clubs, \hat{b} has a negative sign and is not significantly different from zero; following Phillips and Sul (2009), this indicates that the Oil & Gas sector is in transitional divergence and in a turn-around phase. This also applies to the case of return differentials vis-à-vis the regional index of Asia.

Figs. 5–6 present the corresponding relative transition parameters

for the Oil & Gas sector in all ten countries. Both figures highlight the fact that although all three clubs are in a transitional phase, countries in different clubs may have rather different trajectories, such as South Korea (in Club 1) and Singapore (in Club 3). As the world's biggest maker of jack-up rigs that are used to drill for oil in shallow ocean waters, Singapore's oil and gas services have been heavily affected since oil prices plunged in 2014 (Vasagar, 2016). Oil and gas offshore supplies have also suffered. Since the beginning of 2015, 11,000 workers

**Fig. 5.** Relative Transition Parameters: Return differentials vis-à-vis the US (Oil & Gas Industry, 1998m12–2018m3).

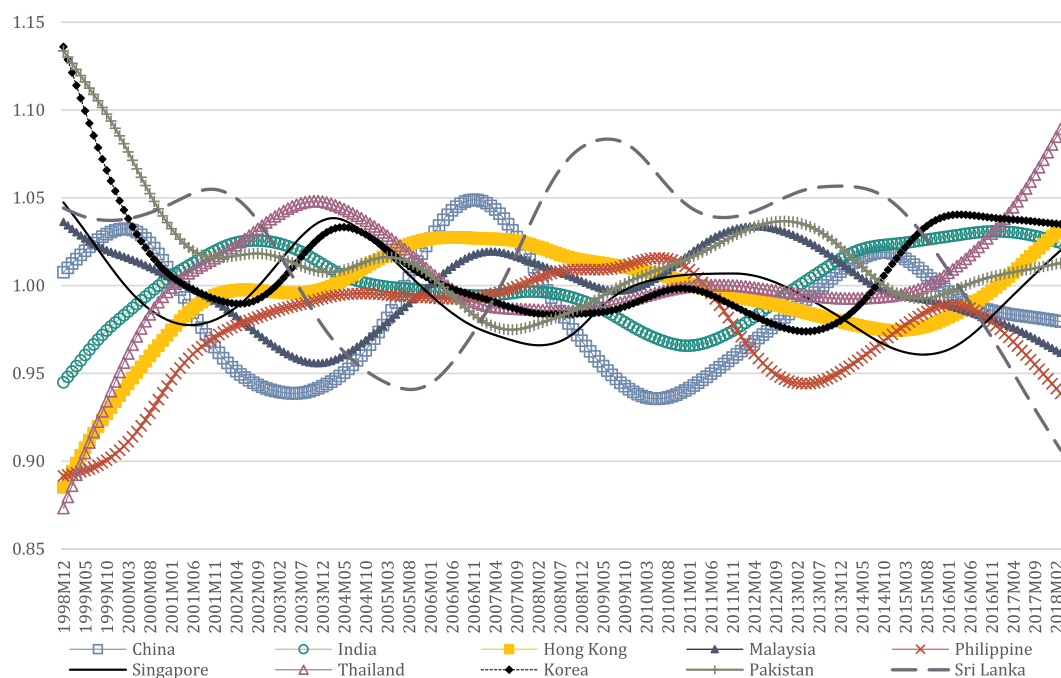


Fig. 6. Relative Transition Parameters: Return differentials vis-à-vis Asia (Oil & Gas Industry, 1998m12–2018m3).

and 8600 subcontractors have been removed from one of Singapore's largest shipbuilders (Asia Pacific Risk Centre, 2017). Singapore's low transition path reflects the knock-on effect of plummeting oil prices on the oil and gas sector in recent years. On the other hand, South Korea's transition path has been well above others countries' since 2014. The reason is that, as the main oil and gas importer in Northeast Asia, South Korea is able to negotiate more favourable terms for long-term purchasing contracts given the decline in oil and gas prices (Kim, 2015).

4.3.2. Technology sector

Two clubs can be identified in the case of return differentials vis-à-vis the US. Hong Kong and South Korea form club 1 that is in a transitional divergence and turn-around phase and the rest of the countries (i.e., China, India, Singapore, Thailand and Taiwan) are in one convergence club 2. The same applies to the return differentials vis-à-vis the regional index of Asia.

Figs. 3–4 present the relative transition parameters for all seven countries in the Technology sector. In both cases Hong Kong and South Korea have transition curves that moved relatively closely in most of the times during the sample period. Towards the end (period 2015–2018) both have travelled upwards faster than other emerging Asian economies. Hong Kong's technology sector has traditionally specialised in the commercialisation and application of innovative products and systems (Hong Kong Trade Development Council, 2017). However, the development of the innovation and technology industry is constrained by the relatively modest private and public investment in Research and Development (R&D) activities (Research Office of Hong Kong Legislative Council, 2015), as shown by almost static level of the relative transition path until 2014 in Figs. 7–8. However, since 2015 the transition path has been rising fast, since the technology sector in Hong Kong has benefited from a number of innovation funds since the establishment of Hong Kong Innovation and Technology Bureau in 2015, as well as close innovation and technological research collaboration with mainland China (e.g., recent plans for a Hong Kong/Shenzhen Innovation and Technology Park). The technology sector in South Korea has weathered the 2008 global financial crisis relatively well compared with other emerging Asian markets. This is reflected in Korea's relative stable transition path during period 2009–2011 in Figs. 7–8. Korea has used the crisis as an opportunity to demonstrate its

strengths in innovation and outperform developed countries thanks to large high-technology innovating firms (OECD, 2012). However, continuously falling world demand, a drought and a high-profile virus outbreak pulled South Korea's economic growth down to its slowest pace since 2013 (Mundy, 2015). Despite such headwind, the South Korea's economy has picked up quite quickly since 2015 driven by the global economic recovery and increased domestic demand, with technology intensive industries such as semiconductors and automobile leading the way of recovery (Deloitte Insights, 2018). This is captured by the gradually rising transition curve since 2015.

4.3.3. Healthcare sector

We identified three clubs in a transitional divergence and turn-around phase in the case of return differentials vis-à-vis the US. These are China and Korea in Club 1, Singapore and Thailand in Club 2, and India, Indonesia and Pakistan in Club 3. When using the differentials vis-à-vis the Asian regional index, Singapore joined China and Korea and formed a convergence club; Thailand joined India and Indonesia to form a club in the turn-around phase; Pakistan became divergent without forming a club with any other economies.

Therefore, in contrast to the Oil & Gas and Technology sectors where results based on the two sets of differentials are very similar in terms of member countries in each club and speed of convergence, the Healthcare sector is a case where the results for the two sets of differentials are quite different. While regional and global integration have proceeded at a similar pace for the Oil & Gas and Technology sectors in Asia, regional integration is slightly stronger in the Healthcare sector, with one convergence club including China, Singapore and Korea when the regional index is used.

Korea's National Healthcare Insurance (NHI) System has covered the entire population since 1989 and, being the fastest aging country in the world (ESCAP, 2016), its healthcare sector has grown at an astonishing speed compared with other Asian countries in the region. This is reflected in Korea's fast rising transitional parameters in Figs. 9–10. Countries with an aging population, such as China and Singapore, also have healthcare insurance and subsidies (Urban Residents Basic Medical Insurance and the New Rural Cooperative Medical Insurance in China Medisave and Medishield schemes in Singapore). Both countries have heavily invested in healthcare products and services but Singapore

