International Review of Financial Analysis 90 (2023) 102909

Contents lists available at ScienceDirect

International Review of Financial Analysis

journal homepage: www.elsevier.com/locate/irfa

Time-varying bond market integration and the impact of financial crises

Weiping Qin [a], Sungjun Cho [b], Stuart Hyde [b,*]

[a] Southampton Business School, University of Southampton, University Road, Southampton, SO17 1BJ, UK
[b] Alliance Manchester Business School, Booth Street West, University of Manchester, Manchester M15 6PB, UK

ARTICLE INFO

JEL codes:
F36
G01
G15

Keywords:
Bond market integration
Financial crisis
Contagion
EMU

ABSTRACT

This paper studies the dynamics of market integration in government bond markets. We utilise a new approach based on Pukthuanthong and Roll (2009) to investigate time-varying integration in 38 markets. We explore the impact of crisis periods, alongside differences in sample length, region, development and whether EMU and EU markets show obvious different integration from non-EU markets. Finally, we examine the effects of bonds' maturities on market integration. Considering the effects of factor heteroscedasticity and contagion during crisis periods, adjusted market integration is notably higher than implied by the Pukthuanthong and Roll (2009) measure. Developed markets experience increasing market integration over time, more than emerging markets. Most emerging markets provide little evidence of greater market integration. The EMU markets become almost fully integrated after the introduction of the Euro. Market integration also increases with maturity.

1. Introduction

The investigation of market integration is an important topic in international asset pricing. On the one hand, a high level of market integration could decrease the cost of capital, provide more investment opportunities for international investors and increase international risk sharing which promotes economic growth (Jappelli & Pistaferri, 2011). On the other hand, increased market integration tends to reduce international diversification benefits and makes economies and markets more sensitive to global financial crises (Christoffersen, Errunza, Jacobs, & Langlois, 2012; Lehkonen, 2015; Yarovaya, Brzeszczyński, & Lau, 2016). Much research focuses on equity markets with limited evidence on time-varying government bond market integration, especially in emerging and frontier markets despite the dramatic growth of global bond markets over the past decades.[1] The extent and dynamics of bond market integration carry implications for portfolio diversification and investment allocation, as well as the independence of monetary policymaking (Lucey & Steeley, 2006; Pozzi & Wolswijk, 2012; Yang, 2005). This paper focuses on the evolution of the market integration of government bond markets over time and the analysis of differences in market integration across markets and maturities.

We provide a comprehensive analysis of market integration and its dynamics in 38 government bond markets, including 24 developed markets and 14 emerging markets from 1989 to 2017. Christiansen (2014) applies an innovative approach proposed by Pukthuanthong and Roll (2009) to examine the level of integration in 10-year government bond returns across 17 European markets. This paper employs the approach to measure market integration during the periods of normality/stability (P&R R^2 measure). However, during crisis periods, this method is shown to suffer the bias in market integration caused by factor volatility and contagion (see, Bekaert, Ehrmann, Fratzscher, & Mehl, 2014; Bekaert, Harvey, & Ng, 2005; Cordella & Ospino Rojas, 2017; Forbes & Rigobon, 2002; Lehkonen, 2015; Qin, Cho, & Hyde, 2022). Therefore, considering this nonnegligible bias, our paper adopts an adjusted measure to eliminate the bias and estimate accurate integration across markets during financial crises. To the best of our knowledge, this is the first research to employ this adjusted method to measure market integration on global government bond markets.

Following Qin et al. (2022), this paper first adjusts the bias caused by factor heteroscedasticity and contagion during recent five main financial crises: the 1994–1995 Mexican crisis, the 1997 Asian crisis, the 1998 Russian/LCTM (Long-term Capital Management) crisis, the 2007–2009 GFC (Global Financial Crisis) and the 2009–2014 ESDC (European Sovereign Debt Crisis). After considering all biases across different financial crises, we find that the recent two crises (the GFC and the ESDC) have a considerable effect on the P&R R^2 measure of market

* Corresponding author.
E-mail addresses: w.qin@soton.ac.uk (W. Qin), sungjun.cho@manchester.ac.uk (S. Cho), stuart.hyde@manchester.ac.uk (S. Hyde).

[1] Lucey et al. (2018) summarise the literature of government bond market integration over recent years. Patel, Goodell, Oriani, Paltrinieri, and Yarovaya (2022) review papers related to financial integration.

https://doi.org/10.1016/j.irfa.2023.102909
Received 25 August 2022; Received in revised form 4 August 2023; Accepted 6 September 2023
Available online 11 September 2023
1057-5219/

integration while the first three earlier (short-lived) crises do not significantly affect the estimated integration. We also examine dynamics of market integration across sample periods, economic levels and geographic locations. Our findings suggest that 1) developed markets are increasingly integrated and maintain a high level of integration over the past decade, but there is no evidence of increasing integration in emerging markets; 2) Americas and Europe present the evidence of increased market integration over the whole sample while the Asia-Pacific region exhibits the lowest level of integration with little increase over time. Moreover, we revisit the issue of the influence of the Euro's introduction on market integration using our methodology and find that EMU markets experience a dramatic rise in market integration after introducing of the Euro and become almost fully integrated prior to the ESDC. After the ESDC, market integration in EMU markets reverts back toward the pre-Euro level. Finally, the examination of maturity effects exhibits that bond markets typically have greater integration at longer maturities.

This paper contributes to the existing literature in two main ways. Firstly, this paper contributes to the methodology of measuring bond market integration. Pukthuanthong and Roll (2009) propose an innovative approach, that is, the explanatory power of global risk factors on market returns in a multi-factor model, to measure market integration in equity markets. Christiansen (2014) is the first paper to apply this method on bond markets and investigate EU 10-year government bond markets. However, as previously stated, this method is significantly biased during crisis periods. In our paper, we extend the research of Christiansen (2014) and consider all biases caused by factor heteroscedasticity and contagion effects during recent five crises. We illustrate that the effects of those two factors on Pukthuanthong and Roll (2009)'s method are nonnegligible, especially during the GFC and ESDC. Secondly, we provide a comprehensive analysis of the dynamics of bond market integration focusing on a large, global sample of government bond markets. We analyse and differentiate the extent and dynamics of market integration across different categories. According to economic level, sample availability, geographic region and bond maturity, we divide bond markets into various categories. Besides, we pay particular attention to investigate the differences of time-varying market integration among EMU, non-EMU but EU and EU markets and examine the effects of the introduction of Euro currency on market integration. The investigation in various categories is essential for rational international investors, especially during crisis periods when they are the most eager to diversify their portfolios. Our study provides very insightful investment implications and also supports policy makers to make their decisions on market openness.

The rest of the paper is organised as follows. Section 2 summarizes the relevant literature. The methodology used in this paper is discussed in Section 3. Section 6 describes the data collection and data description and Section 5 empirically analyses and reports the results. The conclusion is drawn in Section 6.

2. Literature review

While extensive research exists on the market integration across equity markets,[2] there is comparatively less focus on government bond market integration. Prior research investigating government bond market integration has primarily addressed the issue either though examination of the existence of a common international or global factor in yield spreads between government bonds of countries (e.g. Bernoth, Von Hagen, & Schuknecht, 2012; Codogno, Favero, & Missale, 2003; Dungey, Martin, & Pagan, 2000; Geyer, Kossmeier, & Pichler, 2004; Manganelli & Wolswijk, 2009) or, as in this paper, consideration of the presence of such common factors in excess bond returns or bond risk premia across countries (e.g. Abad, Chuliá, & Gómez-Puig, 2010, 2014; Barr & Priestley, 2004; Ilmanen, 1995). A significant proportion of both literatures focuses on bond market integration in developed markets, especially in Europe, the role of international or global factors, and on the influence of the introduction of the Euro on bond market integration.

Kumar and Okimoto (2011) highlight a growing integration in long-term bonds of G6 markets, excluding Japan, whereas short-term bonds retained stable, low integration. Volosovych (2011) identifies an upward trend in market integration from 1875 to 2009 across 13 developed European bond markets, including the UK and US. Christiansen (2014), utilizing a method proposed by Pukthuanthong and Roll (2009), discovers that bond markets of established EU countries and those in the Eurozone demonstrate greater integration than their newer and non-Eurozone counterparts, respectively. Abad et al. (2014) examine integration dynamics between Germany and 16 other EU nations, pinpointing a significant integration decline during the 2007 global financial crisis, particularly for non-Eurozone countries. Echoing this, Cipollini, Coakley, and Lee (2015) report temporal variations in market integration within 13 developed European government bond markets, with a boost post-Euro launch followed by subsequent fragmentation amid the European Sovereign Debt Crisis. Abakah, Addo Jr, Gil-Alana, and Tiwari (2021) underscore a varied dependency across nine developed bond markets, stating that EU markets are more intertwined, whereas the UK and US are comparatively detached. They find this dependency amplifies in crisis periods.

Recently, given increased market liberalization and greater data availability, more attention has started to be paid to emerging and frontier bond markets. Investigating market integration in Asian bond markets, Fung, Yu, and Tam (2008) and Yu, Fung, and Tam (2010) find evidence of low levels of integration and little increase in integration. Similarly, Vo (2009) documents the low level of market integration in Asian government bond markets as do Pretorius, Kabundi, and Unit (2014), Rughoo and You (2016), Park and Lee (2011), Boukhatem, Ftiti, and Sahut (2021). However, the true picture may be more nuanced. For instance, Tsukuda, Shimada, and Miyakoshi (2017) find that bond markets in developed economies in East Asia such as Japan, Singapore and Hong Kong are highly integrated with the global market, but other emerging economies display low levels of integration with East Asian and global markets. Similarly, nascent frontier markets exhibit lower levels of integration offering opportunities for diversification (Piljak, 2013; Piljak & Swinkels, 2017) though Dimic, Piljak, Swinkels, and Vulanovic (2021) provide some evidence of notable changes in the dependence of emerging and frontier government bond markets during financial crises, highlighting the need to better understanding integration during crisis periods. The need to appropriately account for market volatility and periods of crisis is emphasised by Bunda, Hamann, and Lall (2009) who document sharp increases in correlations during the global financial crisis. Chaieb, Errunza, and Gibson (2014, 2020) provide further evidence on the complex and dynamic nature of bond market integration, highlighting the heterogeneity across developed and emerging markets.

Another strand of the literature is to investigate sovereign bond yield convergence across countries especially in European countries. For example, Ehrmann, Fratzscher, Gürkaynak, and Swanson (2011) focus on four European countries (i.e. Germany, France, Italy and Spain) and find strong convergence in sovereign bond yield spreads. The spreads increase during the sovereign debt crisis period but are still quite smaller than the period prior EMU. Sibbertsen, Wegener, and Basse (2014) scrutinize the consistency of government bond yield spreads among EMU countries, citing breaks between 2006 and 2008 and persistence heightening post this period. Jotikasthira, Le, and Lundblad (2015) conclude the long-term bond yields across developed countries are more correlated than the short-term bond yields. Antonakakis, Christou, Cunado, and Gupta (2017) investigate the 17 Euro countries'

[2] See, for example, Bekaert and Harvey (1995), Bekaert et al. (2005), Pukthuanthong and Roll (2009), Bekaert et al. (2014) and more recently, Akbari et al. (2020), Cagliesi and Guidi (2021), Jian and Li (2021), and Nardo et al. (2022) among others.

convergence of sovereign bond yield spread and conclude that no full convergence was observed in all countries, but the level of convergence tends to be higher in the long run. Schwarz (2019) observes a dramatic increase in sovereign bond yield spreads in the Euro area during the GFC and the ESDC period. However, liquidity was found to be a key factor during the GFC, while default risk played a significant role in the ESDC. Gabauer, Subramaniam, and Gupta (2022) examine the transmission mechanism of sovereign bond yield across Asia-Pacific countries, and the convergence becomes stronger during the GFC due to the interconnectedness of monetary policies across countries. Umar, Riaz, and Aharon (2022) study the dynamics of the interdependence of sovereign bond yield across G7 countries and document the interdependence increases in the long run. They also characterize the convergence was stable, decreasing and increasing separately before, during and after the GFC.

Methodologically, a substantial amount of research employs one of three common approaches to investigate market integration and its dynamics across markets. One strand of the literature assesses integration from the estimated parameters of a conditional asset pricing model with global and local risk factors (e.g., Carrieri, Chaieb, & Errunza, 2013; DeJong & DeRoon, 2005; Errunza & Losq, 1985; Errunza, Losq, & Padmanabhan, 1992) while a second employs GARCH-type models in order to consider the presence of heteroscedasticity in calculating dynamic correlations (e.g., Abid, Kaabia, & Guesmi, 2014; Bekaert & Harvey, 1995; Carrieri, Errunza, & Hogan, 2007; Mobarek, Muradoglu, Mollah, & Hou, 2016). The third strand, which is the focus of this paper, seeks to estimate the correlation or percentage of total risk explained by global factors measured using Principal Components Analysis (e.g., Christiansen, 2014; Nardo, Ossola, & Papanagiotou, 2022; Pukthuanthong & Roll, 2009; Qin et al., 2022). Although considerable effort has been devoted to the development on the measurement of market integration, it is hard to find an efficient integration method if considering the trade-off between measurement accuracy and calculation complexity (Billio, Donadelli, Paradiso, & Riedel, 2017). Due to computational simplicity, this paper applies and extends the method of Pukthuanthong and Roll (2009) to measure market integration across bond markets.

3. Methodology

Following Pukthuanthong and Roll (2009), we consider the following multi-factor regression model:

$$y_t = \alpha + \sum_{i=1}^{N} \beta_i x_{it} + \varepsilon_t = \alpha + \beta_1 x_{1t} + \beta_2 x_{2t} + \ldots. + \beta_N x_{Nt} + \varepsilon_t \tag{1}$$

where, y_t is the bond market return, $x_{1t}, x_{2t}, \ldots, x_{Nt}$ are N global risk factors, and $\beta_1, \beta_1, \ldots, \beta_1$ are coefficients. We assume $E[X_t] = 0$, $E[x_{it}x_{jt}] = 0, E[\varepsilon_t] = 0$ and $E[X_t \varepsilon_t] = 0$.

During stable periods, we apply the Pukthuanthong and Roll (2009) method, that is, the explanatory power (R^2) in eq. (1), to estimate the level of the market integration of bond markets. However, during uncertain periods, the measurement of explanatory power in eq. (1) is biased by factor heteroscedasticity and contagion effects (exposure contagion and residual contagion). To account for these biases we follow the innovative method proposed by Qin et al. (2022) to adjust for each bias during volatile times. Two periods are considered according to the level of volatility: a high-variance period (or volatile period, h) and low-variance period (or stable period, l), so the relationship of return volatility between the volatile and the stable period is $\sigma_{yy}^h > \sigma_{yy}^l$. Furthermore, the following presuppositions are adopted:

$$\sigma_{x_i x_i}^h = (1 + \delta_{x_i}) \sigma_{x_i x_i}^l$$

$$\sigma_{\varepsilon\varepsilon}^h = (1 + \delta_\varepsilon) \sigma_{\varepsilon\varepsilon}^l$$

$$\beta_i^h = \left(1 + \delta_{\beta_i}\right) \beta_i^l$$

where $\sigma_{x_i x_i}$ represents the variance of x_i, $\sigma_{\varepsilon\varepsilon}$ denotes the variance of the residuals ε, δ_{x_i}, and δ_ε are greater than -1, and at least one of $\delta_{\beta_i}s$ does not equal to -1 with i ranging from 1, 2, …, to N. After strict mathematical derivation,[3] we obtain the relationship between conditional and unconditional R^2 as

$$R^{2^*} = R^2 \frac{\sum_{i=1}^{N} \left(1 + \delta_{\beta_i}\right)^2 (1 + \delta_{x_i}) \rho_{x_i y}^2}{\sum_{i=1}^{N} \rho_{x_i y}^2 \sum_{i=1}^{N} \left(1 + \delta_{\beta_i}\right)^2 (1 + \delta_{x_i}) \rho_{x_i y}^2 + \sum_{i=1}^{N} \rho_{x_i y}^2 \left(1 - \sum_{i=1}^{N} \rho_{x_i y}^2 + \frac{\delta_\varepsilon \sigma_{\varepsilon\varepsilon}^l}{\sigma_{yy}^l}\right)} \tag{2}$$

where R^{2^*} is the conditional explanatory power in eq. (1), R^2 is the unconditional explanatory power in eq. (1), $\rho_{x_i y}$ is the correlation between global factor x_i and the bond market return y, and δ_{x_i}, δ_ε, δ_{β_i} are separately the relative increases in the variance of x_i, in the variance of ε and in β_i which can be written as: $\delta_{x_i} = \frac{\sigma_{x_i x_i}^h}{\sigma_{x_i x_i}^l} - 1$, $\delta_\varepsilon = \frac{\sigma_{\varepsilon\varepsilon}^h}{\sigma_{\varepsilon\varepsilon}^l} - 1$ and $\delta_{\beta_i} = \frac{\beta_i^h}{\beta_i^l} - 1$. We assume the market is not fully segmented, so at least one of δ_{β_i} is not -1. The unconditional R^2 in eq. (2) is named as R_{QCH}^2. The proof is presented in Appendix A.

Eq. (2) shows that the conditional (estimated) explanatory power is increasing in factor volatility and is decreasing in residual volatility even when the unconditional (real) explanatory power has no change. Therefore, the conditional R^2 is misled by factor heteroscedasticity, exposure contagion and residual contagion during volatile times. In order to analyse individual effect of those three drivers on explanatory power, we consider the following three situations in our empirical analysis:

3.1. Pure bias caused by factor heteroscedasticity (labelled as R_{FH}^2)

Let all δ_{β_i} $(i = 1, 2, \ldots, N)$ and δ_ε be zero but at least one of δ_{x_i} $(i = 1, 2, \ldots, N)$ is not equal to zero. The relationship between conditional and unconditional explanatory power becomes:

$$R^{2^*} = \frac{R^2}{\sum_{i=1}^{N} \rho_{x_i y}^2 \left(1 + \frac{1 - \sum_{i=1}^{N} \rho_{x_i y}^2}{\sum_{i=1}^{N} (1 + \delta_{x_i}) \rho_{x_i y}^2}\right)} \tag{3}$$

3.2. Pure bias caused by exposure contagion (labelled as R_{BC}^2)

Let all δ_{x_i} $(i = 1, 2, \ldots, N)$ and δ_ε be zero but at least one of δ_{β_i} $(i = 1, 2, \ldots, N)$ is not equal to zero. The relationship between conditional and unconditional explanatory power becomes:

$$R^{2^*} = \frac{R^2}{\sum_{i=1}^{N} \rho_{x_i y}^2 \left(1 + \frac{1 - \sum_{i=1}^{N} \rho_{x_i y}^2}{\sum_{i=1}^{N} \left(1 + \delta_{\beta_i}\right)^2 \rho_{x_i y}^2}\right)} \tag{4}$$

3.3. Combined bias caused by factor heteroscedasticity and exposure contagion (labelled as R_{FB}^2)

Let $\delta_\varepsilon = 0$ but there is at least one i $(i = 1, 2, \ldots, N)$ which satisfies $\delta_{x_i} \neq 0$ and $\delta_{\beta_i} \neq 0$ at the same time. The relationship between conditional and unconditional explanatory power becomes:

[3] The detailed derivation can be found in the paper of Qin et al. (2022). The Appendix A also provides a brief proof.

$$R^{2^*} = \frac{R^2}{\sum_{i=1}^{N} \rho_{x_i y}^2 \left(1 + \frac{1 - \sum_{i=1}^{N} \rho_{x_i y}^2}{\sum_{i=1}^{N} \left(1+\delta_{\beta_i}\right)^2 \left(1+\delta_{x_i}\right) \rho_{x_i y}^2} \right)} \tag{5}$$

4. Data

We collect daily data on local currency-denominated government bond indices for 24 developed markets and 14 emerging markets.[4] We consider five maturities: 1–3, 3–5, 5–7, 7–10, 10+ years as well as the bond index for all maturities.

Table 1 presents details of the sample. Most of developed markets have longer samples than emerging markets. Russia has the shortest sample with data only available from 2012. All data samples end in December 2017 except for Hong Kong which ends in August 2016 due to data availability. The data are mostly drawn from Datastream bond indices, but in order to obtain the longest possible sample, additional data are obtained using FTSE, J.P. Morgan, and Citygroup bond indices. We also categorise markets as either developed or emerging based on S&P Dow Jones country classification. Three regions are considered: Americas, Europe and Asia-Pacific.[5]

Table 2 presents the mean and standard deviation of bond index returns across markets and maturities. The average bond returns and standard deviation are both increasing with maturities. This is reasonable since investors take on more risk when holding long-term bonds, and in turn require higher expected returns. Due to the Greek debt crisis which was the foundation of the European sovereign debt crisis in 2009, we observe the Greece bond market has negative returns and the highest volatility across all maturities. Table 2 also reports the statistics for two groups: developed and emerging markets. The two groupings have similar average bond returns across all maturities with emerging group displaying much higher volatility.

The global risk factors are estimated using principal component analysis each year. The covariance matrix consists of the index returns of 11 developed markets: Canada, the US, Australia, France, Germany, Ireland, Japan, Netherlands, Sweden, Switzerland and the UK which have data for the full sample. At the 5–7 year maturity, Ireland is excluded from the covariance matrix due to data availability. In order to reduce the effects of non-synchronous trading, we add the one-day lagged returns of Canada and the US to the covariance matrix. Fig. 1 shows the average cumulative percentages of total variance explained by the first principal component over the whole period. We can see that the first principal component accounts for above 30% of the total at all maturities, the first two increase to about 55% on average, the first three and four explain 65% and 75% separately. Around 80% of total variance can be explained by the first five principal components. The last eight principal components (seven for bonds with 5–7 year maturity) explain the remaining 20% in total. So, for each band of maturities, we choose the first five principal components as the global risk factors.[6]

Five financial crises are considered in our paper: the 1994–1995 Mexican crisis, the 1997 Asian crisis, the 1998 Russian and LTCM crisis, the 2007–2009 GFC and the 2009–2014 ESDC. Table 3 dates the crisis

Table 1
Data collection and country classification.

Market	Start	Database	Economic Level	Region
Australia	30/12/1988	Datastream	Developed	Asia-Pacific
Austria	30/12/1988	Datastream	Developed	Europe
Belgium	30/12/1988	Datastream	Developed	Europe
Canada	30/12/1988	Datastream	Developed	Americas
China	29/06/2007	Datastream	Emerging	Asia-Pacific
Czech Republic	31/07/1998	Datastream	Emerging	Europe
Denmark	30/12/1988	Datastream	Developed	Europe
Finland	01/05/1998	FTSE	Developed	Europe
France	30/12/1988	Datastream	Developed	Europe
Germany	30/12/1988	Datastream	Developed	Europe
Greece	03/04/2000	Citygroup and FTSE	Emerging	Europe
Hong Kong	01/01/2001	J.P. Morgan	Developed	Asia-Pacific
Hungary	29/01/1999	Datastream	Emerging	Europe
India	29/06/2007	Datastream	Emerging	Asia-Pacific
Indonesia	02/01/2008	Citygroup	Emerging	Asia-Pacific
Ireland	30/12/1988	Datastream and J.P. Morgan	Developed	Europe
Israel	13/07/2015	J.P. Morgan	Developed	Europe
Italy	30/12/1988	Datastream	Developed	Europe
Japan	30/12/1988	Datastream	Developed	Asia-Pacific
Malaysia	03/01/2005	Citygroup	Emerging	Asia-Pacific
Mexico	30/06/2010	Datastream	Emerging	Americas
Netherlands	30/12/1988	Datastream	Developed	Europe
New Zealand	30/12/1988	Datastream	Developed	Asia-Pacific
Norway	30/12/1988	DataStrem and Citygroup	Developed	Europe
Philippine	02/01/2008	Citygroup	Emerging	Asia-Pacific
Poland	29/12/2000	Datastream	Emerging	Europe
Portugal	31/12/1992	Datastream	Developed	Europe
Russia	03/01/2012	Citygroup	Emerging	Europe
Singapore	03/01/2001	J.P. Morgan	Developed	Asia-Pacific
South Africa	31/08/2000	Datastream	Emerging	Africa
South Korea	01/01/2001	J.P. Morgan	Developed	Asia-Pacific
Spain	30/12/1988	Datastream	Developed	Europe
Sweden	30/12/1988	Datastream	Developed	Europe
Switzerland	30/12/1988	Datastream	Developed	Europe
Taiwan	03/01/2005	Citygroup	Emerging	Asia-Pacific
Thailand	02/01/2008	Citygroup	Emerging	Asia-Pacific

(continued on next page)

[4] Normally, the volatility of exchange rates is much higher than that of interest rates. The returns with local currency are currency hedged for any investors. To avoid taking the volatility of exchange rate into account, many researchers use local currency, such as Ilmanen (1995), Barr and Priestley (2004), Park and Lee (2011), Christiansen (2014), Pretorius et al. (2014), Chaieb et al. (2020).

[5] South Africa is not included in any of these clusters.

[6] Pérignon, Smith, and Villa (2007) state three principal components are sufficient as common risk factors in investigating bond yields. We also perform our analysis using only the first three principal components as global risk factors. The results are qualitatively similar though with correspondingly lower levels of market integration.

Table 1 (*continued*)

Market	Start	Database	Economic Level	Region
UK	30/12/1988	Datastream	Developed	Europe
US	30/12/1988	Datastream	Developed	Americas

This table describes the statistics of data collection and classification across markets under consideration in this paper. 'Start' reports the starting date of the bond return index. The classification of 'Economic Level' is from S&P Dow Jones. The classification of 'Region' is from International Telecommunications Union.

periods and stable periods as commonly adopted in prior literature, e.g. Forbes and Rigobon (2002), Rigobon (2003), Bekaert et al. (2014) and Filoso, Panico, Papagni, Purificato, and Suarez (2017).

5. Empirical analysis

This section analyses the market integration of bond markets from three main aspects: 1) we measure the bias in the P&R R^2 during crisis periods; 2) we estimate time-varying market integration across markets; 3) we compare the differences of market integration across maturities. In the first two sub-sections, consistent with the extant literature such as Abad et al. (2010, 2014), Volosovych (2011), Christiansen (2014) and Cipollini et al. (2015), we analyse 10+ year government bond market returns as the representative bond market. The 10+ year government bond returns are highly related to returns with other maturities. Table 4 reports the correlation of bond returns across maturities. The correlations of 10+ year returns with other maturities are above 0.6 and increase with maturity.[7] The 10+ year bond returns are the most correlated with 7–10 year bond returns (0.8634) and are the least correlated with 1–3 year returns (0.6091).

5.1. *The bias in the approach in Pukthuanthong and Roll (2009)*

The approach proposed by Pukthuanthong and Roll (2009) to measure market integration has been widely adopted for equity markets (e.g., Berger & Pukthuanthong, 2012; Berger, Pukthuanthong, & Yang, 2011; Lehkonen, 2015; Nardo et al., 2022) and for bond markets (Christiansen, 2014). However, recent papers have pointed out that the method proposed by Pukthuanthong and Roll (2009) is biased by factor heteroscedasticity, changes of factor loadings and residual heteroscedasticity during volatile periods (see, Akbari, Ng, & Solnik, 2020; Cordella & Ospino Rojas, 2017; Qin et al., 2022). This section will empirically measure the level of bias caused by each factor and their combination and estimate unconditional market integration during crises.

Table 5 presents the biases in the R^2 caused by factor heteroscedasticity, changes in factor loadings by contagion and residual heteroscedasticity during financial crises. Since the data for the group of emerging markets starts in 2000, only developed markets are analyzed during the first three crises. Using Pukthuanthong and Roll (2009)'s approach, the first two columns measure the R^2 separately during the crisis year(s) and during the crisis period. For example, during the 1994–1995 Mexican crisis, the first R^2 is calculated by averaging the R^2 in 1994 and 1995 and the second R^2 is calculated during the crisis period only: from 19th December 1994 to 31st March 1995. Aside from the 1997 Asian crisis and the 1998–1999 Russian/LTCM crisis, the values during crisis periods are lower than ones in crisis years. In other words, the P&R R^2 measure during the crisis tends to imply less integration.

The next four columns correspond to eqs. (2)–(5), reporting the R^2 after controlling factor heteroscedasticity (R^2_{FH}), controlling changes in factor loadings R^2_{BC}, controlling both factor heteroscedasticity and changes in factor loadings (R^2_{FB}), and controlling the first two factors plus residual heteroscedasticity (R^2_{QCH}). The last four columns calculate the pure bias caused by influential factors mentioned above during crises. In developed markets, the bias caused by factor heteroscedasticity is largely positive during the 1998–1999 Russian/LTCM crisis and the 2007–2009 GFC, which means the increase in factor volatilities drives the P&R R^2 higher and after adjusting for the pure bias caused by factor heteroscedasticity, the measured level of integration is lower. For the 2009–2014 ESDC, the bias purely caused by factor heteroscedasticity is negligible whether considering developed markets or emerging markets. The changes in factor loadings do not appear to largely affect the conditional R^2 during any crisis except for the 1994–1995 Mexican crisis. After adjusting for all biases, the R^2 becomes higher during most of the crises, especially for developed markets. The ESDC sees the largest adjustments with the average value in developed markets increasing from 0.4262 to 0.5986. Comparing the last two columns, we can find that after considering the effects of residual heteroscedasticity, the R^2 values increase dramatically during most crises, which suggests that the pure bias caused by residual heteroscedasticity is highly negative. The reasonable explanation may be that contagion drives an increase in residual volatility during crises and causes the explanatory power of global risk factors on bond returns to decrease. Overall, we observe that the P&R R^2 suggests the market integration decreased during recent financial crises, especially in developed markets. However, once we account for possible measurement biases, the measure suggests that, consistent with prior literature such as Pozzi and Wolswijk (2012), Abad et al. (2014), Cipollini et al. (2015), Chaieb et al. (2020), market integration has fallen much less during these crises.

Fig. 2 plots the time varying average R^2 estimated by Pukthuanthong and Roll (2009) and the adjusted method, separately represented by a blue and red line. The values are estimated each year. In stable times the two methods have the same value. In a crisis year, the adjusted method calculates the weighted-valued (adjusted) R^2 of the stable period and the crisis period in the year. We can see that during the 1994–1995 Mexican crises, the 1997 Asian crisis and the 1998 Russian/LTCM crisis, there is no evident adjustment in the P&R R^2. However, during the GFC and the ESDC, the measure in Pukthuanthong and Roll (2009) underestimates the level of market integration for developed markets.