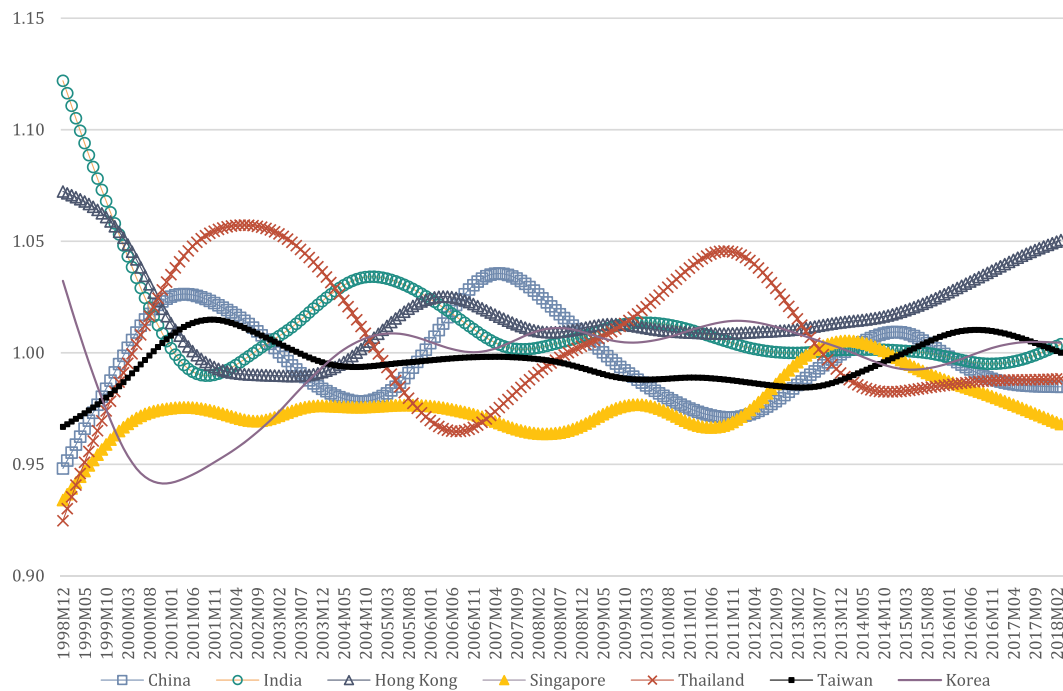


Fig. 7. Relative Transition Parameters: Return differentials vis-à-vis the US (Technology Industry, 1998m12–2018m3).

has lagged compared to China (Cheng, Wayne, Qin, & Lin, 2017), which is shown captured by the gap towards the very end of our sample period in Figs. 9–10. These three countries have formed a convergence club, probably because they are all in the process of aging at an unprecedented pace, although the timing and pace of this transition varies across them (ESCAP, 2017).

4.4. Further analysis

Asian stock market returns were highly volatile during the crisis

(Fig. 1) and a number of initiatives have been put forward jointly by the Asian economies shortly after the outbreak of the crisis (e.g., The Chiang Mai Initiative Multi-lateralization (CMIM) Agreement signed in December 2009 and (took effect in March 2010), ASEAN Comprehensive Investment Agreement (ACIA) signed in 2009 (took effect in 2012)) to promote regional cooperation and integration. Therefore, having examined the whole sample data in the period section, in this section we investigate whether the extent and pattern of global and regional integration has been affected by the 2008 global financial crisis.

We split the sample into two sub-samples (1998m12–2009m5 and

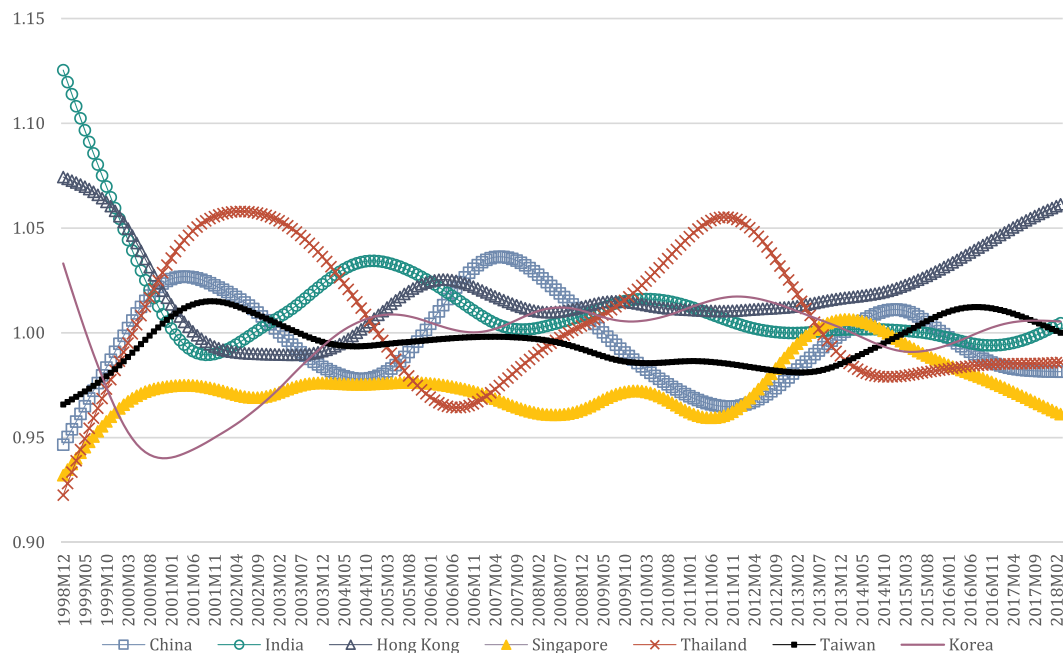


Fig. 8. Relative Transition Parameters: Return differentials vis-à-vis Asia (Technology Industry, 1998m12–2018m3).

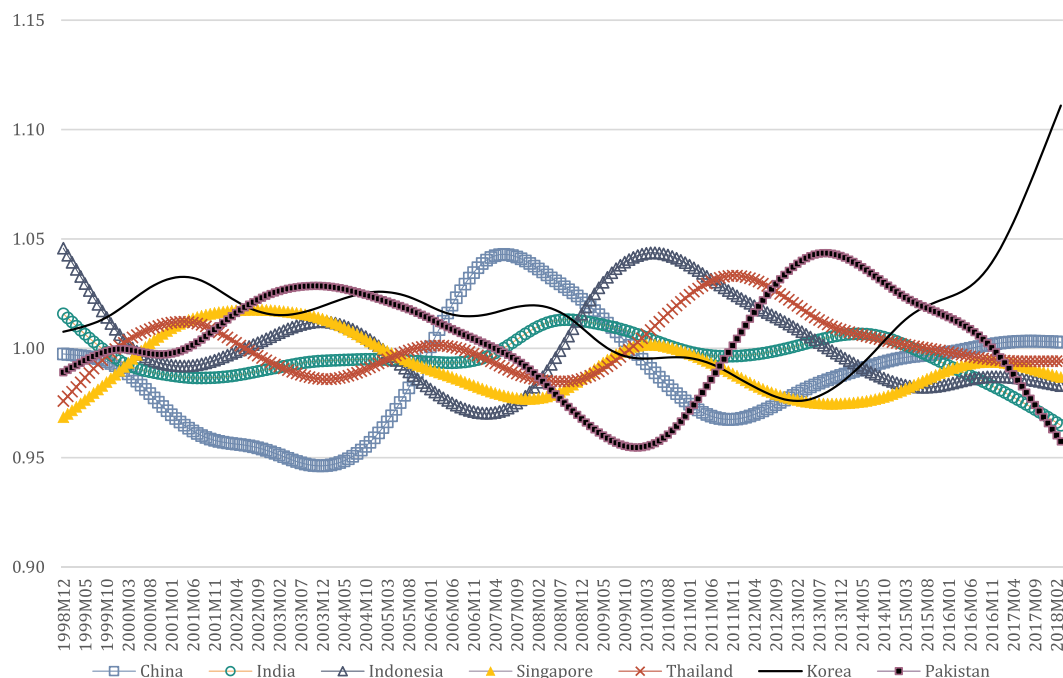


Fig. 9. Relative Transition Parameters: Return differentials vis-à-vis the US (Healthcare Industry, 1998m12–2018m3).

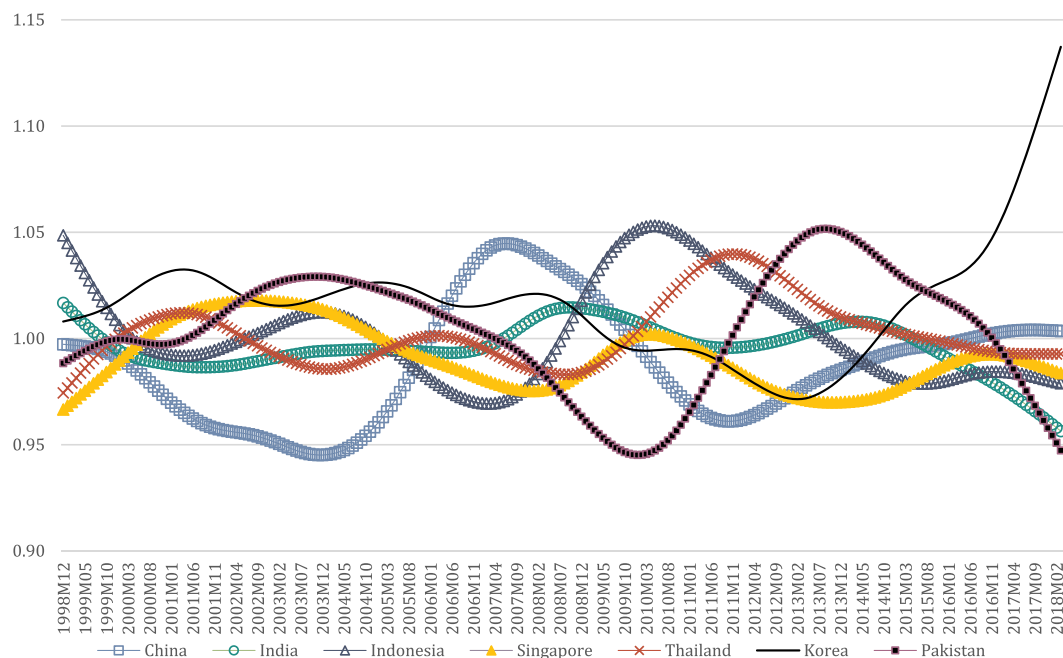


Fig. 10. Relative Transition Parameters: Return differentials vis-à-vis Asia (Healthcare Industry, 1998m12–2018m3).