The first plot shows the dynamics of the average market integration of all markets over time. The P&R R^2 is typically lower than the bias-adjusted R^2 especially during the two recent financial crises: the GFC and the ESDC. The P&R R^2 level of integration drops to 0.3145 in 2011, followed by an increase until 2013. However, after adjusting for the biases in market integration caused by the crises, the level of market integration is observed to become more stable and the trend in integration is smoother over time. Here, contagion causes higher residual volatility and temporarily reduces the explanatory power of global risk factors on bond returns. In developed markets, the bias is higher, which hints at why the differences in market integration between developed and emerging markets are greater than suggested by the Pukthuanthong and Roll (2009) measure. The P&R R^2 in 2013 is typically quite high in emerging markets, but after adjusting for all biases, market integration falls. The potential reason may be that during the ESDC, contagion does not largely affect emerging bond markets, irrespective of residual volatility or factor loadings.

5.2. *Time-varying market integration*

This section discusses the dynamics of market integration over time. First, we separate the markets into three groups according to data availability: Pre-1990, 1990–1999 and Post-2000. The Pre-1990 cohort includes bond markets whose data starts Pre-1990. The 1990–1999 cohort consists of markets with data availability starting from 1990 but

[7] Results using other maturities are quantitatively similar and available on request.

Table 2
Summary statistics of bond markets.

	Australia		Austria		Belgium		Canada		China		Czech Republic		Denmark		Finland	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
All Mat	0.0303	0.3049	0.0222	0.2073	0.0245	0.2322	0.0262	0.2863	0.0154	0.3352	0.0223	0.1796	0.0251	0.2480	0.0181	0.2137
1–3Y	0.0252	0.1266	0.0158	0.0698	0.0172	0.0820	0.0192	0.1129	0.0116	0.1420	0.0112	0.0865	0.0175	0.1022	0.0106	0.0778
3-5Y	0.0290	0.2386	0.0197	0.1386	0.0212	0.1607	0.0231	0.2087	0.0138	0.2513	0.0140	0.1089	0.0213	0.1799	0.0147	0.1843
5-7Y	0.0317	0.3340	0.0225	0.1951	0.0244	0.2173	0.0259	0.2768	0.0154	0.3833	0.0177	0.1717	0.0243	0.2450	0.0195	0.2530
7-10Y	0.0336	0.4383	0.0248	0.2631	0.0274	0.2870	0.0283	0.3505	0.0156	0.4382	0.0216	0.2375	0.0278	0.3031	0.0216	0.3131
10 + Y	0.0361	0.5458	0.0294	0.4826	0.0323	0.4622	0.0336	0.4903	0.0187	0.6668	0.0252	0.3211	0.0334	0.5168	0.0330	0.4965

	France		Germany		Greece		Hong Kong		Hungary		India		Indonesia		Ireland	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
All Mat	0.0245	0.2569	0.0216	0.2631	−0.0187	1.3209	0.0150	0.1811	0.0346	0.2755	0.0314	0.2757	0.0440	0.7725	0.0273	0.3255
1–3Y	0.0166	0.0811	0.0153	0.0729	−0.0176	1.4121	0.0104	0.0939	0.0321	0.2563	0.0291	0.0998	0.0296	0.1673	0.0215	0.2068
3-5Y	0.0210	0.1609	0.0185	0.1532	−0.0135	1.3763	0.0158	0.1940	0.0334	0.3306	0.0307	0.1710	0.0355	0.4654	0.0260	0.2694
5-7Y	0.0241	0.2261	0.0218	0.2157	−0.0228	1.0102	0.0194	0.2822	0.0379	0.4627	0.0313	0.2410	0.0418	0.6282	0.0188	0.3541
7-10Y	0.0271	0.2915	0.0237	0.2912	−0.0230	1.0199	0.0231	0.3840	–	–	0.0304	0.3145	0.0452	0.8046	0.0298	0.4020
10 + Y	0.0320	0.4758	0.0303	0.5276	0.0105	1.2182	0.0265	0.5740	0.0374	0.7058	0.0332	0.3962	0.0529	0.9745	0.0316	0.5055

	Israel		Italy		Japan		Malaysia		Mexico		Netherlands		New Zealand		Norway	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
All Mat	0.0126	0.1368	0.0317	0.3219	0.0114	0.1487	0.0142	0.2067	0.0300	0.3366	0.0218	0.2351	0.0308	0.2245	0.0248	0.1890
1–3Y	0.0027	0.0305	0.0237	0.1296	0.0066	0.0484	0.0127	0.1133	0.0273	0.1904	0.0154	0.0678	0.0280	0.1155	0.0149	0.1997
3-5Y	0.0089	0.0853	0.0287	0.2298	0.0099	0.1053	0.0141	0.1639	0.0274	0.2371	0.0192	0.1401	0.0282	0.1533	0.0205	0.3032
5-7Y	0.0153	0.1521	0.0316	0.3153	0.0126	0.1741	0.0151	0.2302	0.0286	0.3568	0.0223	0.2013	0.0306	0.2273	0.0256	0.1975
7-10Y	0.0205	0.2227	0.0342	0.4011	0.0152	0.2427	0.015	0.3205	0.0367	0.4466	0.0245	0.2681	0.0266	0.2953	0.0270	0.2707
10 + Y	0.0250	0.3481	0.0369	0.5857	0.0203	0.3672	0.0175	0.4691	0.0345	0.5817	0.0255	0.3142	0.0321	0.3888	0.0272	0.3540

	Philippine		Poland		Portugal		Russia		Singapore		South Africa		South Korea		Spain	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
All Mat	0.0280	0.3955	0.0286	0.1970	0.0279	0.4179	0.0352	0.4828	0.0134	0.2133	0.0394	0.4474	0.0211	0.2249	0.0283	0.2517
1–3Y	0.0105	0.0364	0.0238	0.1872	0.0237	0.2707	0.0334	0.2648	0.0066	0.0602	0.0332	0.1478	0.0170	0.1052	0.0232	0.1127
3-5Y	0.0138	0.0875	0.0271	0.1973	0.0277	0.4150	0.0358	0.4749	0.0118	0.1402	0.0366	0.2639	0.0198	0.2358	0.0272	0.2211
5-7Y	0.0171	0.1393	0.0299	0.2718	0.0289	0.5504	0.0381	0.6001	0.0157	0.2262	0.0399	0.3831	0.0185	0.2436	0.0284	0.3043
7-10Y	0.0195	0.2219	0.0278	0.3528	0.0326	0.5673	0.0376	0.6624	0.0175	0.3368	0.0414	0.4618	0.0250	0.3571	0.0338	0.3872
10 + Y	0.0228	0.3156	0.0333	0.4834	0.0217	0.3734	0.0416	1.0278	0.0175	0.6345	0.0420	0.6530	0.0286	0.5367	0.0308	0.5764

	Sweden		Switzerland		Taiwan		Thailand		UK		US		Developed		Emerging	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
All Mat	0.0273	0.2579	0.0158	0.1741	0.0085	0.1627	0.0191	0.1995	0.028	0.3648	0.0231	0.3208	0.0230	0.2500	0.0237	0.3991
1–3Y	0.0217	0.1177	0.0099	0.0847	0.0049	0.0593	0.0119	0.0477	0.0210	0.1026	0.0163	0.0846	0.0167	0.1065	0.0181	0.2293
3-5Y	0.0247	0.2100	0.0128	0.1388	0.0066	0.0873	0.0165	0.1315	0.0244	0.1853	0.0215	0.2125	0.0207	0.1943	0.0209	0.3105
5-7Y	0.0273	0.2848	0.0148	0.1560	0.0084	0.1367	0.0198	0.2013	0.0268	0.2546	0.0242	0.2979	0.0231	0.2577	0.0227	0.3726
7-10Y	0.0302	0.3557	0.0171	0.2077	0.0086	0.1772	0.0224	0.2994	0.0293	0.3437	0.0263	0.3931	0.0261	0.3322	0.0230	0.4429
10 + Y	0.0320	0.4069	0.0205	0.3282	0.0030	0.3324	0.0282	0.3431	0.0336	0.5535	0.0326	0.6568	0.0293	0.4741	0.0286	0.6063

This table summaries the statistics of bond index returns across markets. Six maturities are considered: all maturity, 1–3 year maturity, 3–5 year maturity, 5–7 year maturity, 7–10 year maturity, and 10+ year maturity. The local-currency daily return indexes are collected and the returns are expressed by percentage.

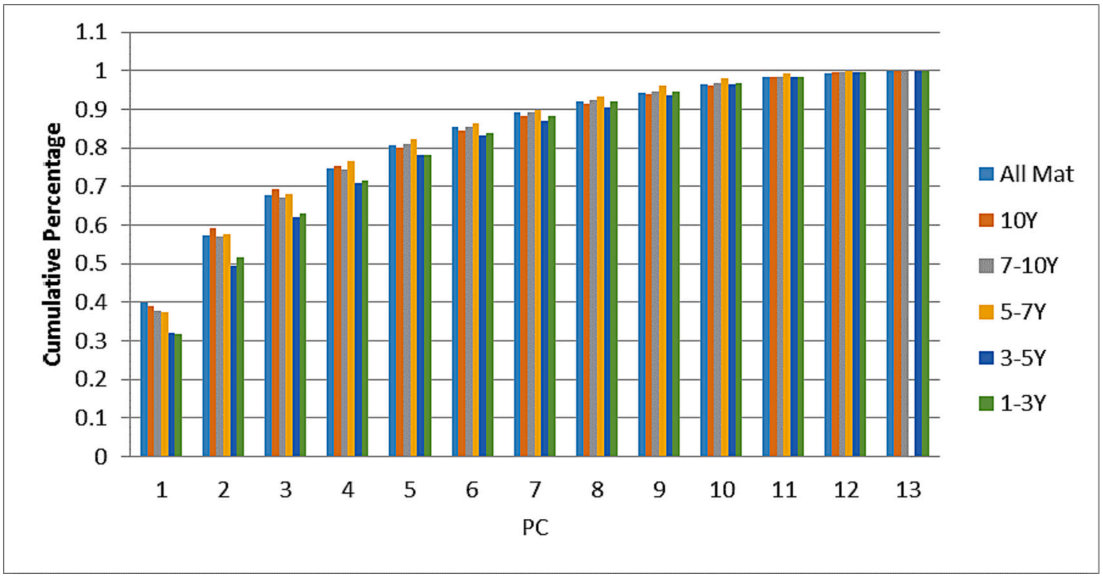


Fig. 1. Average cumulative percentage.
This figure illustrates the average cumulative percentage of total return variance explained by sorted eigenvalues during 1989–2017. In each calendar year, the cumulative percentage of total return variance is estimated by first principal components which are extracted from the 11 main developed markets. The main markets which construct the convariance matrix are the markets with the longest history and the largest economies.

Table 3
Crisis and stable periods.

Crisis	Crisis Period	Stable Period
1994–1995 Mexican crisis	19/12/1994–31/03/1995	01/06/1994–16/12/1994
1997 Asian crisis	17/10/1997–16/11/1997	01/01/1996–16/10/1997
1998 Russian/LCTM crisis	03/08/1998–15/10/1998	02/03/1998–01/06/1998
2007–2009 GFC	07/08/2007–15/03/2009	01/01/2003–31/12/2006
2009–2014 ESDC	01/06/2009–23/06/2014	01/01/2015–31/12/2017

This table lists five main financial crises and their corresponding crisis periods and stable periods during 1989–2017.

Table 4
Correlation coefficients of bond returns across maturities.

Correlation	All Mat	10 + Y	7-10Y	5-7Y	3-5Y	1–3Y
All Mat	1	0.7450	0.8681	0.9265	0.9554	0.9106
10 + Y	0.7450	1	0.8634	0.7933	0.7222	0.6091
7-10Y	0.8681	0.8634	1	0.9105	0.8555	0.7486
5-7Y	0.9265	0.7933	0.9105	1	0.9318	0.8347
3-5Y	0.9554	0.7222	0.8555	0.9318	1	0.8956
1–3Y	0.9106	0.6091	0.7486	0.8347	0.8956	1

This table shows the correlation of bond returns among bond markets across six different maturities: all maturity ('All Mat'), 1–3 year maturity (1–3Y), 3–5 year maturity (3-5Y), 5–7 year maturity (5-7Y), 7–10 year maturity (7-10Y), and 10+ year maturity (10 + Y).

before 2000. The third cohort: Post-2000, contains all bond markets with data starting since 2000.[8]

The upper-left graph in Fig. 3 illustrates the dynamics of market integration in these three cohorts. The first two cohorts both exhibit a high level of market integration and have an increased trend over time up to 2007. The post-2000 cohort which mostly comprises emerging markets is characterized by a low level of market integration over the entire albeit shorter sample. This level of integration remains stable over time. The upper-right graph compares market integration between developed and emerging markets. Clearly, as can be seen, developed markets have much higher levels of market integration than emerging markets. Market integration keeps increasing in developed markets until 2007, then tends to level out at around 0.6. However, emerging markets are observed to have a low level of integration with global factors, with market integration remaining below 0.2 over time. Market integration falls to the lowest level during the ESDC. Chaieb et al. (2020) investigate the effects of domestic factors (such as political risks, credit risks, inflation and liquidity) on sovereign bond markets and find that markets with high political and credit risks, high and volatile inflation and low liquidity are less integrated than markets with low political and credit risks, low and stable inflation and high liquidity. Most developed markets are normally considered to have high political stability, low credit risks, low inflation and high liquidity, which determines higher integration than emerging markets of which many have high political and default risks or high inflation or low liquidity. The lower-right graph shows the difference of market integration across regions. We consider three categories based on geographic locations: Americas, Europe and Asia-Pacific. From the graph, we can see that the markets in Americas have the highest level of integration, just followed by European markets. Asian markets have low market integration, which is consistent with previous literature (e.g. Park & Lee, 2011; Pretorius et al., 2014; Vo, 2009). Market integration is observed to increase until 1999, but there is little increase after 2000. As expected, market integration is at its lowest levels since the early years of the sample during the ESDC given this crisis is centred on European bond markets.

Given much prior focus on changes in market integration after the introduction of the Euro, we also examine the differences in market integration in the EMU, EU and non-EU markets. The result is presented in the lower-left graph in Fig. 3. Consistent with Pozzi and Wolswijk (2012), Cipollini et al. (2015) and Ehrmann and Fratzscher (2017), market integration in EMU markets dramatically increases after 1999 following the introduction of the Euro such that the markets become almost fully integrated. After 2009 following the ESDC, market integration is observed to fall back almost to pre-Euro levels (0.68 in 2010–2012 and 0.67 in 1999). This suggests that the impact of debt

[8] The starting date is shown in Table 1 for each market.

Table 5
The R^2 and bias during crises.

Crisis	Category	R^2_{PRy}	R^2_{PR}	R^2_{FH}	R^2_{BC}	R^2_{FB}	R^2_{QCH}	ΔR^2_{FH}	ΔR^2_{BC}	ΔR^2_{FB}	ΔR^2_{QCH}
1994–1995 Mexican crisis	All /Developed	0.4463	0.3644	0.4627	0.4779	0.5787	0.4653	−0.0982	−0.1134	−0.2142	−0.1009
1997 Asian crisis	All /Developed	0.4846	0.5529	0.6396	0.5315	0.6542	0.4950	−0.0868	0.0214	−0.1013	0.0578
1998–1999 Russian/LTCM	All /Developed	0.5232	0.6065	0.3396	0.5939	0.3140	0.5604	0.2669	0.0126	0.2925	0.0460
2007–2009 GFC	All	0.4857	0.4623	0.3254	0.5401	0.3845	0.5786	0.1369	−0.0778	0.0778	−0.1163
	Developed	0.5759	0.5530	0.3914	0.6292	0.4548	0.6768	0.1616	−0.0762	0.0982	−0.1238
	Emerging	0.0572	0.0317	0.0120	0.1173	0.0507	0.1125	0.0197	−0.0856	−0.0190	−0.0808
2009–2014 ESDC	All	0.3755	0.3264	0.3391	0.4015	0.4030	0.4626	−0.0127	−0.0752	−0.0767	−0.1363
	Developed	0.4741	0.4262	0.4435	0.5122	0.5212	0.5986	−0.0172	−0.0860	−0.0950	−0.1724
	Emerging	0.0937	0.0410	0.0409	0.0852	0.0653	0.0741	0.0001	−0.0442	−0.0243	−0.0331

This table reports a series of the R^2 and the bias caused by influential factors in financial crises. R^2_{PRy} is (average) R^2 during the crisis year(s) using the P&R (2009) method; R^2_{PR} is P&R (2009) R^2 during the crisis period; R^2_{FH} is R^2 after adjusting for the bias caused by factor heteroscedasticity during the crisis period, which is calculated by the Eq. (4); R^2_{BC} is R^2 after adjusting for the bias caused by beta changes during the crisis period, which is calculated by the Eq. (5); R^2_{FB} is R^2 after adjusting for the bias caused by factor heteroscedasticity and beta changes during the crisis period, which is based on the Eq. (6); R^2_{QCH} is unconditional R^2 after adjusting for all bias caused by the crisis, including factor heteroscedasticity, beta changes and residual heteroscedasticity, which is calculated based on the general eq. (3). The last four columns calculate the bias caused by influential factors. $\Delta R^2_{FH} = R^2_{PR} - R^2_{FH}$, measures the pure bias caused by factor heteroscedasticity during crises; $\Delta R^2_{BC} = R^2_{PR} - R^2_{BC}$, measures the pure bias caused by beta changes during crises; $\Delta R^2_{FB} = R^2_{PR} - R^2_{FB}$, measures the bias caused by factor heteroscedasticity and beta changes; $\Delta R^2_{QCH} = R^2_{PR} - R^2_{QCH}$, measures the total bias caused by crises. The values are averaged across markets.

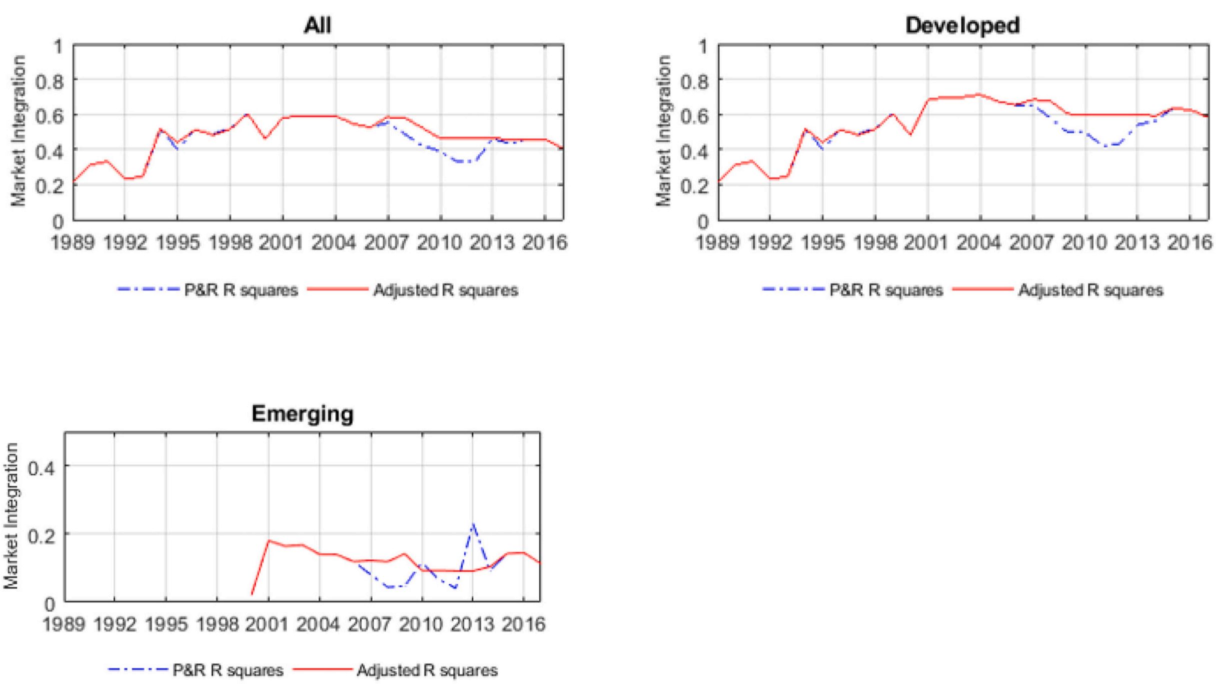


Fig. 2. Dynamics of market integration.
This figure shows the dynamics of average market integration using Pukthuanthong and Roll (2009)'s method and the adjusted method for all markets, developed markets and emerging markets. 'P&R R^2' is the explanatory power of global risk factors on bond index returns in each estimation year. 'Adjusted R^2' is explanatory power after adjusting for all biased caused by influential factors during financial crises.

crisis is more harmful for government bond markets in EMU countries from the perspective of integration process and funding costs. The main reason is due to the imbalances in economic and financial situations among EMU countries (such as country-specific liquidity, credit quality, etc.), which become stronger during debt crisis (Abad et al., 2010; Von Hagen, Schuknecht, & Wolswijk, 2011).

While the plots of market integration in Figs. 2 and 3 suggest that there is a tendency for bond markets to become more integrated over time, Table 6 reports the results of a more formal test, regressing market integration on a simple time trend. Panel A reports the results across markets and Panel B reports the results for the various sample, economic and regional groupings.

We can see that the dynamics of market integration across individual markets are heterogeneous which is also supported by Chaieb et al. (2020). For 17 out of 35 bond markets there is evidence of a significant positive time trend and Czech Republic experience a substantial decrease over time suggesting the market is decoupling from global markets and becoming more segmented.[9] Consistent with Kumar and Okimoto (2011), it is predominantly developed markets which exhibit the increasing levels of market integration over time with little systematic support for increasing integration in emerging markets. For the groupings based on sample availability, all three appear to exhibit

[9] There are only 35 markets in total as 3 markets, Hong Kong, Israel and Taiwan are not investigated due to insufficient observations.

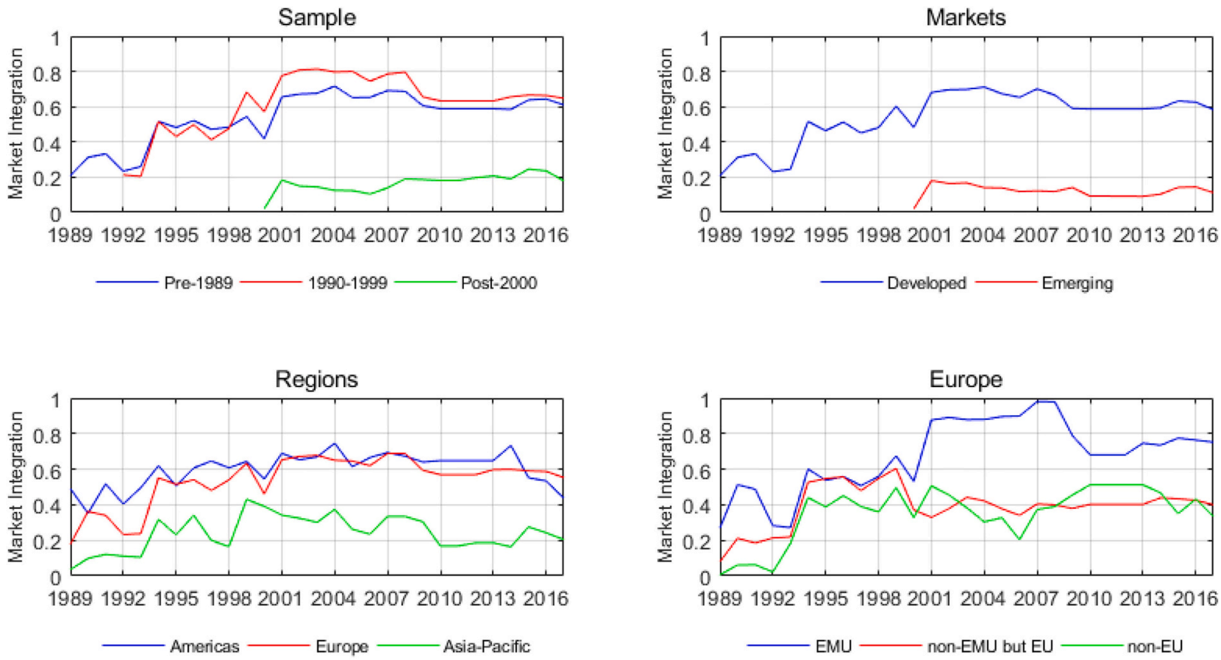


Fig. 3. Dynamics of adjusted market integration across clusters.
This figure illustrates the dynamics of adjusted market integration over 1989–2017 in each subgroup. This paper divides markets to four categories according to sample availability ('Sample'), whether markets are developed or emerging ('Markets'), geographic regions (Regions) and Euro adoption in Europe markets ('Europe').
The appendix C compares the differences of market integration using Pukthuanthong and Roll (2009) and our adjusted method in these four categories. In most subgroups, the bias during the GFC and ESDC is dramatic, especially for the cohorts of 1990–1999, Europe markets and EMU markets. In the EMU group, the method of Pukthuanthong and Roll (2009) shows a dramatic drop from almost fully integrated in 2007 to 0.4 in 2012. But the adjusted method figures out that market integration still keeps a higher level during recent financial crises although a slight decline was happened after 2007.

significant positive trends (increasing integration) over time. As suggested by the individual market analysis, on average developed markets have become more integrated over time but there is no such evidence for emerging markets. Across regions, European markets have experienced the largest increase in integration over time followed by the Americas. However, there is no significant evidence of a trend in integration in the Asia-Pacific region which is dominated by emerging markets.

There are a number of potential reasons why the Asia-Pacific region remains more segmented. Eichengreen and Park (2005) suggest that lower capital market liberalization and market underdevelopment may be the main reasons for the low levels of integration in Asia while Vo (2009) argues that it may be due to many reasons, including barriers on international trades and investment, home bias, different investment cultures, high credit and liquidity risks. Further in contrast to developed bond markets in other regions, Park and Lee (2011) suggest the development of financial infrastructure and the legal framework of bond markets are still struggling in emerging Asia with low transparency and lack of strong governance resulting in high segmentation.

5.3. Comparisons of market integration across maturities

The evidence presented above is based on 10+ year maturity government bonds. Since investors have different investment preferences on maturity band and sovereign bonds have different funding costs across maturities which is affected by market integration, a natural question which arises, is whether we observe different levels and patterns of integration in bond markets with different maturities.

Table 7 shows average market integration across markets and maturities. The average market integration of developed markets is largely greater than that of emerging markets irrespective of the maturity of the bond market. For example, in the all maturities sample, the average level of integration is 0.5522 in developed markets but only 0.1095 in emerging markets. Though, the level of market integration is more variable across developed markets. For instance, in the three most integrated developed markets: Austria, Belgium and Finland the level of integration is 0.8606, 0.8064 and 0.8262 respectively while Israel, Japan and South Korea have the lowest market integration, with levels of 0.2833, 0.1090 and 0.2641 respectively. In emerging markets, Czech Republic (0.2332) and Poland (0.1762) have the higher levels of market integration compared to other emerging markets, while China (0.0155) is the most segmented. Moreover, Italy, Portugal and Spain experience high volatility on market integration due to the sovereign debt crisis. In most of the markets, consistent with Diebold, Li, and Yue (2008) and Kumar and Okimoto (2011), market integration increases with maturities. In general, the average of market integration is 0.3469 with 1–3 years and 0.5522 with 10+ years in developed markets and 0.0438 with 1–3 years and 0.1071 with 10+ years in emerging markets.

It is worth mentioning that in Greece, the average market integration of government bonds with maturity 1–3 years is quite high (0.8427). The high value is from the ESDC period. After the announcement of Greek government's fiscal deficit in December 2009, three major credit rating agencies successively downgraded Greece's sovereign credit rating, which unveiled the Greek debt crisis and caused the dramatic increase in sovereign funding costs. According to Chaieb et al. (2014), countries with high political risks and high credit risks could experience low integration in bond markets. However, since 2010, international financial institutions (such as the IMF and the European Central Bank) launched bailout bonds with hundreds of billions of euros to help Greece decrease sovereign default. Meanwhile, the Greek government also actively pursued a series of policies to improve domestic financial and economic conditions and intend to decrease sovereign funding costs.

Figure 4 plots the average time-varying market integration for different maturities for all markets, and then developed markets and emerging markets separately. For all markets, the market integration of bonds with 10+ years maturity is almost the same as for bonds with 7–10 years maturity except for the period of 2000–2009. Shortest-term

Table 6
Time trends of adjusted market integration.

Market	Obs	Coeff	t-Stat	Market	Obs	Coeff	t-Stat
Panel A Time trend across markets							
Australia	29	0.0061	1.9785*	Mexico	3	−0.0606	−1.0658
Austria	20	0.0051	1.0040	Netherlands	29	0.0166	5.4874***
Belgium	26	0.0183	4.6189***	New Zealand	26	0.0036	0.7684
Canada	29	0.0086	5.9063***	Norway	24	0.0023	0.7495
China	8	0.0016	1.1583	Philippine	4	−0.0266	−1.2189
Czech Republic	17	−0.0146	−2.8462**	Poland	17	0.0180	6.9922***
Denmark	25	0.0136	5.1593***	Portugal	5	0.1340	1.7958
Finland	8	−0.0252	−2.7550	Russia	3	−0.0087	−0.1784
France	29	0.0184	5.5660***	Singapore	17	0.0270	5.5566***
Germany	29	0.0251	6.6725***	South Africa	17	−0.0027	−1.4869
Greece	6	−0.0850	−2.0590	South Korea	10	−0.0033	−0.2325
Hungary	18	0.0081	6.2825***	Spain	23	0.0048	0.5013
India	8	0.0030	0.8691	Sweden	29	0.0141	4.8749***
Indonesia	4	0.0355	2.9804	Switzerland	29	0.0175	6.4782***
Ireland	29	0.0110	2.3645**	Thailand	4	0.0264	0.9520
Italy	24	0.0019	0.2812	UK	29	0.0140	3.9788***
Japan	29	0.0047	4.1453***	US	29	0.0098	6.1833***
Malaysia	8	0.0102	2.0233*				
Panel B Time trend across categories							
Sample				Markets			
Category	Obs	Coeff	t-Stat	Category	Obs	Coeff	t-Stat
Pre-1990	29	0.0133	6.2883***	Developed	29	0.0125	5.3584***
1990–1999	26	0.0122	3.3495***	Emerging	18	−0.0017	−0.8858
Post-2000	18	0.0051	2.4916**				
Regions				Europe			
Category	Obs	Coeff	t-Stat	Category	Obs	Coeff	t-Stat
All World	29	0.0053	2.3327**	EMU	29	0.0167	5.0678***
Americas	29	0.0055	2.5890**	EU	29	0.0039	1.4304
Europe	29	0.0108	4.5387***	non-EU	29	0.0114	3.8975***
Asia-Pacific	29	0.0024	1.1495				

This table reports the time trends of market integration across markets and subgroups. The ‘Obs’ means observations. The ‘Coeff’ in the table is the estimated coefficient by regressing market integration on a time variable over available years. The number of available years and t-statistics are reported in the table. Panel A ignores the time trends of Hong Kong, Israel and Taiwan due to limited observations. ***, ** and * indicate significance at the 1%, 5% and 10% level.

bonds are the least integrated, followed by bonds with the next shortest maturities (3–5 years and 5–7 years). After 2008, the differences in market integration becomes greater across maturities especially the bonds between 1 and 3 years and 3–5 years maturity, and the bonds between 5 and 7 years and 7–10 years maturity. Given developed markets form over 60% of the sample, they display a similar pattern to the average of all markets. However, emerging markets exhibit a different picture. Market integration is still observed to increase with maturity, but the overall level of integration remains low. Further, although integration falls to very low levels during the ESDC such that bonds with 1–3 years maturity are almost fully segmented, the magnitude of decoupling or reduction in integration is less than for developed bond markets (since this group is dominated by European markets). Following the sovereign debt crisis, market integration reverts back toward pre-crisis levels.