2009m6–2018m3) to capture the pre- and post-crisis respectively (for a similar starting point for post-crisis period see [Aswani \(2017\)](#), [Bampinas and Panagiotidis \(2017\)](#), [Vo and Ellis \(2018\)](#)).⁹ We then carry

⁹ Prior to splitting our sample, we also applied the [Narayan and Popp \(2010\)](#) unit root test which allows for breaks (in level and slope). Indeed a common break around year 2008 (i.e., during period 2007m10–2009m5) is detected in almost all series, supporting our choice of dates for the pre- (1998m12–2009m5) and post-crisis (2009m6–2018m3) periods. Also, we are aware that some studies exclude the crisis period or analyse the crisis period separately due to its extreme volatility, but in our case this period is not sufficiently long for a meaningful statistical analysis. We experimented excluding

out the P–S *logt* and club convergence tests for these two sub-samples.

4.4.1. Logt test

The *logt* test results for pre- and post- crisis period are presented in Panels B and C in [Table 2](#). At the aggregate level there is full panel convergence with the speed of convergence faster in the pre- than in the

(footnote continued)

the volatile period 2007m10–2009m5 and carrying out similar tests for the two sub-samples of 1998m12–2007m9 (pre-crisis period) and 2009m6–2018m3 (post-crisis period). The overall conclusions are similar to those presented in this section and hence we did not include these results.

Table 4

Club convergence tests for non-convergence sectors in the pre- (1998M12–2009m5) and post-crisis period (2009m6–2018m3)

		Stock return differentials vis-à-vis the US			Stock return differentials vis-à-vis regional index of Asia			
			b	t-Stat		B	t-Stat	
Pre-crisis period (1998M12–2009m5)								
Oil & Gas	Club 1	China, India, Hong Kong, Malaysia, Philippines, Singapore, Thailand, Korea, Pakistan	0.292 [*]	3.629	Club 1	China, India, Hong Kong, Malaysia, Philippines, Singapore, Thailand, Korea, Pakistan	0.337 [*]	4.048
	Divergent	Sri Lanka			Divergent	Sri Lanka		
Healthcare	Club 1	China, India, Indonesia, Singapore	−0.037 ^T	−0.364	Club 1	China, India, Indonesia, Singapore	−0.032 ^T	−0.316
	Club 2	Thailand, Korea	0.209 [*]	0.262	Club 2	Thailand, Korea	0.204 [*]	0.258
Technology	Divergent	Pakistan			Divergent	Pakistan		
	Club 1	China, India, Hong Kong, Thailand, Taiwan, Korea	0.562 [*]	4.751	Club 1	China, India, Hong Kong, Thailand, Taiwan, Korea	0.517 [*]	4.301
Basic Materials	Divergent	Singapore			Divergent	Singapore		
	Club 1	China, India, Indonesia, Malaysia, Philippines, Taiwan, Korea	0.175 [*]	2.212	Club 1	China, India, Indonesia, Malaysia, Philippines, Taiwan, Korea	0.177 [*]	2.236
Consumer Services	Club 2	Hong Kong, Thailand, Pakistan	0.027 [*]	0.870	Club 2	Hong Kong, Thailand, Pakistan	0.027 [*]	0.930
	Club 1	China, India, Hong Kong, Malaysia, Philippines, Singapore, Thailand, Taiwan, Korea, Sri Lanka	0.106 [*]	1.516	Club 1	China, India, Hong Kong, Malaysia, Philippines, Singapore, Thailand, Taiwan, Korea, Sri Lanka	0.128 [*]	1.780
	Divergent	Pakistan			Divergent	Pakistan		
Post-crisis period (2009m6–2018m3)								
Oil & Gas	Club 1	India, Thailand, Korea	0.291 [*]	2.113	Club 1	India, Thailand, Korea	0.198 [*]	1.424
	Club 2	China, Hong Kong, Malaysia, Philippines, Singapore, Pakistan, Sri Lanka	1.083 [*]	4.714	Club 2	China, Hong Kong, Malaysia, Philippines, Singapore, Pakistan, Sri Lanka	0.988 [*]	4.179
Healthcare	Club 1	China, India, Indonesia, Singapore, Thailand, Pakistan,	1.801 [*]	9.232	Club 1	China, India, Indonesia, Singapore, Thailand, Pakistan,	1.759 [*]	8.606
	Divergent	Korea			Divergent	Korea		
Technology	Club 1	India, Thailand, Taiwan, Korea	0.221 [*]	0.816	Club 1	India, Thailand, Taiwan, Korea	0.234 [*]	0.854
	Divergent	Hong Kong, Singapore, Pakistan			Divergent	Hong Kong, Singapore, Pakistan		
Telecommunications	Club 1	India, Malaysia, Thailand, Korea, Pakistan	0.033 [*]	0.292	Club 1	India, Malaysia, Thailand, Korea, Pakistan	0.048 [*]	0.423
	Club 2	Indonesia, Philippines	−2.963 ^T	−1.557	Club 2	Indonesia, Philippines	−2.987 ^T	−1.566
Utilities	Club 3	Hong Kong, Singapore	0.613 [*]	0.402	Club 3	Hong Kong, Singapore	0.616 [*]	0.46
	Club 1	China, India, Hong Kong, Malaysia, Thailand, Pakistan	0.655 [*]	1.815	Club 1	China, India, Hong Kong, Malaysia, Thailand, Pakistan	0.639 [*]	1.749
	Club 2	Philippines, Korea	−2.634 ^T	−1.240	Club 2	Philippines, Korea	−2.651 ^T	−1.250

* Indicates rejection of the null hypothesis of convergence at the 5% significance level.

^T Indicates transitional divergence and turn-around phase.

post-crisis period. This is true for both differentials vis-à-vis the US and the regional index. Most importantly, while the speed of convergence in the pre-crisis period is very similar between the two sets of differentials (i.e., 1.105 and 1.120), during the post-crisis period it is slightly higher for the differentials vis-à-vis the US (i.e., 0.723) rather than the regional index (i.e., 0.678), which suggests a marginally stronger global (rather than regional) integration at the aggregate level after the crisis. However, given the slower speed of convergence in the post- compared with the pre-crisis period, it seems that the crisis has slowed down both global and regional integration in Asia.

The logt tests for the pre- and post-crisis periods at the industry level confirm again that the Oil & Gas, Healthcare and Technology industries do not exhibit full panel convergence. Two additional industries, namely Basic Materials and Consumer Services in the pre-crisis period and Telecommunications and Utilities in the post-crisis period, also do not show full panel convergence. It is worth mentioning that in the post-crisis period the speed of convergence for the differentials vis-à-vis the US is consistently higher than that for the regional index (though only slightly) whenever full panel convergence is present, consistently with the findings at the aggregate level (Panel A in Table 2).

4.4.2. Club convergence tests

For industries where full panel convergence is rejected, we implement the club convergence tests. Looking at the pre-crisis period (upper panel in Table 4), the rejection of full panel convergence was mainly due to the divergence of Sri Lanka, Pakistan, and Singapore in the case of Oil & Gas, Healthcare and Technology industry respectively. Pakistan is the divergent country again in the Consumer Services sector and it forms the second convergence club with Hong Kong and Thailand in the

Basic Materials sector. During the post-crisis period (lower panel in Table 4), Korea (in the case of Healthcare sector) and Hong Kong, Singapore and Pakistan (in the case of Technology sector) are divergent economies. Various clubs are found in other industries, which explains the rejection of full panel convergence.