6. Conclusion

This paper investigates time-varying market integration in bond markets across 24 developed markets and 14 emerging markets and a range of maturities. Following Christiansen (2014) we use the approach of Pukthuanthong and Roll (2009) to estimate market integration for a global sample. However, we argue that this approach fails to accurately measure market integration during the periods of crisis. Forbes and Rigobon (2002) and Bekaert et al. (2014) note how correlation and comovement are influenced by heteroscedasticity and contagion during crisis periods and therefore it is potentially important to adjust for these effects. We document the extent of these effects when measuring bond market integration and propose the use of a new bias corrected measure (Qin et al., 2022) to accurately capture the actual level of market integration.

Our results show that 1) The Pukthuanthong and Roll (2009) method largely underestimates the level of market integration during the longer GFC and ESDC periods, especially in developed markets. We posit that the main potential reason may be the effects of contagion on idiosyncratic factors' volatility. After adjusting for the known bias, the actual level of market integration is higher and less volatile. 2) Consistent with the extant literature we find that developed markets gradually become more integrated until 2007 and afterwards market integration tends to plateau. Emerging markets are characterized by the low levels of average market integration throughout time. Across regions, the Americas are the most integrated, followed by Europe. Markets in Asia-Pacific have the lowest integration over time. 3) After the introduction of the Euro, the EMU markets become almost fully integrated, but the same evidence is not found in non-EMU markets. 4) Most developed markets are time-increasing on market integration, but emerging markets are not. 5) Consistent with the importance of global risk factors tending to increase with maturity (Diebold et al., 2008) we observe that market integration increases with maturity although the differences are minimal in emerging markets.

The findings can provide strong implication for international investors and financial policymakers. First, the low market integration in emerging markets and in the Asia-Pacific region suggests international investors may benefit by diversifying their portfolios across markets and regions. Second, for policymakers, this paper provides a more comprehensive understanding of the extent of market integration and its dynamics. The high level of market integration in financial markets could promote the development of financial institutions and financial systems and thus facilitate economic development. However, financial markets with high market integration can also be strongly influenced by external shocks, such as contagion during financial crises, which induces more uncertainty. Thus, the policymakers not only need to promote financial

Table 7
Average adjusted market integration across maturities.

Markets	All Mat	10+	7-10Y	5-7Y	3-5Y	1–3Y	Markets	All Mat	10+	7-10Y	5-7Y	3-5Y	1–3Y
Australia	0.3324	0.3596	0.3479	0.3021	0.2520	0.1921	Netherlands	0.7999	0.7708	0.8038	0.7431	0.7167	0.5831
	(0.1407)	(0.1471)	(0.1480)	(0.1445)	(0.1449)	(0.1258)		(0.1828)	(0.1942)	(0.1880)	(0.1842)	(0.2084)	(0.2416)
Austria	0.8606	0.8640	0.8723	0.8238	0.7763	0.6240	New Zealand	0.5070	0.5362	0.5076	0.4582	0.3829	0.2666
	(0.1406)	(0.1322)	(0.1194)	(0.1610)	(0.1561)	(0.2037)		(0.1899)	(0.1650)	(0.1876)	(0.1666)	(0.1762)	(0.1664)
Belgium	0.8064	0.8189	0.8078	0.7830	0.7443	0.6210	Norway	0.4862	0.5200	0.4882	0.3744	0.2644	0.1316
	(0.2068)	(0.2039)	(0.2042)	(0.1875)	(0.2163)	(0.2407)		(0.0467)	(0.0430)	(0.0535)	(0.0387)	(0.0986)	(0.0379)
Canada	0.6172	0.6467	0.6086	0.5710	0.4962	0.2642	Philippine	0.0930	0.5844	0.6843	0.6425	0.5918	0.4476
	(0.1064)	(0.0977)	(0.1144)	(0.1184)	(0.1313)	(0.1248)		(0.0981)	(0.0344)	(0.0397)	(0.0548)	(0.0758)	(0.1097)
China	0.0155	0.0162	0.0151	0.0117	0.0176	0.0205	Poland	0.1762	0.1679	0.1472	0.1150	0.0826	0.0292
	(0.0088)	(0.0094)	(0.0080)	(0.0098)	(0.0134)	(0.0185)		(0.0970)	(0.1022)	(0.1009)	(0.0682)	(0.0570)	(0.0166)
Czech Republic	0.2332	0.1911	0.1980	0.1320	0.0887	0.0638	Portugal	0.7552	0.6786	0.7081	0.6378	0.3876	0.3831
	(0.1130)	(0.1244)	(0.1149)	(0.1187)	(0.0852)	(0.0641)		(0.3054)	(0.2944)	(0.3449)	(0.4392)	(0.4478)	(0.3100)
Denmark	0.6635	0.6795	0.6699	0.5696	0.4856	0.3427	Russia	0.0333	0.0250	0.0392	0.0402	0.0285	0.0188
	(0.1476)	(0.1368)	(0.1371)	(0.1203)	(0.1325)	(0.1918)		(0.0237)	(0.0122)	(0.0273)	(0.0388)	(0.0140)	(0.0176)
Finland	0.8262	0.8450	0.8364	0.7666	0.7048	0.5071	Singapore	0.3311	0.2444	0.3297	0.2975	0.2499	0.1612
	(0.0424)	(0.0268)	(0.0339)	(0.0170)	(0.0705)	(0.0287)		(0.0583)	(0.1672)	(0.0710)	(0.0412)	(0.0541)	(0.0585)
France	0.7646	0.7416	0.7736	0.6670	0.6802	0.5685		0.0604	0.0591	0.0594	0.0654	0.0565	0.0398
	(0.1970)	(0.2144)	(0.1938)	(0.2096)	(0.2118)	(0.2367)	South Africa	(0.0719)	(0.0652)	(0.0722)	(0.0769)	(0.0647)	(0.0332)
Germany	0.7218	0.6903	0.7221	0.6937	0.6440	0.5431		0.2641	0.2722	0.2953	0.2359	0.1818	0.0893
	(0.2479)	(0.2712)	(0.2376)	(0.2215)	(0.2466)	(0.2503)	South Korea	(0.0801)	(0.0859)	(0.0794)	(0.0716)	(0.0604)	(0.0455)

Markets	All Mat	10+	7-10Y	5-7Y	3-5Y	1–3Y	Markets	All Mat	10+	7-10Y	5-7Y	3-5Y	1–3Y
Greece	0.8437	0.2743	0.3273	0.2990	0.1941	0.8427	Spain	0.6451	0.6256	0.6439	0.5001	0.5674	0.4592
	(0.0044)	(0.0573)	(0.1883)	(0.1662)	(0.0192)	(0.0041)		(0.2852)	(0.3006)	(0.2798)	(0.3613)	(0.3096)	(0.3539)
Hong Kong	0.6830	0.7226	0.7012	0.6546	0.5864	0.3467	Sweden	0.4642	0.4752	0.4764	0.3825	0.3488	0.2747
	–	–	–	–	–	–		(0.1748)	(0.1750)	(0.1854)	(0.2156)	(0.2134)	(0.2007)
Hungary	0.0748	0.0667	–	0.0479	0.0274	0.0148	Switzerland	0.3697	0.3206	0.3933	0.2914	0.1960	0.1033
	(0.0582)	(0.0511)	–	(0.0343)	(0.0147)	(0.0111)		(0.1866)	(0.1907)	(0.1972)	(0.1438)	(0.1090)	(0.0530)
India	0.0308	0.0264	0.0331	0.0304	0.0362	0.0314	Taiwan	0.0318	0.0049	0.0601	0.0657	0.0890	0.0115
	(0.0251)	(0.0221)	(0.0239)	(0.0176)	(0.0253)	(0.0131)		–	–	–	–	–	–
Indonesia	0.0599	0.0503	0.0503	0.0322	0.0507	0.0313	Thailand	0.1867	0.1508	0.1905	0.1849	0.1633	0.1106
	(0.0135)	(0.0374)	(0.0275)	(0.0119)	(0.0112)	(0.0055)		(0.0513)	(0.0383)	(0.0512)	(0.0579)	(0.0397)	(0.0478)
Ireland	0.6299	0.6967	0.6137	0.5736	0.4440	0.2359	UK	0.5674	0.5619	0.5945	0.5044	0.4728	0.3442
	(0.1469)	(0.0931)	(0.1636)	(0.1735)	(0.2208)	(0.1584)		(0.1929)	(0.1962)	(0.2029)	(0.1976)	(0.1810)	(0.1480)
Israel	0.2833	0.2923	0.2813	0.2177	0.1222	0.0560	US	0.6118	0.6175	0.6248	0.5871	0.5292	0.3888
	(0.1155)	(0.1201)	(0.1451)	(0.1086)	(0.0331)	(0.0270)		(0.1036)	(0.1095)	(0.1092)	(0.1241)	(0.1282)	(0.1571)
Italy	0.6619	0.6538	0.6711	0.5423	0.5925	0.4973							
	(0.2119)	(0.2191)	(0.2003)	(0.2974)	(0.2596)	(0.3162)	*Categories based on Economic Level*						
Japan	0.1090	0.1048	0.1140	0.0987	0.0781	0.0596	All Markets	0.4830	0.4769	0.5031	0.4330	0.3971	0.3040
	(0.0599)	(0.0642)	(0.0675)	(0.0554)	(0.0423)	(0.0395)		(0.1214)	(0.1184)	(0.1324)	(0.1262)	(0.1303)	(0.1395)
Malaysia	0.0545	0.0449	0.0441	0.0433	0.0571	0.0306	Developed Markets	0.5522	0.5463	0.5593	0.4947	0.4548	0.3469
	(0.0406)	(0.0488)	(0.0338)	(0.0291)	(0.0233)	(0.0166)		(0.1546)	(0.1538)	(0.1574)	(0.1534)	(0.1561)	(0.1625)
Mexico	0.0998	0.1150	0.0959	0.0677	0.0465	0.0367	Emerging Markets[a]	0.1095	0.1071	0.1267	0.0851	0.0662	0.0438
	(0.0763)	(0.0831)	(0.0906)	(0.0460)	(0.0325)	(0.0298)		(0.0438)	(0.0418)	(0.0501)	(0.0377)	(0.0326)	(0.0253)

This table shows the average market integration of bond markets with all maturity, the maturity of 10+ years, 7–10 years, 5–7 years, 3–5 years, 1–3 years across markets and economic-level subgroups. The standard deviation is reported in parentheses.

[a] Due to extremely high values of market integration of Greece bond market with 1–3 year maturity in 2005 and 2006, Greece is not considered here and in Figure 3.

integration to gain benefits, but also take measures to enhance financial systems and establish solid financial markets.

Data availability

The authors do not have permission to share data.

Appendix A. Proof of the bias in the conditional explanatory power coefficient

Assume a multi-factor regression model:

$$y_t = \alpha + \beta_1 x_{1t} + \beta_2 x_{2t} + \ldots + \beta_N x_{Nt} + \varepsilon_t \tag{A.1}$$

where, the dependent variable y_t is the market return, the independent variables $x_{1t}, x_{2t}, \ldots, x_{Nt}$ are N global risk factors, where $E[X_t] = 0$ and $E[x_{it}x_{jt}] = 0$ with $i \neq j$, α is a constant, β_i are the coefficients, $i, j = 1, 2, \ldots, N$ and ε_t is the error term with $E[\varepsilon_t] = 0$ and $E[X_t \varepsilon_t] = 0$.

Consider a sample characterized by high and low variance periods such that the variance of y_t is lower in the low-variance (stable) period (l) and higher in the high-variance (volatile) period (h), so $\sigma_{yy}^h > \sigma_{yy}^l$. Meanwhile, for the regression eq. (A.1), assume the relationship between factor variance, residual variance and the factor loadings in the high and low variance periods is: $\sigma_{x_i x_i}^h = (1 + \delta_{x_i})\sigma_{x_i x_i}^l$, $\sigma_{\varepsilon\varepsilon}^h = (1 + \delta_\varepsilon)\sigma_{\varepsilon\varepsilon}^l$ and $\beta_i^h = (1 + \delta_{\beta_i})\beta_i^l$, where

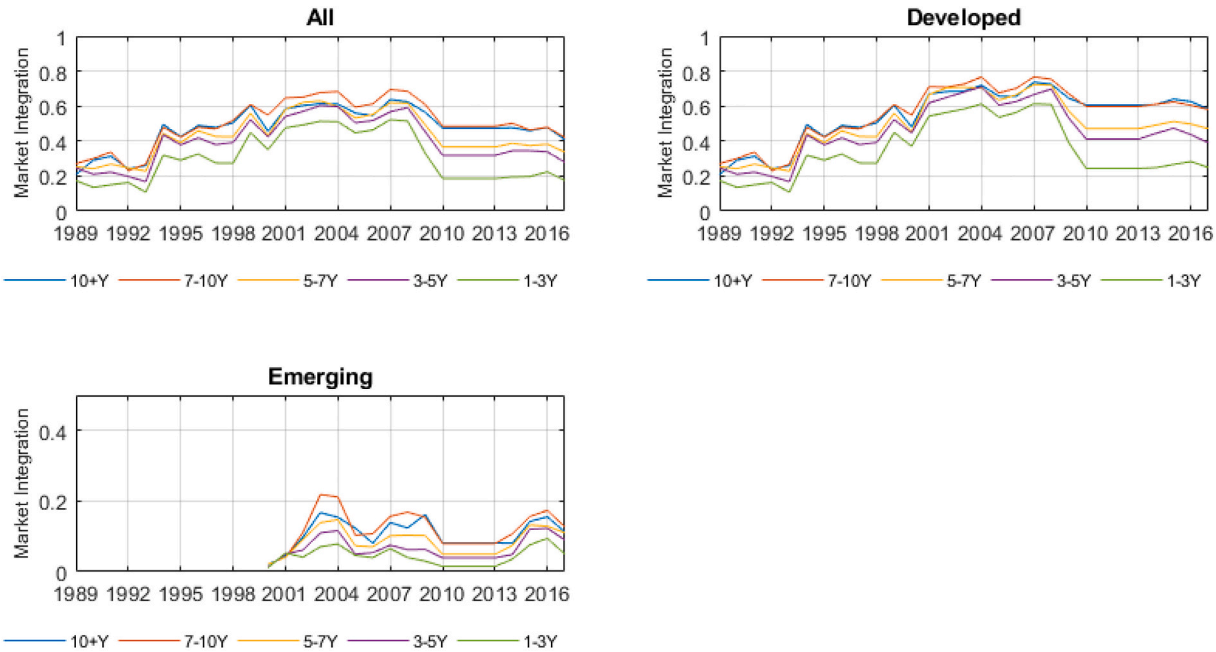


Fig. 4. Dynamics of adjusted market integration across maturities.
This figure presents the dynamics of the market integration of bond markets with all maturity, maturities with 10+ years, 7–10 years, 5–7 years, 3–5 years and 1–3 years over 1989–2017. Three groups are considered: all markets, developed markets and emerging markets.