As for the speed of convergence, in the pre-crisis period it is faster for differentials vis-à-vis the regional index rather than the US whenever a convergence club is found, whilst the opposite is true for the post-crisis period (except Club 1 in Technology sector in both periods which is the other way around). This confirms our earlier findings at the aggregate level of relatively stronger global (rather than regional) integration in Asia in the post- crisis period.

To sum up, the sub-sample analysis indicates that first, Asian aggregate stock markets are globally and regional integrated throughout the pre- and post-crisis period but the speed of convergence seems to have been held back after the crisis. Although Asia weathered the recent financial crisis relatively well compared with other regions (Kenç et al., 2016), the crisis has nevertheless interrupted Asian financial integration (Borensztein & Loungani, 2011; Park, 2013; Thanoon, 2017). The global crisis has made investors take a more inward-looking view (Rughoo & You, 2016), which may have caused strong home-biased investment activities after the crisis. Borensztein and Loungani (2011) find that the extent of home bias in Asia as a region appears slightly stronger than in other regions such as Latin America and Eastern Europe and, more importantly, that such phenomenon is likely to be related to home bias in the individual countries towards their domestic stock markets rather than a preference for assets from the region. One of its drivers in Asia is the large domestic bank assets in Asian economies' banking system. As argued by Park and Mercado

(2014), these imply a less diversified domestic financial system, which increases home bias because local investors have limited choices for portfolio diversification. The 2008 global financial crisis, followed by the sovereign debt crisis in Europe during 2010, sent a wave of pessimism across the globe, with global risk aversion increasing (Filardo, 2012). The recent global financial crisis originating from the US affected emerging equity markets primarily through a decline in investor's risk appetite (Chudik & Fratzscher, 2011). More inward-looking and more risk averse investors combined with a strong domestic home bias in Asia after the crisis may have caused the speed of both global and regional integration in Asian economies to slow down.

Second, in the post-crisis period, both aggregate level and industrial level evidence suggest that global integration is slightly stronger than regional integration. This is in contrast to some recent studies including Wang (2014) and Lee and Jeong (2016). Our findings can be rationalised as follows. Since the 2008 financial crisis, Asia's cross-border equity holdings have been increased but have remained considerably biased towards major countries outside the region (rather than those within). For instance, despite the fact that Asia's outward equity investment outstanding rose to \$3.5 trillion in 2016 from \$3.2 trillion in 2015, Asia's continued outward portfolio investment bias has led to a lower intraregional outward equity investment share – down to 19.0% in 2016 from 20.0% in 2015 (Asian Economic Integration Report, 2017).

Third, it is also interesting to notice some patterns at country level. Pakistan is the divergent country in a number of instances in the pre-crisis period but is found to be much more integrated with other countries in the post-crisis period. Of Hong Kong, Singapore and Korea, two or three of them often form or belong to the same group. We have not found China to be the divergent economy in the region as suggested by some previous studies, regardless of the time-span (i.e., whole, pre- or post-crisis period); instead, China appears to be either integrated with the full panel or with a group of other economies in a sub-club, probably as a result of the greater development and liberalisation of its equity markets relative to bond markets over the past two decades, as well as increasing business and trade linkages regionally and globally (Glick & Hutchison, 2013). Indeed, a recent study by Arslanalp, Liao, Piao, and Seneviratne (2016) finds that financial spillovers from China to regional markets are on the rise, with the main transmission channel being trade linkages, although direct financial linkages are playing an increasing role.

5. Robustness checks

5.1. β -convergence test

To test for the robustness of our results, we also apply the β -convergence test to our panel of stock return differentials. This has first been used in the growth literature (see Barro and Sala-i-Martin (1991)) and then also been employed in a number of studies to assess financial integration in money, bond, exchange rate, real estate and equity market (e.g., Vajanne, 2006; Babecky, Frait, Komarek, & Komarkova, 2010; Rizavi, Naqvi, & Rizvi, 2011; Srivatsa & Lee, 2012; Rughoo & You, 2016).

The β -convergence test regresses the growth rate of a variable on the initial level. Specifically, we run the following regression to estimate β -convergence for our panel of return differentials on stock returns:

$$\Delta RD_{i,t} = \alpha_i + \beta RD_{i,t-1} + \sum_{l=1}^L \Delta RD_{i,t-l} + \varepsilon_{i,t},$$

where $RD_{i,t}$ represents the return differentials on stock returns of economy i at time t , Δ is the difference operator, α_i is the country-specific constant, and $\varepsilon_{i,t}$ is the white-noise disturbance. The lag length L is based on the Schwarz information criterion; the maximum length is twelve since we are using monthly data.

The value of β indicates whether or not convergence occurs and if it does at what speed. Specifically, the β coefficient can take values ranging from 0 to -2 , and a negative beta coefficient implies the existence of convergence. If the value of β is -1 , it indicates the highest possible speed of convergence and integration. On the contrary, the extreme values of 0 and -2 imply no integration. When the value of β lies between 0 and -1 , it indicates monotonous convergence, and if it lies between -1 and -2 it indicates oscillating or fluctuating convergence.

We run the regression for both aggregate and industry level return differentials vis-à-vis the US and the regional index for the whole sample period as well as the pre- and post-crisis sub-samples. The results are reported in Table 5. They broadly confirm our P–S convergence test results, indicating that for the whole sample period there is both global and regional integration in Asia as the value of β is negative and is either slightly below or above -1 . Global integration occurs because of monotonous convergence (i.e., β lies between 0 and -1) in some sectors and oscillating or fluctuating convergence in others (i.e., β lies between -1 and -2), while regional convergence seems to be oscillating or fluctuating in all industries. A closer comparison between the pre- and post-crisis period results for the β coefficient tests and the P–S convergence test shows some key differences. First, in Table 5 the aggregate data suggest less fluctuating convergence in the post-crisis period (indicated by β closer to value -1) at both the global and regional level. However, 8 out of 10 industries exhibit more fluctuating convergence during the post-crisis period (indicated by β moving away from value -1 towards -2) in the case of differentials vis-à-vis the US, and 7 out of 10 in the case of the differentials vis-à-vis the regional index. Second, in cases when fluctuating convergence is observed, whether at the regional or global level, the β convergence test does not provide further information as to whether it might be due to convergence subgroups or some divergent economies. For instance, in the case of the Technology sector for the differentials vis-à-vis the regional index, despite the value β being between -1 and -2 (i.e., -1.234 , which suggesting oscillating or fluctuating convergence), the β convergence test does not reveal the existence of subgroup convergence, unlike the P–S method (see Tables 3 and 4).

Despite being a widely employed method, the β convergence test provides limited information on the speed of convergence in the sense that it computes the mean reversion of the panel units, and hence there is no indication of the dynamic behaviour of individual countries within the panel, nor does this test allow for variation over time (Islam, 2003).¹⁰ These issues are addressed by the P–S convergence test, which is based on a time-varying coefficient factor model and allows for individual heterogeneity. Pesaran (2006) and Apergis, Christoua, and Hassapis (2013) argue that, by definition, β -convergence is more suited to test for convergence within an economy. For these reasons and the fact that our study examines panel convergence with country-specific characteristics being intrinsic to our analysis, we give preference to the results based on the P–S method.

5.2. Results using alternative frequency (weekly) data

In this section we investigate the robustness of our findings to different data frequencies. This is an important issue because different data frequencies are linked to different investment horizons. We examine therefore weekly data¹¹ from the same data sources as in Section

¹⁰ The adequacy of β convergence regressions has also been questioned by a number of researchers in the growth literature (e.g., Binder and Pesaran (1999), Durlauf, Johnson, and Temple (2005)).

¹¹ As pointed out by Raj and Dhal (2008), daily data capture speedy transmission of information, as both short- and long-run dynamic linkages matter for market integration (Voronkova, 2004, Hassan and Naka, 1996), but weekly stock returns are useful to avoid the problem of non-synchronous trading in some thinly traded stock markets (Cha & Oh, 2000).

Table 5
 β -convergence test results.