$\sigma_{x_ix_i}, \sigma_{\varepsilon\varepsilon}$ are separately the variances of the global factors x_i and of the residuals ε. We also assume the market is not fully segmented, so at least one of δ_{β_i} is not -1.

The explanatory power of global risk factors (expressed as R^2 below) in eq. (A.1) can be written as[10]

$$R^2 = \sum_{i=1}^{N} \left[\rho_{x_iy}\right]^2 \tag{A.2}$$

where, ρ_{x_iy} is the correlation between each of the N global risk factors (x_i) and the market return (y).

In order to obtain ρ_{x_iy}, we separately derive two relationships between stable period and volatile period. The first one is the covariance of x_i and y, that is,

$$\sigma^h_{x_iy} = \left(1+\delta_{\beta_i}\right)\left(1+\delta_{x_i}\right)\sigma^l_{x_iy} \tag{A.3}$$

The other is the variance of y:

$$\sigma^h_{yy} = \sigma^l_{yy}\left[1+\sum_{i=1}^{N}\left[\left(1+\delta_{\beta_i}\right)^2\left(1+\delta_{x_i}\right)-1\right]\left(\rho^l_{x_iy}\right)^2+\frac{\delta_\varepsilon\sigma^l_{\varepsilon\varepsilon}}{\sigma^l_{yy}}\right] \tag{A.4}$$

Combining eqs. (A.3) and (A.4) with the assumption $\sigma^h_{x_ix_i} = \left(1+\delta_{x_i}\right)\sigma^l_{x_ix_i}$, we obtain the relationship of correlations ρ_{x_iy} between the two periods:

$$\rho^h_{x_iy} = \frac{\sigma^h_{x_iy}}{\sigma^h_{x_i}\sigma^h_y} = \rho^l_{x_iy}\frac{\left(1+\delta_{\beta_i}\right)\left[\left(1+\delta_{x_i}\right)\right]^{1/2}}{\left\{1+\sum_{i=1}^{N}\left[\left(1+\delta_{\beta_i}\right)^2\left(1+\delta_{x_i}\right)-1\right]\left(\rho^l_{x_iy}\right)^2+\frac{\delta_\varepsilon\sigma^l_{\varepsilon\varepsilon}}{\sigma^l_{yy}}\right\}^{1/2}} \tag{A.5}$$

Finally, combining eqs. (A.2) and (A.5), then

$$R^{2,h} = R^{2,l}\frac{\sum_{i=1}^{N}\left(1+\delta_{\beta_i}\right)^2\left(1+\delta_{x_i}\right)\left(\rho^l_{x_iy}\right)^2}{\sum_{i=1}^{N}\left(\rho^l_{x_iy}\right)^2\sum_{i=1}^{N}\left(1+\delta_{\beta_i}\right)^2\left(1+\delta_{x_i}\right)\left(\rho^l_{x_iy}\right)^2+\sum_{i=1}^{N}\left(\rho^l_{x_iy}\right)^2\left(1-\sum_{i=1}^{N}\left(\rho^l_{x_iy}\right)^2+\frac{\delta_\varepsilon\sigma^l_{\varepsilon\varepsilon}}{\sigma^l_{yy}}\right)} \tag{A.6}$$

The explanatory power of global risk factors in eq. (A.1) is thus affected by three factors: factor heteroscedasticity (δ_{x_i}), changes in factor loadings (δ_{β_i}) and residual heteroscedasticity (δ_ε) during uncertain periods.

[10] Due to the orthogonality of each two risk factors, the covariance between them is zero, that is, $cov(x_i, x_j) = 0, i \neq j$.

Appendix B

B.1. The R^2 and bias during the 1994–1995 Mexican crisis

This table illustrates the R^2 and bias during the 1994–1995 Mexican crisis in 10+ year government bond markets. The crisis period is from 19 December 1994 to 31 March 1995 and the stable period is from 1 June 1994 to 16 December 1994.

Country	R^2_{PRy}	R^2_{PR}	R^2_{FH}	R^2_{BC}	R^2_{FB}	R^2_{QCH}	ΔR^2_{FH}	ΔR^2_{BC}	ΔR^2_{FB}	ΔR^2_{QCH}
Australia	0.3910	0.4656	0.5913	0.4348	0.5314	0.3987	−0.1256	0.0309	−0.0658	0.0669
Belgium	0.5675	0.4608	0.5864	0.6670	0.7647	0.5008	−0.1256	−0.2062	−0.3039	−0.0400
Canada	0.6136	0.5283	0.6415	0.4826	0.5926	0.5809	−0.1132	0.0458	−0.0643	−0.0526
Denmark	0.5506	0.3568	0.4736	0.4444	0.5576	0.6100	−0.1168	−0.0877	−0.2008	−0.2532
France	0.5620	0.5249	0.6171	0.6568	0.7600	0.5625	−0.0922	−0.1319	−0.2351	−0.0375
Germany	0.4748	0.4293	0.5146	0.5935	0.6825	0.4408	−0.0853	−0.1642	−0.2532	−0.0115
Ireland	0.6240	0.5127	0.6130	0.6197	0.7290	0.7564	−0.1003	−0.1071	−0.2163	−0.2438
Italy	0.3209	0.1518	0.2146	0.4003	0.5085	0.3457	−0.0629	−0.2485	−0.3568	−0.1940
Japan	0.0321	0.0659	0.0973	0.0638	0.0933	0.0675	−0.0314	0.0021	−0.0274	−0.0017
Netherlands	0.6306	0.4291	0.5290	0.6455	0.7449	0.6805	−0.0999	−0.2164	−0.3157	−0.2514
New Zealand	0.3799	0.3994	0.5286	0.5730	0.6987	0.5097	−0.1292	−0.1737	−0.2994	−0.1103
Norway	0.5391	0.3918	0.5122	0.6793	0.7749	0.5492	−0.1205	−0.2875	−0.3831	−0.1575
Spain	0.1243	0.1253	0.1815	0.1724	0.2546	0.1276	−0.0562	−0.0472	−0.1293	−0.0023
Sweden	0.3242	0.3405	0.3711	0.2975	0.4092	0.2123	−0.0305	0.0431	−0.0687	0.1283
Switzerland	0.2219	0.1136	0.1707	0.4202	0.5333	0.3212	−0.0571	−0.3066	−0.4197	−0.2076
UK	0.6973	0.4271	0.5746	0.4875	0.6269	0.7144	−0.1475	−0.0604	−0.1998	−0.2873
US	0.5340	0.4725	0.6483	0.4852	0.5752	0.5316	−0.1758	−0.0127	−0.1027	−0.0591

B.2. The R^2 and bias during the 1997 Asian crisis

This table illustrates R^2 and bias during the 1997 Asian crisis in 10+ year government bond markets. The crisis period is from 17 October 1997 to 11 November 1997 and the stable period is from 01 January 1996 to 16 October 1997.

Country	R^2_{PRy}	R^2_{PR}	R^2_{FH}	R^2_{BC}	R^2_{FB}	R^2_{QCH}	ΔR^2_{FH}	ΔR^2_{BC}	ΔR^2_{FB}	ΔR^2_{QCH}
Australia	0.4143	0.6123	0.7522	0.4884	0.5304	0.4667	−0.1399	0.1239	0.0819	0.1456
Belgium	0.7470	0.6775	0.7568	0.6567	0.8033	0.7274	−0.0794	0.0207	−0.1259	−0.0499
Canada	0.6774	0.7564	0.8529	0.5498	0.7249	0.6443	−0.0965	0.2065	0.0315	0.1120
Denmark	0.6249	0.3636	0.5097	0.5944	0.7289	0.6249	−0.1461	−0.2307	−0.3653	−0.2612
France	0.6273	0.5069	0.5748	0.5698	0.7333	0.6136	−0.0679	−0.0629	−0.2264	−0.1068
Germany	0.4776	0.3298	0.3220	0.6102	0.7180	0.5618	0.0078	−0.2804	−0.3882	−0.2320
Ireland	0.6078	0.6614	0.7642	0.6841	0.8397	0.6590	−0.1028	−0.0227	−0.1784	0.0024
Italy	0.3015	0.4410	0.5202	0.6520	0.7977	0.3787	−0.0791	−0.2110	−0.3566	0.0624
Japan	0.0447	0.2580	0.2677	0.0196	0.0265	0.0296	−0.0097	0.2383	0.2315	0.2284
Netherlands	0.6828	0.8638	0.9278	0.7701	0.8888	0.7169	−0.0640	0.0937	−0.0250	0.1469
New Zealand	0.4090	0.6946	0.7265	0.4124	0.4533	0.4516	−0.0320	0.2821	0.2413	0.2429
Norway	0.4438	0.6652	0.7788	0.7265	0.8523	0.5541	−0.1136	−0.0614	−0.1872	0.1110
Spain	0.1589	0.0453	0.0842	0.2449	0.3655	0.0980	−0.0390	−0.1996	−0.3202	−0.0527
Sweden	0.4959	0.5506	0.7017	0.4745	0.6637	0.4177	−0.1512	0.0761	−0.1132	0.1329
Switzerland	0.3549	0.7033	0.8062	0.4626	0.6234	0.2551	−0.1029	0.2407	0.0799	0.4482
UK	0.4728	0.5182	0.6952	0.3405	0.5380	0.5705	−0.1770	0.1777	−0.0198	−0.0523
US	0.6983	0.7513	0.8329	0.7782	0.8336	0.6457	−0.0816	−0.0269	−0.0823	0.1056

B.3. The R^2 and bias during the 1998 Russian/LTCM crisis

This table illustrates R^2 and bias during the 1998 Russian/LTCM crisis in 10+ year government bond markets. The crisis period is from 3 August 1998 to 15 October 1998 and the stable period is from 02 March 1998 to 1 June 1998.

Country	R^2_{PRy}	R^2_{PR}	R^2_{FH}	R^2_{BC}	R^2_{FB}	R^2_{QCH}	ΔR^2_{FH}	ΔR^2_{BC}	ΔR^2_{FB}	ΔR^2_{QCH}
Australia	0.4143	0.6123	0.7522	0.4884	0.5304	0.4667	−0.1399	0.1239	0.0819	0.1456
Belgium	0.7470	0.6775	0.7568	0.6567	0.8033	0.7274	−0.0794	0.0207	−0.1259	−0.0499
Canada	0.6774	0.7564	0.8529	0.5498	0.7249	0.6443	−0.0965	0.2065	0.0315	0.1120
Denmark	0.6249	0.3636	0.5097	0.5944	0.7289	0.6249	−0.1461	−0.2307	−0.3653	−0.2612
France	0.6273	0.5069	0.5748	0.5698	0.7333	0.6136	−0.0679	−0.0629	−0.2264	−0.1068
Germany	0.4776	0.3298	0.3220	0.6102	0.7180	0.5618	0.0078	−0.2804	−0.3882	−0.2320
Ireland	0.6078	0.6614	0.7642	0.6841	0.8397	0.6590	−0.1028	−0.0227	−0.1784	0.0024
Italy	0.3015	0.4410	0.5202	0.6520	0.7977	0.3787	−0.0791	−0.2110	−0.3566	0.0624

(continued on next page)

(*continued*)

Country	R^2_{PRy}	R^2_{PR}	R^2_{FH}	R^2_{BC}	R^2_{FB}	R^2_{QCH}	ΔR^2_{FH}	ΔR^2_{BC}	ΔR^2_{FB}	ΔR^2_{QCH}
Japan	0.0447	0.2580	0.2677	0.0196	0.0265	0.0296	−0.0097	0.2383	0.2315	0.2284
Netherlands	0.6828	0.8638	0.9278	0.7701	0.8888	0.7169	−0.0640	0.0937	−0.0250	0.1469
New Zealand	0.4090	0.6946	0.7265	0.4124	0.4533	0.4516	−0.0320	0.2821	0.2413	0.2429
Norway	0.4438	0.6652	0.7788	0.7265	0.8523	0.5541	−0.1136	−0.0614	−0.1872	0.1110
Spain	0.1589	0.0453	0.0842	0.2449	0.3655	0.0980	−0.0390	−0.1996	−0.3202	−0.0527
Sweden	0.4959	0.5506	0.7017	0.4745	0.6637	0.4177	−0.1512	0.0761	−0.1132	0.1329
Switzerland	0.3549	0.7033	0.8062	0.4626	0.6234	0.2551	−0.1029	0.2407	0.0799	0.4482
UK	0.4728	0.5182	0.6952	0.3405	0.5380	0.5705	−0.1770	0.1777	−0.0198	−0.0523
US	0.6983	0.7513	0.8329	0.7782	0.8336	0.6457	−0.0816	−0.0269	−0.0823	0.1056

B.4. The R^2 and bias during the 2007–2009 GFC

This table illustrates R^2 and bias during the 2007–2009 GFC in 10+ year government bond markets. The crisis period is from 7 August 2007 to 15 March 2009 and the stable period is from 01 January 2003 to 31 December 2006.

Country	R^2_{PRy}	R^2_{PR}	R^2_{FH}	R^2_{BC}	R^2_{FB}	R^2_{QCH}	ΔR^2_{FH}	ΔR^2_{BC}	ΔR^2_{FB}	ΔR^2_{QCH}
Australia	0.3485	0.2587	0.1225	0.3874	0.1956	0.4747	0.1362	−0.1286	0.0631	−0.2160
Austria	0.9377	0.9276	0.8238	0.9397	0.8520	0.9828	0.1038	−0.0121	0.0756	−0.0552
Belgium	0.9271	0.9120	0.7902	0.9126	0.7944	0.9790	0.1218	−0.0007	0.1176	−0.0670
Canada	0.5906	0.5844	0.3319	0.7401	0.4880	0.6746	0.2525	−0.1557	0.0964	−0.0902
Czech Republic	0.1277	0.0721	0.0290	0.3043	0.1378	0.3248	0.0431	−0.2322	−0.0657	−0.2527
Denmark	0.3215	0.2103	0.0899	0.4621	0.2401	0.6289	0.1204	−0.2518	−0.0299	−0.4186
France	0.9171	0.9059	0.7748	0.9232	0.8157	0.9623	0.1311	−0.0173	0.0902	−0.0564
Germany	0.8689	0.8386	0.6676	0.8616	0.7119	0.9557	0.1710	−0.0230	0.1268	−0.1171
Hungary	0.0330	0.0131	0.0044	0.0032	0.0013	0.0033	0.0087	0.0099	0.0118	0.0098
Ireland	0.6963	0.6954	0.4833	0.7832	0.5897	0.9713	0.2121	−0.0878	0.1056	−0.2760
Italy	0.7730	0.7429	0.5152	0.8535	0.6828	0.9648	0.2277	−0.1106	0.0601	−0.2219
Japan	0.1831	0.1323	0.0528	0.2058	0.0784	0.0647	0.0795	−0.0735	0.0540	0.0676
Netherlands	0.9050	0.8818	0.7324	0.9156	0.7994	0.9544	0.1494	−0.0337	0.0824	−0.0726
New Zealand	0.2507	0.1702	0.0756	0.5472	0.2780	0.6302	0.0946	−0.3770	−0.1078	−0.4600
Norway	0.2938	0.2958	0.1298	0.3758	0.1804	0.3640	0.1659	−0.0801	0.1154	−0.0683
Poland	0.0364	0.0244	0.0083	0.0596	0.0235	0.0437	0.0161	−0.0352	0.0009	−0.0193
Singapore	0.1537	0.1631	0.0675	0.1110	0.0452	0.0215	0.0956	0.0521	0.1179	0.1416
South Africa	0.0317	0.0173	0.0063	0.1022	0.0402	0.0784	0.0110	−0.0849	−0.0229	−0.0611
Spain	0.8649	0.8404	0.6541	0.8367	0.6545	0.9810	0.1863	0.0037	0.1859	−0.1406
Sweden	0.5161	0.5356	0.2965	0.6756	0.4313	0.6227	0.2392	−0.1400	0.1043	−0.0870
Switzerland	0.1845	0.2354	0.1034	0.2261	0.0946	0.2377	0.1321	0.0093	0.1409	−0.0023
UK	0.6125	0.5917	0.3579	0.5937	0.3513	0.7108	0.2338	−0.0020	0.2404	−0.1191
US	0.5980	0.5847	0.3668	0.6031	0.3584	0.6773	0.2179	−0.0184	0.2263	−0.0926

B.5. The R^2 and bias during the 2009–2014 ESDC

This table illustrates R^2 and bias during the 2009–2014 ESDC in 10+ year government bond markets. The crisis period is from 1 June 2009 to 23 June 2014 and the stable period is from 01 January 2015 to 31 December 2017.

Country	R^2_{PRy}	R^2_{PR}	R^2_{FH}	R^2_{BC}	R^2_{FB}	R^2_{QCH}	ΔR^2_{FH}	ΔR^2_{BC}	ΔR^2_{FB}	ΔR^2_{QCH}
Australia	0.2651	0.2267	0.2383	0.2114	0.2447	0.3423	−0.0116	0.0153	−0.0180	−0.1156
Austria	0.7426	0.6771	0.7210	0.7749	0.7989	0.8556	−0.0439	−0.0978	−0.1218	−0.1785
Belgium	0.6326	0.4535	0.5177	0.6751	0.6766	0.8988	−0.0642	−0.2217	−0.2232	−0.4453
Canada	0.6890	0.6660	0.6709	0.7139	0.7258	0.7223	−0.0049	−0.0479	−0.0598	−0.0563
China	0.0224	0.0074	0.0053	0.0053	0.0042	0.0099	0.0021	0.0021	0.0032	−0.0025
Czech Republic	0.1289	0.0755	0.0963	0.0552	0.0574	0.0769	−0.0209	0.0202	0.0181	−0.0014
Denmark	0.7399	0.7738	0.7925	0.8160	0.8442	0.8199	−0.0188	−0.0422	−0.0704	−0.0461
France	0.6359	0.4980	0.5260	0.7041	0.6963	0.8468	−0.0281	−0.2061	−0.1983	−0.3489
Germany	0.7886	0.7680	0.7952	0.7988	0.8195	0.8423	−0.0272	−0.0308	−0.0516	−0.0743
Hungary	0.1448	0.0599	0.0301	0.0763	0.0544	0.1138	0.0298	−0.0164	0.0055	−0.0540
India	0.0390	0.0154	0.0173	0.0081	0.0082	0.0162	−0.0019	0.0074	0.0072	−0.0008
Ireland	0.1181	0.0128	0.0125	0.3435	0.3577	0.6731	0.0004	−0.3307	−0.3449	−0.6603
Italy	0.3480	0.1146	0.0687	0.4730	0.3165	0.5281	0.0460	−0.3584	−0.2018	−0.4134
Japan	0.1630	0.1258	0.1258	0.1532	0.1799	0.1568	0.0001	−0.0274	−0.0540	−0.0310
Malaysia	0.0455	0.0323	0.0362	0.0265	0.0205	0.0210	−0.0038	0.0058	0.0119	0.0113
Netherlands	0.8134	0.7922	0.8217	0.8001	0.8142	0.8438	−0.0295	−0.0079	−0.0221	−0.0517

(*continued on next page*)

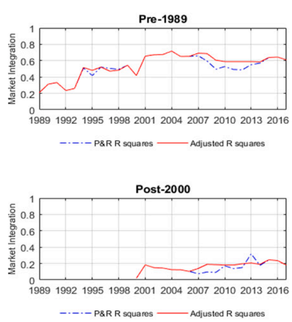
(*continued*)

Country	R^2_{PRy}	R^2_{PR}	R^2_{FH}	R^2_{BC}	R^2_{FB}	R^2_{QCH}	ΔR^2_{FH}	ΔR^2_{BC}	ΔR^2_{FB}	ΔR^2_{QCH}
New Zealand	0.3466	0.3232	0.3371	0.3666	0.3959	0.3947	−0.0139	−0.0434	−0.0726	−0.0715
Norway	0.3800	0.3471	0.3717	0.3002	0.3615	0.5411	−0.0246	0.0469	−0.0144	−0.1940
Poland	0.1353	0.0580	0.0629	0.3443	0.2587	0.2498	−0.0048	−0.2863	−0.2007	−0.1918
Singapore	0.3625	0.3176	0.3500	0.3302	0.3683	0.3556	−0.0324	−0.0125	−0.0507	−0.0380
South Africa	0.0974	0.0384	0.0383	0.0807	0.0538	0.0312	0.0001	−0.0423	−0.0154	0.0072
South Korea	0.1436	0.1148	0.1223	0.1898	0.2126	0.2823	−0.0075	−0.0750	−0.0978	−0.1675
Spain	0.3549	0.1244	0.0810	0.3954	0.2476	0.4794	0.0434	−0.2710	−0.1232	−0.3550
Sweden	0.5772	0.5897	0.6171	0.5080	0.5755	0.5244	−0.0274	0.0817	0.0141	0.0652
Switzerland	0.4174	0.3886	0.4221	0.4676	0.5295	0.5500	−0.0334	−0.0789	−0.1408	−0.1613
UK	0.6041	0.5729	0.5913	0.6269	0.6670	0.6281	−0.0184	−0.0540	−0.0941	−0.0552
US	0.6568	0.6381	0.6870	0.5961	0.5922	0.6868	−0.0489	0.0420	0.0459	−0.0487

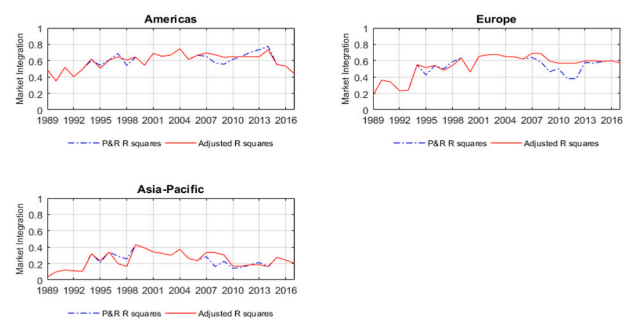
Appendix C. Dynamics of market integration in two methods across clusters

This figure shows the dynamics of average market integration using Pukthuanthong and Roll (2009)'s method and adjusted method in three categories based on time availability, geographic location and Euro adoption in Europe markets. 'P&R R^2' is the explanatory power of global risk factors on bond index returns in each estimation year. 'Adjusted R^2' is explanatory power after adjusting for all biased caused by influential factors during financial crises. The sample is 1989–2017.

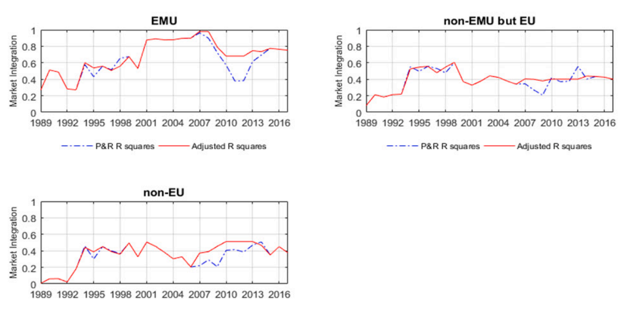
Panel A Sample



Panel B Markets

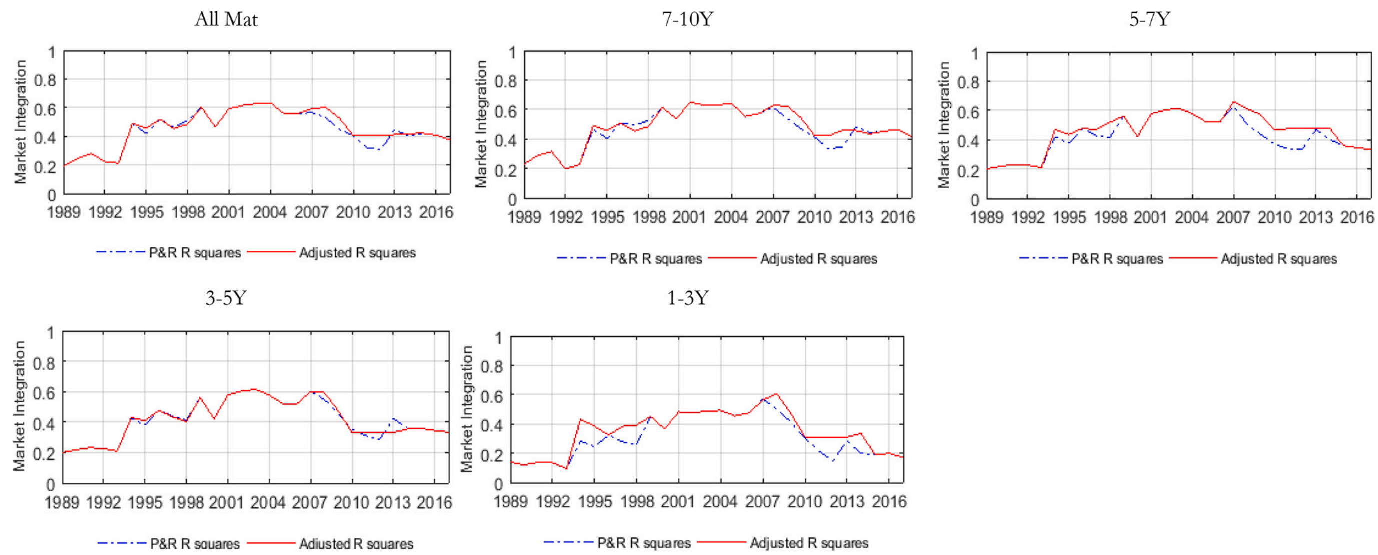


Panel C Europe



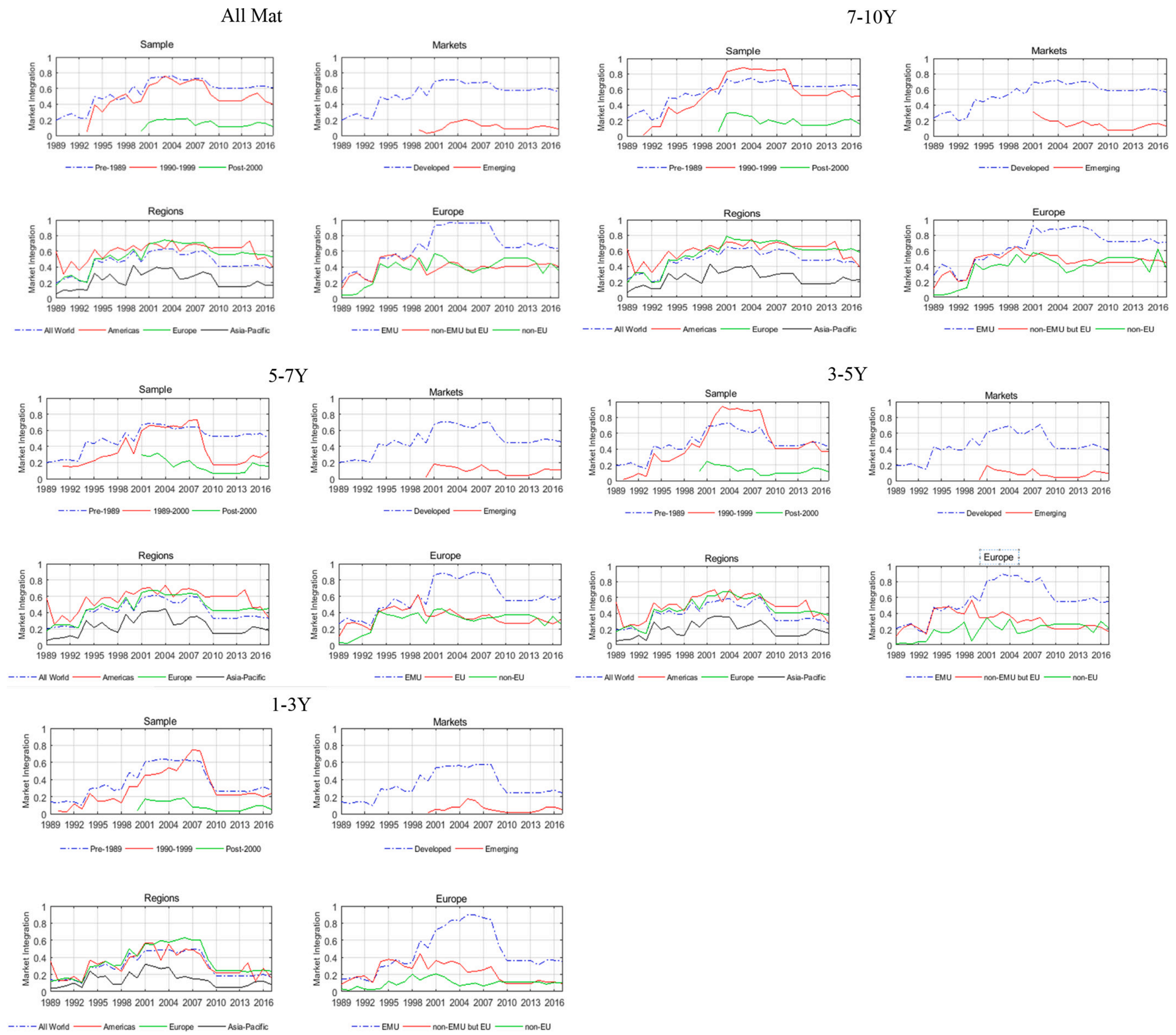
Appendix D. Dynamic of market integration in two method across maturities

This figure shows the dynamics of average market integration using Pukthuanthong and Roll (2009)'s method and adjusted method for all markets with all maturity, 7–10 years, 5–7 years, 3–5 years and 1–3 years. 'P&R R^2' is the explanatory power of global risk factors on bond index returns in each estimation year. 'Adjusted R^2' is explanatory power after adjusting for all biased caused by influential factors during financial crises.