Stock return differentials	Aggregate			Oil & Gas			Basic Materials			Industrials		
	Pre-crisis	Post-crisis	Whole period	Pre-crisis	Post-crisis	Whole period	Pre-crisis	Post-crisis	Whole period	Pre-crisis	Post-crisis	Whole period
Vis-à-vis the US	-1.092	-1.068	-1.034	-1.013	-1.051	-1.018	-0.988	-1.076	-0.934	-0.996	-1.123	-1.032
Vis-à-vis regional index of Asia	-1.169	-1.093	-1.143	-1.106	-1.028	-1.083	-1.010	-1.032	-1.073	-1.068	-1.069	-1.02

Stock return differentials	Consumer Goods			Healthcare			Consumer Services			Telecommunications		
	Pre-crisis	Post-crisis	Whole period	Pre-crisis	Post-crisis	Whole period	Pre-crisis	Post-crisis	Whole period	Pre-crisis	Post-crisis	Whole period
Vis-à-vis the US	-0.931	-1.04	-0.947	-1.039	-1.011	-1.027	-0.944	-1.174	-0.98	-1.070	-1.118	-1.075
Vis-à-vis regional index of Asia	-1.045	-1.228	-1.073	-1.052	-1.125	-1.079	-1.006	-1.107	-1.023	-1.092	-1.193	-1.112

Stock return differentials	Utilities			Financials			Technology		
	Pre-crisis	Post-crisis	Whole period	Pre-crisis	Post-crisis	Whole period	Pre-crisis	Post-crisis	Whole period
Vis-à-vis the US	-1.301	-1.196	-1.215	-0.96	-1.178	-0.987	-1.086	-1.115	-1.057
Vis-à-vis regional index of Asia	-1.05	-1.154	-1.05	-1.188	-1.118	-1.151	-1.234	-1.18	-1.207

Note: all β coefficient are significant at least at 5% level.

Table 6

Log t convergence tests for the whole sample (1998M12–2018M3) (Panel A), pre- (1998M12–2009M5) (Panel B) and post-crisis period (2009m6–2018m3) (Panel C) using weekly data frequency.

Aggregate/sectors	Panel A: whole sample (1998M12–2018M3)				Panel B: pre-crisis period (1998M12–2009M5)				Panel C: post-crisis period (2009m6–2018m3)			
	Stock return differentials vis-à-vis the US		Stock return differentials vis-à-vis regional index of Asia		Stock return differentials vis-à-vis the US		Stock return differentials vis-à-vis regional index of Asia		Stock return differentials vis-à-vis the US		Stock return differentials vis-à-vis regional index of Asia	
	b	t-Stat	b	t-Stat	b	t-Stat	b	t-Stat	b	t-Stat	b	t-Stat
Aggregate stock market indices	0.944*	26.222	0.947*	26.693	0.838*	159.880	0.837*	158.594	0.946*	23.919	0.937*	23.500
Oil & Gas	-0.141	-5.563	-0.141	-5.553	-0.360 ^T	-1.200	-0.350 ^T	-1.161	-0.048 ^T	-0.251	-0.061 ^T	-0.317
Basic Materials	0.753*	4.033	0.76*	4.076	-0.295	-2.811	-0.293	-2.783	-0.090 ^T	-0.287	-0.102 ^T	-0.326
Industrials	0.657*	21.791	0.667*	22.032	0.110*	0.922	0.113*	0.955	1.418*	98.568	1.417*	97.553
Consumer Goods	1.047*	12.062	1.054*	12.019	0.427*	30.272	0.430*	29.472	0.650*	1.408	0.641*	1.388
Healthcare	-0.193 ^T	-1.425	-0.19 ^T	-1.377	-1.761	-11.371	-1.758	-11.167	0.134*	0.407	0.127*	0.383
Consumer Services	0.436*	6.689	0.441*	6.813	-0.400	-4.323	-0.396	-4.283	1.003*	27.891	0.997*	27.829
Telecommunications	1.007*	52.026	1.015*	51.584	0.152*	0.726	0.154*	0.748	-0.330	-7.255	-0.331	-7.188
Utilities	0.280*	6.915	0.283*	7.076	0.712*	6.628	0.710*	6.605	-0.303	-5.556	-0.303	-5.626
Financials	1.406*	152.768	0.435*	104.565	0.559*	50.641	0.552*	50.165	0.594*	5.486	0.591*	5.411
Technology	0.435*	103.405	0.435*	104.564	-0.68	-34.65	-0.681	-33.001	-0.655	-33.277	-0.657	-35.022

* Indicates rejection of the null hypothesis of convergence at the 5% significance level.

^T Indicates transitional divergence and turn-around phase.

4.1 and apply again the P–S $\log t$ and convergence tests.

The log t test results are reported in Panel A, B and C of Table 6 for the whole sample, and the pre- and post-crisis period respectively.¹² The full panel convergence at the aggregate level suggests both regional and global integration at a very similar speed, although panel convergence is missing in some sectors during over the whole sample, and the pre- and post-crisis periods. The results overall are very similar to those for the monthly data (see Table 2). For instance, during the pre-crisis period they are virtually identical at both the aggregate and

industry level regardless of which set of differentials are employed.

However, it is noticeable that when weekly data are used, both global and regional integration appear to have grown stronger in the post-crisis period (Panel B in Table 6) and have a faster speed of convergence, in contrast to the slower speed of found for this sub-sample when monthly data are used (see Tables 2 and 4). This finding is consistent with those of Tiwari et al. (2015), who conclude that Asian stock markets are more integrated at lower frequencies. As suggested by Narayan et al. (2014), such discrepancy may have been due to the fact that the international portfolio mix is likely to differ between short- and long-term investment horizons. Nevertheless, global integration is found to be marginally faster than regional integration in the post-crisis period (Panel C in Table 6), which is consistent with the monthly results (Table 2).

We also carried out club convergence tests for industries where full

¹² We also carried out the Narayan and Popp (2010) unit root test which allows for breaks for the weekly data. The results (i.e., the break dates) are very similar to those for the monthly data (they are not included to save space), and therefore we define as before the pre-crisis period as 1998m12–2009m5 and the post-crisis one as 2009m6–2018m3.

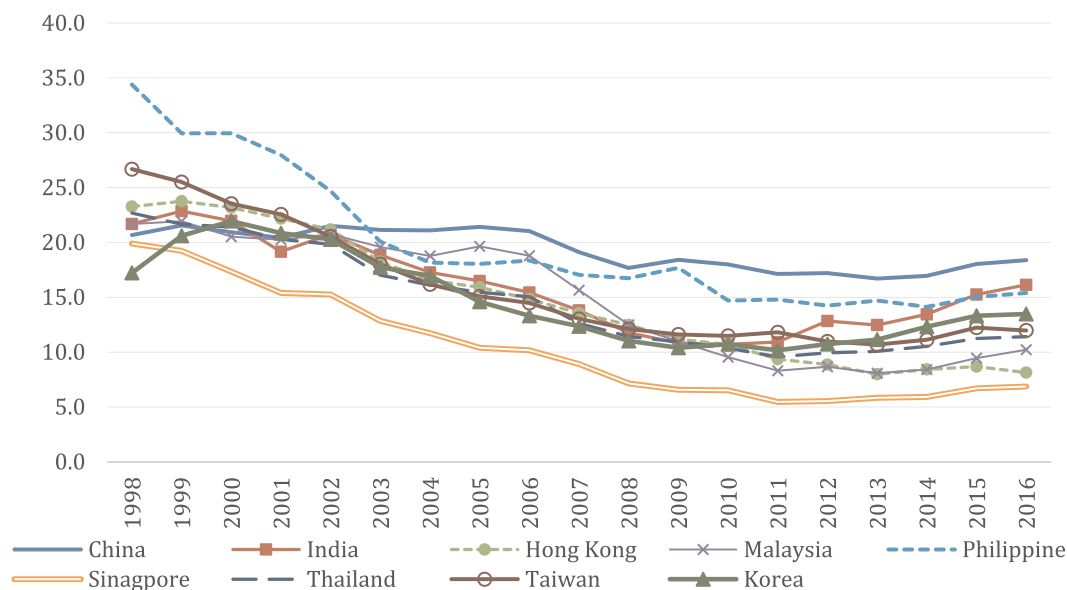


Fig. 11. Bilateral Trade Relations between Asian economies and the US (% of total exports).

panel convergence is missing. The results are not presented here to save space but can be summarised as follows. We find that in the pre-crisis/post-crisis period the speed of convergence in the case of differentials vis-à-vis the regional index is faster/slower than for the differentials vis-à-vis the US (except for the Technology sector), which is again consistent with the monthly results, i.e., there is stronger regional integration in the pre-crisis period global one in the post-crisis period.

As already mentioned, the weekly results broadly confirm the monthly ones, except that the speed of convergence after the crisis decreases in the case of monthly data whilst it increases in the case of the weekly ones. To analyse long-run integration of markets high frequency daily or weekly may not be as appropriate as lower frequency ones (i.e., monthly and quarterly) that are more strongly linked to economic fundamentals (Hakkio and Rush (1991)). Also, lower frequency data can avoid the complications arising from returns to successive transactions tending to be negatively serially correlated (due to, for instance, the so-called bid-ask bounce), and the fact that the initial impact of trades on prices is often at least partially reversed (Chaboud, Chiquoine, Hjalmarsson, & Loretan, 2008). Therefore, given the focus of the present study on long-run convergence, we give more weight to the monthly results, whilst acknowledging that higher frequency data may lead to stronger evidence of integration (see Tiwari et al., 2015).

6. Asian stock market integration and trade linkages

Foreign trade has long been the key growth engine for the Asian economies (i.e., Jin, 2002; Khalafalla & Webb, 2001; Mahadevan, 2009; Marelli & Signorelli, 2011). During 1998–2016, exports as a percentage of GDP for the economies included in our study averaged 66.7%, well above that of the US (11.4%) and the Euro Area (37.4%) based on data from the World Bank.

If particular markets are significantly influenced by international factors (such as trade), then it is possible that the overall market performance will be affected by those (Huth, 1994). For this reason, some researchers have examined empirically the influence of trade linkages on financial markets integration as such linkages can result in a higher degree of synchronisation of asset price movements. For instance, Chinn and Forbes (2004) suggest that trade linkages are the most crucial determinants of integration between large and small stock markets.

Paramati, Roca, and Gupta (2016) find that trade intensity in the Australasian region is a significant driver of the interdependence between their stock markets in both the short and long runs. Bracker,

Docking, and Koch (1999) and Narayan et al., 2014 report instead mixed results on the effects of trade linkages on stock market integration. Didier, Love, and Peria (2012) find that trade does not play a role in explaining stock market co-movement during the 2008 financial crisis period.

Given the importance of foreign trade to the Asian economies, in this section we examine the influence of trade integration on Asian stock market integration. Specifically, we measure trade integration as the relative openness of the Asian economies (*OP*) and their bilateral trade relations (*BT*) (Figs. 11 and 12) with the US or with the Asia region (see Narayan et al., 2014 for similar measurements); we would expect these two variables to boost stock market integration in Asia.

In addition to trade integration (i.e., *OP* and *BT*), we also consider a number of other important determinants of stock returns as shown in Eq. (5)¹³:

$$INTGRA_{ij,t} = \alpha + \beta BT_{ij,t} + \gamma OP_{ij,t} + \delta RI_{ij,t} + \epsilon ER_{ij,t} + \eta MD_{ij,t} + \theta DY_{ij,t} + \vartheta FC + \varepsilon_{i,t} \quad (5)$$

where $INTGRA_{ij,t}$ denotes the degree of stock market integration between market *i* and *j*, *i* refers to each individual Asian economy, *j* stands for either Asia (in the case of regional integration) or the US (in the case of global integration), *t* denotes the time period, *RI*, *ER*, *MD*, *DY* and *FC* are the real interest rate differentials, exchange rate risk, local stock market development, dividend yields and 2008/9 global financial crisis respectively, and ε is the error term.

The real interest differential (*RI*) is employed to capture relative competitiveness (as in Paramati et al. (2016)). A higher value for *RI* implies a larger interest spread between economy *i* and Asia (or the US). The spread affects the mobility of international capital flows and leads to less market integration (Adler & Qi, 2003) between economy *i* and Asia (or the US).

The exchange rate risk variable (*ER*) measures volatility in bilateral exchange rates which is seen as a source of uncertainty for investors (Narayan et al. (2014)) and thus has an adverse influence on stock market integration. Both *RI* and *ER* have been used in previous studies to explain time-varying stock market correlations (e.g., Bekaert, Harvey, Lundblad, & Siegel, 2013; Bracker et al., 1999; Büttner & Hayo, 2011; Didier et al., 2012) and are expected to reduce stock market

¹³ For a review of stock market integration determinants please see Guesmi, Teulon, and Muzaffar (2014) and Guesmi et al. (2017).

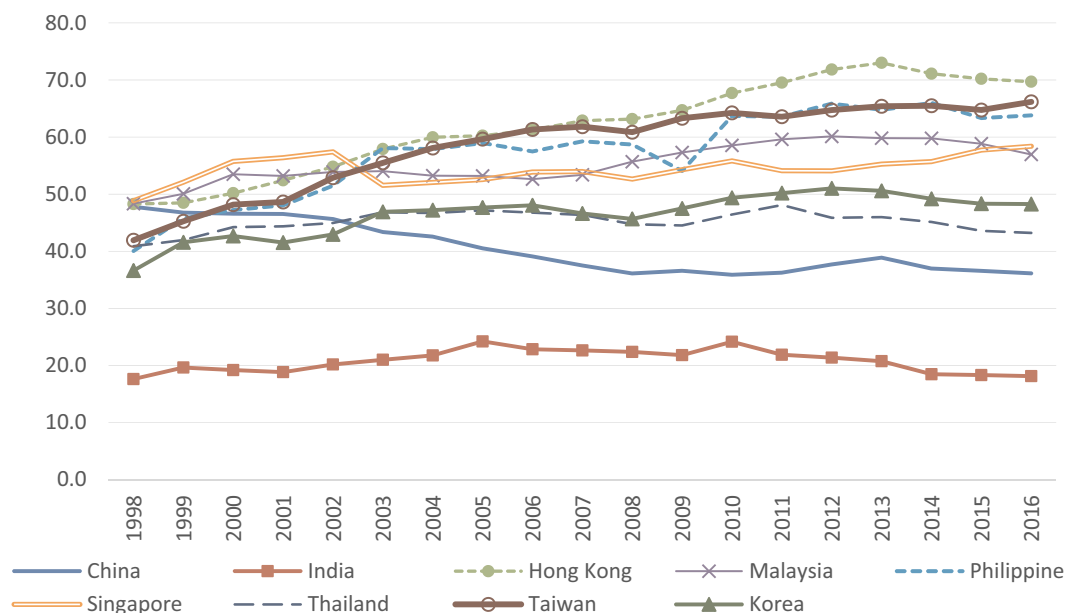


Fig. 12. Bilateral Trade Relations between Asian economies and the region (% of total exports).

integration in Asia.

We also introduce two additional factors to capture the relative condition of the local stock market of an individual economy, namely relative stock market development (MD) and dividend yields differentials (DY), both measured relative to Asia and the US. Previous studies have employed stock market development as an important determinant of financial integration (e.g., Guesmi and Nguyen (2014), Guesmi, Moisseron, and Teulon (2014), Narayan et al. (2014)). We adopt the relative version of this variable where an increase in the value of MD implies that the local stock market is developing faster than the Asian region or the US. More developed financial markets are likely to share information more intensively, which leads to a common discount factor and a more homogeneous valuation of equity among these markets (Baele, 2005). As a result, this variable may in part proxy for a gradual shift from segmentation to financial integration (as found in Bekaert and Harvey (1995) and Ng (2000)).

The stock dividend yields is an important factor influencing the local price of stock market risk (Guesmi, Abid, & Kaabia, 2017; Guesmi, Teulon, & Muzaffar, 2014). Dividend yield is also a suitable measure of the cost of equity capital and is closely linked to stock market integration in emerging economies (Bekaert & Harvey, 2000). Substantial dividend yield differentials can add to investment uncertainty and home-market bias, leading to more segmented or less integrated stock markets. We employ the relative version of this variable where dividend yields differentials (DY) between individual economy and the Asia region or the US are constructed.

FC denotes a dummy for the 2008 global financial crisis. Given the evidence obtained from our convergence tests, i.e., weaker integration after the crisis, we expect FC to have an adverse effect on stock market integration in Asia. This impact of FC has also been found by Narayan et al. (2014) and Wang (2014).

Finally, we move to the measurement of stock market integration in Eq. (5), i.e., *INTGRA*. The previously mentioned studies on trade linkages and financial integration often employ correlations to measure the level of integration between stock markets. Following our convergence analysis in Section 4, we use instead an innovative measure of integration based on the relative transition parameters. The trajectory of the parameters moving towards/away from the unit value indicates whether the economy is converging towards/diverging away from the other members in the panel. Regardless of the trajectory of these parameters, it is their distance from the panel average that matters.

Thus, we take the absolute values of the gap between the relative transition parameter (in Figs. 3 and 4) and the unit value and employ it as our measures of global and regional integration respectively. A declining/increasing value indicates that an economy is converging towards/diverging away from the panel mean.