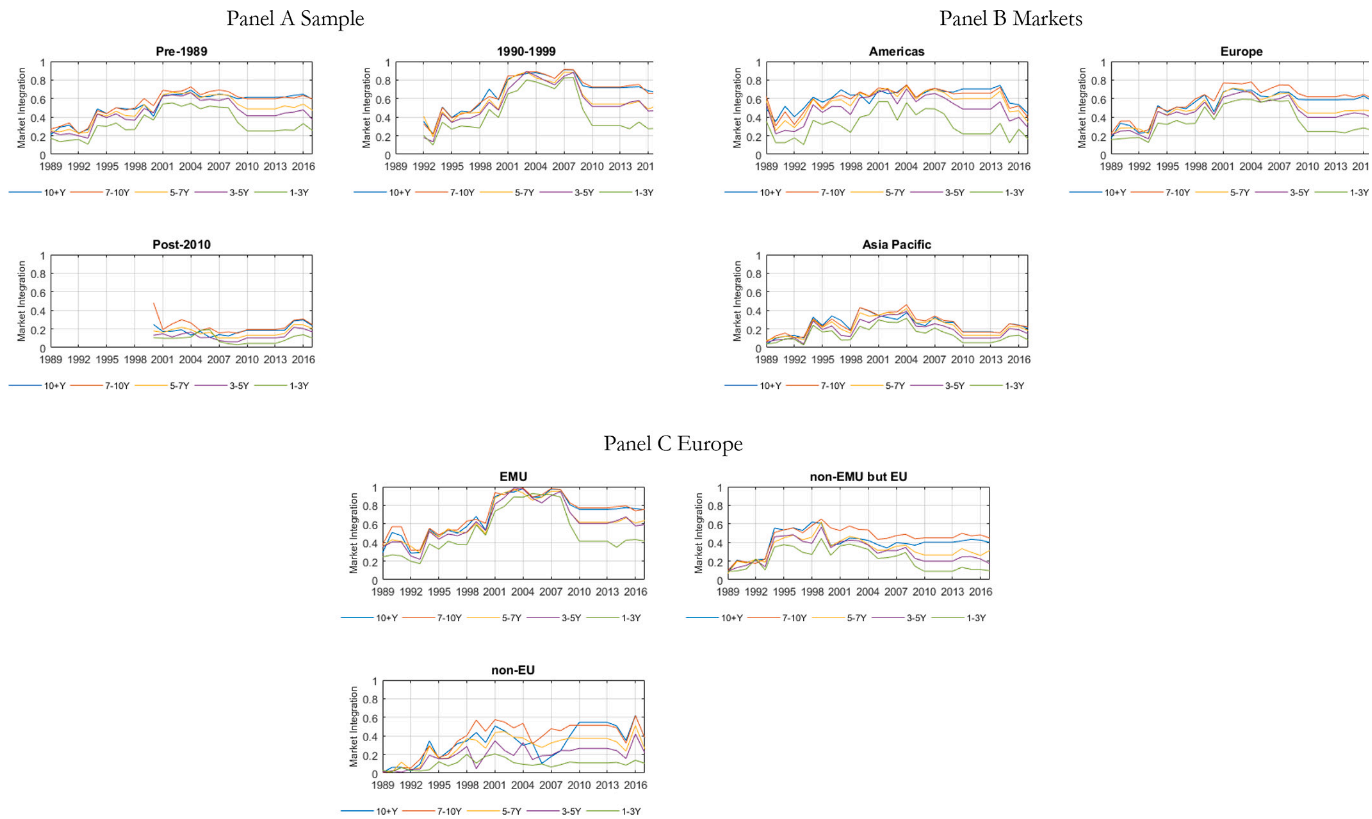
Appendix E. Dynamics of the adjusted market integration of each maturity across clusters

This figure illustrates the dynamics of average adjusted market integration for bond markets with all maturity, 7–10 years, 5–7 years, 3–5 years and 1–3 years over 1989–2017 in each subgroup. This paper divides markets according to time availability, economic level, geographic location and Euro adoption in Europe markets.



Appendix F. Dynamics of the adjusted market integration of each cluster across maturities

This figure presents the dynamics of the market integration of bond markets with all maturity, maturities with 10+ years, 7–10 years, 5–7 years, 3–5 years and 1–3 years in three categories based on time availability, geographic location and Euro adoption in Europe markets over 1989–2017.



References

Abad, P., Chuliá, H., & Gómez-Puig, M. (2010). EMU and European government bond market integration. *Journal of Banking and Finance, 34*, 2851–2860.

Abad, P., Chuliá, H., & Gómez-Puig, M. (2014). Time-varying integration in European government bond markets. *European Financial Management, 20*, 270–290.

Abakah, E. J. A., Addo, E., Jr., Gil-Alana, L. A., & Tiwari, A. K. (2021). Re-examination of international bond market dependence: Evidence from a pair copula approach. *International Review of Financial Analysis, 74*, Article 101678.

Abid, I., Kaabia, O., & Guesmi, K. (2014). Stock market integration and risk premium: Empirical evidence for emerging economies of South Asia. *Economic Modelling, 37*, 408–416.

Akbari, A., Ng, L., & Solnik, B. (2020). Emerging markets are catching up: Economic or financial integration? *Journal of Financial and Quantitative Analysis, 55*, 2270–2303.

Antonakakis, N., Christou, C., Cunado, J., & Gupta, R. (2017). Convergence patterns in sovereign bond yield spreads: Evidence from the euro area. *Journal of International Financial Markets Institutions and Money, 49*, 129–139.

Barr, D. G., & Priestley, R. (2004). Expected returns, risk and the integration of international bond markets. *Journal of International Money and Finance, 23*, 71–97.

Bekaert, G., Ehrmann, M., Fratzscher, M., & Mehl, A. (2014). The global crisis and equity market contagion. *Journal of Finance, 69*, 2597–2649.

Bekaert, G., & Harvey, C. R. (1995). Time-varying world market integration. *Journal of Finance, 50*, 403–444.

Bekaert, G., Harvey, C. R., & Ng, A. (2005). Market integration and contagion. *Journal of Business, 78*, 39–69.

Berger, D., & Pukthuanthong, K. (2012). Market fragility and international market crashes. *Journal of Financial Economics, 105*, 565–580.

Berger, D., Pukthuanthong, K., & Yang, J. J. (2011). International diversification with frontier markets. *Journal of Financial Economics, 101*, 227–242.

Bernoth, K., Von Hagen, J., & Schuknecht, L. (2012). Sovereign risk premiums in the European government bond market. *Journal of International Money and Finance, 31*, 975–995.

Billio, M., Donadelli, M., Paradiso, A., & Riedel, M. (2017). Which market integration measure? *Journal of Banking and Finance, 76*, 150–174.

Boukhatem, J., Ftiti, Z., & Sahut, J. M. (2021). Bond market and macroeconomic stability in East Asia: A nonlinear causality analysis. *Annals of Operations Research, 297*, 53–76.

Bunda, I., Hamann, A. J., & Lall, S. (2009). Correlations in emerging market bonds: The role of local and global factors. *Emerging Markets Review, 10*, 67–96.

Cagliesi, G., & Guidi, F. (2021). A three-tiered nested analytical approach to financial integration: The case of emerging and frontier equity markets. *International Review of Financial Analysis, 74*, Article 101698.

Carrieri, F., Chaieb, I., & Errunza, V. (2013). Do implicit barriers matter for globalization? *Review of Financial Studies, 26*, 1694–1739.

Carrieri, F., Errunza, V., & Hogan, K. (2007). Characterizing world market integration through time. *Journal of Financial and Quantitative Analysis, 42*, 915–940.

Chaieb, I., Errunza, V., & Gibson, R. (2014). *Integration of sovereign bonds markets: Time variation and maturity effects. Swiss Finance Institute Research Paper Series No. 14–47*.

Chaieb, I., Errunza, V., & Gibson, R. (2020). Measuring sovereign bond market integration. *Review of Financial Studies, 33*, 3446–3491.

Christiansen, C. (2014). Integration of European bond markets. *Journal of Banking and Finance, 42*, 191–198.

Christoffersen, P., Errunza, V., Jacobs, K., & Langlois, H. (2012). Is the potential for international diversification disappearing? A dynamic copula approach. *Review of Financial Studies, 25*, 3711–3751.

Cipollini, A., Coakley, J., & Lee, H. (2015). The European sovereign debt market: From integration to segmentation. *European Journal of Finance, 21*, 111–128.

Codogno, L., Favero, C., & Missale, A. (2003). EMU and government bond spreads. *Economic Policy, 18*, 503–532.

Cordella, T., & Ospino Rojas, A. (2017). *Financial globalization and market volatility: An empirical appraisal. Policy research working paper; no. WPS 8091*. Washington, D.C: World Bank Group.

DeJong, F., & DeRoon, F. A. (2005). Time-varying market integration and expected returns in emerging markets. *Journal of Financial Economics, 78*, 583–613.

Diebold, F. X., Li, C., & Yue, V. Z. (2008). Global yield curve dynamics and interactions: a dynamic Nelson–Siegel approach. *Journal of Econometrics, 146*, 351–363.

Dimic, N., Piljak, V., Swinkels, L., & Vulanovic, M. (2021). The structure and degree of dependence in government bond markets. *Journal of International Financial Markets Institutions and Money, 74*, Article 101385.

Dungey, M., Martin, V. L., & Pagan, A. R. (2000). A multivariate latent factor decomposition of international bond yield spreads. *Journal of Applied Econometrics, 15*, 697–715.

Ehrmann, M., & Fratzscher, M. (2017). Euro area government bonds–fragmentation and contagion during the sovereign debt crisis. *Journal of International Money and Finance, 70*, 26–44.

Ehrmann, M., Fratzscher, M., Gürkaynak, R. S., & Swanson, E. T. (2011). Convergence and anchoring of yield curves in the euro area. *Review of Economics and Statistics, 93*, 350–364.

Eichengreen, B., & Park, Y. C. (2005). Financial liberalization and capital market integration in East Asia. In Y. C. Park, T. Ito, & Y. Wang (Eds.), *A new financial market structure for East Asia* (pp. 46–83). Cheltenham: Edward Elgar Publishing.
Errunza, V., & Losq, E. (1985). International asset pricing under mild segmentation: Theory and test. *Journal of Finance, 40*, 105–124.
Errunza, V., Losq, E., & Padmanabhan, P. (1992). Tests of integration, mild segmentation and segmentation hypotheses. *Journal of Banking and Finance, 16*, 949–972.
Filoso, V., Panico, C., Papagni, E., Purificato, F., & Suarez, M. V. (2017). *Causes and timing of the European debt crisis: An econometric evaluation*. EERI Research Paper Series.
Forbes, K. J., & Rigobon, R. (2002). No contagion, only interdependence: Measuring stock market comovements. *Journal of Finance, 57*, 2223–2261.
Fung, L., Yu, I.-W., & Tam, C.-S. (2008). Assessing the integration of Asian's equity and bond markets. In Bank for International Settlements (Ed.), *Regional financial integration in Asia: Present and future. 42. Bank for International Settlements* (pp. 1–37).
Gabauer, D., Subramaniam, S., & Gupta, R. (2022). On the transmission mechanism of Asia-Pacific yield curve characteristics. *International Journal of Finance and Economics, 27*, 473–488.
Geyer, A., Kossmeier, S., & Pichler, S. (2004). Measuring systemic risk in EMU government yield spreads. *Review of Finance, 8*, 171–197.
Ilmanen, A. (1995). Time-varying expected returns in international bond markets. *Journal of Finance, 50*, 481–506.
Jappelli, T., & Pistaferri, L. (2011). Financial integration and consumption smoothing. *The Economic Journal, 121*, 678–706.
Jian, Z., & Li, X. (2021). Skewness-based market integration: A systemic risk measure across international equity markets. *International Review of Financial Analysis, 74*, Article 101664.
Jotikasthira, C., Le, A., & Lundblad, C. (2015). Why do term structures in different currencies co-move? *Journal of Financial Economics, 115*, 58–83.
Kumar, M. S., & Okimoto, T. (2011). Dynamics of international integration of government securities' markets. *Journal of Banking and Finance, 35*, 142–154.
Lehkonen, H. (2015). Stock market integration and the global financial crisis. *Review of Finance, 19*, 2039–2094.
Lucey, B. M., & Steeley, J. (2006). Measuring and assessing the effects and extent of international bond market integration. *Journal of International Financial Markets Institutions and Money, 16*, 1–3.
Lucey, B. M., Vigne, S. A., Ballester, L., Barbopoulos, L., Brzeszczynski, J., Carchano, O., … Goodell, J. W. (2018). Future directions in international financial integration research-a crowdsourced perspective. *International Review of Financial Analysis, 55*, 35–49.
Manganelli, S., & Wolswijk, G. (2009). What drives spreads in the euro-area government bond market? *Economic Policy, 24*, 191–240.
Mobarek, A., Muradoglu, G., Mollah, S., & Hou, A. J. (2016). Determinants of time varying co-movements among international stock markets during crisis and non-crisis periods. *Journal of Financial Stability, 24*, 1–11.
Nardo, M., Ossola, E., & Papanagiotou, E. (2022). Financial integration in the EU28 equity markets: Measures and drivers. *Journal of Financial Markets, 57*, Article 100633.
Park, C. Y., & Lee, J. W. (2011). Financial integration in emerging Asia: Challenges and prospects. *Asian Economic Policy Review, 6*, 176–198.
Patel, R., Goodell, J. W., Oriani, M. E., Paltrinieri, A., & Yarovaya, L. (2022). A bibliometric review of financial market integration literature. *International Review of Financial Analysis*, 102035.
Pérignon, C., Smith, D. R., & Villa, C. (2007). Why common factors in international bond returns are not so common. *Journal of International Money and Finance, 26*, 284–304.
Piljak, V. (2013). Bond markets co-movement dynamics and macroeconomic factors: Evidence from emerging and frontier markets. *Emerging Markets Review, 17*, 29–43.
Piljak, V., & Swinkels, L. (2017). Frontier and emerging government bond markets. *Emerging Markets Review, 30*, 232–255.
Pozzi, L., & Wolswijk, G. (2012). The time-varying integration of euro area government bond markets. *European Economic Review, 56*, 36–53.
Pretorius, A., Kabundi, A., & Unit, M. P. (2014). Dynamic integration of emerging market bond yields into the global bond market. *Economic Research Southern Africa*. No. 436.
Pukthuanthong, K., & Roll, R. (2009). Global market integration: An alternative measure and its application. *Journal of Financial Economics, 94*, 214–232.
Qin, W., Cho, S., & Hyde, S. (2022). Measuring market integration during crisis periods. *Journal of International Financial Markets Institutions and Money, 78*, Article 101555.
Rigobon, R. (2003). On the measurement of the international propagation of shocks: Is the transmission stable? *Journal of International Economics, 61*, 261–283.
Rughoo, A., & You, K. (2016). Asian financial integration: Global or regional? Evidence from money and bond markets. *International Review of Financial Analysis, 48*, 419–434.
Schwarz, K. (2019). Mind the gap: Disentangling credit and liquidity in risk spreads. *Review of Finance, 23*, 557–597.
Sibbertsen, P., Wegener, C., & Basse, T. (2014). Testing for a break in the persistence in yield spreads of EMU government bonds. *Journal of Banking and Finance, 41*, 109–118.
Tsukuda, Y., Shimada, J., & Miyakoshi, T. (2017). Bond market integration in East Asia: Multivariate GARCH with dynamic conditional correlations approach. *International Review of Economics and Finance, 51*, 193–213.
Umar, Z., Riaz, Y., & Aharon, D. Y. (2022). Network connectedness dynamics of the yield curve of G7 countries. *International Review of Economics and Finance, 79*, 275–288.
Vo, X. V. (2009). International financial integration in Asian bond markets. *Research in International Business and Finance, 23*, 90–106.
Volosovych, V. (2011). Measuring financial market integration over the long run: Is there a U-shape? *Journal of International Money and Finance, 30*, 1535–1561.
Von Hagen, J., Schuknecht, L., & Wolswijk, G. (2011). Government bond risk premiums in the EU revisited: The impact of the financial crisis. *European Journal of Political Economy, 27*, 36–43.
Yang, J. (2005). International bond market linkages: A structural VAR analysis. *Journal of International Financial Markets Institutions and Money, 15*, 39–54.
Yarovaya, L., Brzeszczyński, J., & Lau, C. K. M. (2016). Intra-and inter-regional return and volatility spillovers across emerging and developed markets: Evidence from stock indices and stock index futures. *International Review of Financial Analysis, 43*, 96–114.
Yu, I. W., Fung, K. P., & Tam, C. S. (2010). Assessing financial market integration in Asia–equity markets. *Journal of Banking and Finance, 34*, 2874–2885.