On the basis of data availability, we excluded Indonesia, Pakistan and Sri Lanka from our analysis and chose the sample period 2000m1–2016m12. Variable definitions and data sources are reported in Table 7. Figs. 11 and 12 illustrate the evolution of the bilateral trade relationships between the Asian economies and the US and the region as a whole respectively during 1998–2016. The comparison between the two Figures clearly shows that intraregional trade is far more important for the Asia economies than trade with the US. The bilateral trade relationship between Asian economies and the US became less important during 1998–2009 but it picked up again after that, especially for India, South Korea and Thailand. On the other hand, the bilateral trade relationship between the Asian economies have developed substantially after the 1997 Asian financial crisis, with most economies entering a period of stabilisation after 2010.

Some descriptive statistics and correlation coefficients are presented in Table 8. All correlation coefficients are below 0.8, suggesting that there is generally no concern over the correlations among determinants.

The panel regression results are summarised in Table 9. We estimated both fixed and random effect models. However, the Hausman specification test suggests that the former is more appropriate and hence we focus on these results. It can be seen that bilateral trade (*BT*) is a highly significant variable for both global and regional stock market integration, but with opposite signs. As expected, in the case of regional integration, stronger bilateral trade accelerates regional integration as it lowers the adjusted transition parameters, i.e., it reduces the distance from the panel average. Our study confirms the asset price synchronisation effect of trade linkages. More stable trade relationships in Asia after the crisis (as opposed to strengthening trade relationships in the pre-crisis period) as shown in Fig. 12 partially explain the slowing down regional integration in the Asian stock market in the post-crisis period reflected in the convergence results of Section 4.3.

However, stronger bilateral trade between the Asian economies and the US decelerated their stock market integration. It generated large trade surpluses for the Asian countries, thus increasing their exposure to the risk of a crisis whenever the net importers in the West faced a recession as during the 2008 global financial crisis. Therefore, as

Table 7
Macroeconomic variable definitions and data sources.

Variable measurement	Data source
Bilateral trade relations (BT) (%) : Exports of country <i>i</i> to country <i>j</i> as a percentage of total exports of country <i>i</i> . <i>i</i> is the 9 economies included in the section (i.e., China, Hong Kong, India, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand); <i>j</i> is the US and the Asian regional index in the case of measuring global and regional integration respectively. The Asian regional index for this variable is the weighted average of the values indicating the bilateral trade relations of the 9 economies where weights is based on each economies' real GDP.	Direction of Trade Statistics and Datastream
Relative Openness (OP) (%) : Openness of the 9 economies and the US is measured as the total exports plus imports as a percentage of GDP. Then the value of the 9 economies is divided by the value of the Asia region and the US respectively. The Asian regional index for this variable is the weighted average of the values indicating the openness of the 9 economies where weights are based on each economies' real GDP.	Datastream
Exchange rate risks (ER) : it is derived using a GARCH model (see Narayan et al. (2014) for a similar treatment). Domestic currency of the 9 economies against the USD is employed in the case of global integration. The value of Asian regional currency unit is constructed by Japan's Research Institute of Economy, Trade and Industry (RIETI) and Hitotsubashi University following Ogawa and Shimizu (2005) . They calculate the value of Asian regional currency using countries and areas' respective shares of purchasing power parity (PPP)-based GDP and foreign trade.	Datastream, RIETI and author's calculation
Real interest rate differentials (IR) (%) : Gap between nominal interest rate differentials and inflation differentials. Interest rate and inflation differentials between the 9 economies with the US and the Asian regional indices are used in the case of global and regional integration respectively. The Asian regional indices for interest rate and inflation are the weighted average of the 9 economies where weights are based on each economies' real GDP. Inflation rate is measured as percentage change in Consumer Price Index (CPI). Interest rate is the short-term lending rate.	Datastream and author's calculation
Global financial crisis dummy (FC) : This variable captures the effect of FC from in 2007–2009 (i.e., 2007m1–2009m12)	Derived by author
Relative stock market development (MD) (%) : local stock market development is measured as the domestic market capitalisation to nominal GDP ratio. Then the local value of the 9 economies is divided by the value of the Asia region and the US respectively. The stock market development of the Asia region is calculated as the ratio of the sum of the 9 economies' domestic market capitalisation to the sum of the 9 economies' nominal GDP.	Datastream
Dividend yield differentials (DY) (%) : Local dividend yield is obtained based on the 9 economies, US and Asia region market index (see Guesmi and Nguyen (2014) for the same measurement). The differentials are the gap between 9 economies and Asia region and the US respectively.	Datastream

discussed by [Iwata, Montesclaros, and Qi \(2015\)](#), in the case of trade interdependence between Asia and the West (e.g., the US), the former being the net exporter and the latter being the net importer, greater trade linkages can increase the risk of instability. As recently pointed out by the [OECD \(2018\)](#), a more interconnected world through trade and other types of economic integration can also strengthen synchronisation when it leads to heightened financial contagion. [Ozkan and Unsal \(2012\)](#) find that trade integration is a key determinant of the severity of the financial crisis for the domestic economy. Despite the potential benefits of international trade, in the case of the Asian economies (net exporters) and the US (net importer) stronger trade linkages are associated with a higher level of perceived risk of contagion, which may have distorted the behaviour of investors thereby reducing stock market integration between Asia and the US.

Openness (*OP*) is instead insignificant in the case of Asian economies' integration with the US. This is a similar finding to [Bekaert & Harvey, 1995](#), [Levine and Zervos \(1996\)](#) and [Bekaert and Harvey \(2000\)](#), who suggest that domestic liberalisation may not necessarily attract foreign investment due to the home bias in equity portfolio, country-specific risks and the lack of local market information on company stocks. Recently [Vithessonthi and Kumarasinghe \(2016\)](#) also find no empirical support to the notion that openness affects stock market integration for the Asian economies.

Openness has a positive sign in the case of regional integration. It

implies that if an Asian market becomes relatively more open to international trade compared with the region, this decelerates regional financial integration. Combined with the regional trade linkage (*BT*) effect, this finding suggests that although inter-regional trade linkages accelerate regional stock market integration, becoming more open to global trade in general may achieve the opposite. This could be partially explained by the competitive stance of the Asian economies against each other as the majority of them regard exporting to developed markets as an important national development strategy ([Razmi & Hernandez, 2011](#)). Also once a country opens itself to trade, the growth process becomes self-sustaining due to the optimal use of imported intermediate inputs ([Basu & Morey, 2005](#)), which makes it less necessary to integrate with competitors.

The real interest rate differential (*RI*) has the expected positive sign and is significant, which suggests that an increase in this variable reduces integration by increasing the distance between the individual relative transition parameters and the panel average. This confirms the substantial effects the interest rate spread has on financial asset allocation ([Chinn & Forbes, 2004](#); [Kose, Otrook, & Whiteman, 2008](#)).

The exchange rate risk (*ER*) also has the expected positive sign and highly significant in the case of regional integration, but insignificant in the case of global integration of the Asian stock markets. This is consistent with the study by [Bracker et al. \(1999\)](#) and [Bekaert et al. \(2013\)](#),

Table 8
Descriptive statistics and correlation coefficients.

	Vis-à-vis the US								Vis-à-vis the Asia region							
	Mean	S.D.	BT	OP	ER	IR	MD	DY	Mean	S.D.	BT	OP	ER	IR	MD	DY
BT	14.7	4.9	1.000						49.7	13.1	1.000					
OP	6.9	5.3	−0.336	1.000					2.0	1.6	0.565	1.000				
ER	1.4	1.1	−0.266	−0.169	1.000				2.3	3.6	0.213	−0.186	1.000			
IR	0.9	3.6	0.278	−0.287	−0.024	1.000			−1.4	3.7	−0.269	−0.268	0.1246	1.000		
MD	119.3	149.8	−0.358	0.680	−0.255	−0.137	1.000		262.3	324.5	0.518	0.754	−0.150	−0.147	1.000	
DY	−0.1	0.9	−0.292	0.418	−0.019	−0.301	0.269	1.000	0.6	0.9	0.441	0.397	−0.109	−0.303	0.229	1.000

Note: Mean and S.D. are in %. All variables are measured in relation to the US/Asian region. See [Table 7](#) for detailed variable definitions.

Table 9
Panel regression results.

Dependent variable: adjusted relative transition parameters	Global integration equation	Regional integration equation
C	−0.3328* (0.2020)	2.6286*** (0.3813)
BT	0.0933*** (0.0081)	−0.0282*** (0.0081)
OP	0.0041 (0.0209)	0.1609** (0.0684)
ER	0.0371 (0.0310)	0.0238** (0.0116)
RI	0.0264*** (0.0094)	0.0234** (0.0097)
FC	0.8272*** (0.0870)	0.5874*** (0.0895)
MD	0.0019*** (0.0005)	−0.0006* (0.0004)
DY	0.0366 (0.0416)	−0.0063 (0.0412)
Number of observations	1836	1836
Adjusted-R ²	0.3868	0.3452

Note: Please see Table 7 for variable description. The dependent variable is the adjusted relative transition parameters. Fixed effect model is adopted based on Hausman test. ***, ** and * indicate the statistical significance at the 1%, 5% and 10% level respectively.

who find a minimal impact of exchange rate uncertainty on stock market integration.

The relative stock market development (*MD*) variable accelerates regional integration as expected, which confirms that a higher *MD* reduces market segmentation (Bekaert and Harvey (1995), Ng (2000), Baele, 2005). However, the opposite is true for global integration. Despite the stock market development achieved by the Asian economies, as discussed by Chan, Covrig, and Ng (2005) and Ananchotikul, Piao, and Zoli (2015), investors tend to invest in more developed stock markets (e.g., the US) because of higher liquidity and lower transaction costs in the latter, with a negative impact on the Asian markets' global integration with the US.

The stock dividend yields differentials are insignificant for both regional and global integration. Thus this factor does not seem to lead to home-market bias in Asia and it does not adversely affect integration. This could be due to the benefit of financial liberalisation that reduces the dividend yields differentials consistently over the years (Bekaert & Harvey, 2000). Indeed the mean dividend yields differentials are as low as −0.1% (vis-à-vis the US) and 0.6% (vis-à-vis Asia region) (see Table 8), indicating a rather low home-market bias, especially given the transaction cost and excess risk premium often attached to Asian markets by investors.

Finally, the crisis dummy is positive and highly significant in both cases, implying that the crisis has negatively affected integration by increasing the distance of the transition parameters vis-à-vis the panel mean. This is consistent with the P–S convergence tests results (i.e., Section 4.3) also suggesting that the global financial crisis has held back both global and regional integration.

To sum up, our results imply that trade linkages and stock market development boost regional, but not global stock market integration in Asia. Real interest rate differentials and the recent financial crisis are negatively related to both regional and global integration, while the exchange rate risk and trade openness only affect the former.

7. Conclusions

This paper investigates whether the Asian stock markets are more integrated at the global or regional level (the US being an indicator for the former and a regional index for Asia for the latter) after the 1997 Asian financial crisis. We analyse return differentials at both the aggregate and industry level, the latter shedding light on which sectors drive integration. Specifically we carry out the Phillips and Sul (2007) tests for panel and club convergence, which are more powerful than conventional β - and σ -convergence tests, and examine convergence patterns in both the pre- and post-crisis periods. We also investigate the influence of economic and financial factors, especially trade linkages, on the level of global and regional integration in Asia. Our findings can be summarised as follows.

First, we find full panel convergence in both differentials relative to Asia and the US, with the speed of convergence \hat{b} indicating marginally

faster regional (as opposed to global) convergence for the whole sample period (1998m12–2018m3). Industry level convergence tests reveal that, despite the overall evidence of convergence at the aggregate level, 3 (i.e., Oil & Gas, Healthcare and Technology) out of 10 industries do not exhibit full panel convergence, indicating the integration is mainly driven by other sectors while these 3 sectors are holding it back.

Second, the sub-period results show that at the aggregate level the Asian stock markets have been globally and regionally integrated throughout the pre- and post-crisis periods, but the speed of convergence has declined after the crisis. Industry level analysis indicates that in addition to the three industries mentioned above, Basic Materials and Consumer Services in the pre-crisis period and Telecommunications and Utilities in the post-crisis period also do not show panel convergence. Our finding is in contrast to recent studies such as Wu et al. (2015) and Wang (2014) reporting that the links between the Asian stock markets become stronger when there is a shock (e.g., the 2008 Asian financial crisis). We find that both global and regional integration was held back by the 2008 financial crisis.

Third, focusing on the more recent post-crisis period, both the aggregate and industry level evidence suggests that global integration is slightly stronger than regional integration. Although the Asian economies have been engaged in greater regional cooperation after the crisis (Asian Development Bank, 2013), stock market integration in the region has not benefited from such cooperation and has been affected by the crisis more than global integration.

Fourth, club convergence test for the non-divergence sectors for the whole, pre- and post-crisis period reveal the existence of a number of sub-clubs, clubs in transitional divergence and the turn-around phase, and divergent economies, which explains the lack of full panel convergence in these sectors. Some patterns at country level also emerge. Pakistan is the divergent country in a number of instances in the pre-crisis period but it became much more integrated with other countries in the post-crisis period. Among the relatively more developed economies in the region (i.e., Hong Kong, Singapore and Korea), two or three of them often form or belong to the same group. In contrast to previous studies that suggest China being the divergent economy in the region, we find China is well integrated with the full panel or with a group of other economies in a sub-club.

As robustness check, we employ β -convergence test and data with higher (weekly rather than monthly) frequency. The β -convergence test broadly confirms the results based on the P–S test but also highlights some of its limitations. The P–S *logt* and club convergence tests using weekly data overall produce consistent results with the monthly ones, except that there is no evidence that the 2008 crisis interrupted regional and global integration (as found using monthly data), rather the speed of convergence for both is actually slightly faster in the crisis period. This is consistent with Tiwari et al. (2015), where stronger integration is found when a higher data frequency data is employed.

Finally, we investigated the influence of economic and financial factors on global and regional stock market integration in Asia, paying

particular attention to the role of trade linkages within the region and between Asia and the US. We find that while trade linkages and stock market development promote regional stock market integration in Asia, they reduce of speed of Asian global integration. Real interest rate differentials and the recent financial crisis slowed down both global and regional integration, while the exchange rate risk and trade openness only influence the latter. This also confirms that the 2008 crisis had an adverse impact on both global and regional integration.

Our findings have some important policy and investment implications follow our findings. As already mentioned, we find regional integration being slightly stronger than global integration during 1998–2018, reflecting the successful efforts made by regional institution such as ASEAN after the 1997 Asian financial crisis. On the other hand, we find both global and regional integration being held back by the 2008 global financial crisis (especially the latter). This suggests that, despite the progress on the initial Chiang Mai Initiative Multilateralization (CMIM) after the crisis, more regional agreements and cooperation are needed. For instance, according to Capannelli (2011), the Asian countries required approximately between \$40 and \$60 billion in liquidity support when faced with the 2008 global financial crisis. However, the largest five ASEAN economies were able to access individually less than \$12 million from CMIM fund. During the crisis, Korea and Singapore did not try to activate the CMI, rather they opted for the mobilization of bilateral support lines from the US Federal Reserve. The crisis highlighted the fact that Asia's regional financial safety net was too modest to play a meaningful role (Rhee, Sumulong, & Vallée, 2013) and steps towards using regional cooperation to strengthen the regional financial safety net (e.g., increasing the CMIM fund's size by extracting fund from for instance foreign exchange reserve) are needed. Greater financial inclusion and innovation would also contribute to achieve this objective and make the Asian economies more resilient in the presence of external shocks and more integrated (Ding, Peiris, & Lam, 2014).

Further, Asian's integration with the US has become slightly stronger than regional integration after the 2008 crisis. Our analysis of the effects of various macroeconomic factors points to several measures that could contribute to more integrated financial markets in Asia including more regional trade agreements (in order to strengthen intraregional trade linkages) and more monetary policy coordination (to ensure exchange rate stability and reduce real interest rates differentials). In particular, an effective surveillance mechanism should be implemented such as the Asian Currency Union Deviation Index advocated by Ogawa and Shimizu (2011) and Pontines and You (2015). In addition, given the different degrees and patterns of integration across economies and sectors, policy makers should take a multi-track or multi-speed approach instead of one-fit-all approach to achieve more financial integration in Asia.

Finally, our findings also have implications for investors seeking portfolio diversification. Despite the evidence of global and regional integration for the aggregate stock index, several industries identified in our study do not appear to be tightly integrated across countries and therefore offer some investment opportunities for both global and regional diversification. By contrast, given the strong evidence of China's both global and regional integration, investment in the Chinese stock market does not appear to be a good strategy to achieve either regional or global diversification. Diversification among the most developed Asian economies (i.e., Hong Kong, Korea and Singapore) would also not have the intended effect.

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