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A global look into stock market comovements

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Abstract

By investigating the developments and determinants of the dependence of domestic stock returns on latent global factors for 37 advanced and emerging countries during 1996–2015, this article illuminates contemporary trends in international finance with implications to the potential gains from international portfolio diversification and the independent effect of domestic monetary policy. There were upward time-trends in the dependences in the majority of the countries and at a global level, suggesting steady advances of international stock market integration or gradual declines of the potential gains from diversifying a stock portfolio internationally. The integration was greater in advanced countries than in emerging ones while progressing more rapidly in emerging countries than in advanced ones, suggesting relative attractiveness of emerging markets as an investment destination. An indication of a global financial cycle is that the degree of the dependences for different country groups changed over time in a similar fashion. Differences in those dependences across the countries and those over time were explained by the openness of international trade, the size of domestic stock market, and policies of monetary authorities: the level of short-term interest rates, the openness of the capital account, and the variability of foreign exchange rates. In that cycle, there emerged a dilemma between the mobility of international portfolio stock investments and the independent effect of domestic interest-rate policy over not only the sample period but also in the run-up to the 2008 crisis, as far as nominal short-term interest-rate differentials with respect to the United States were concerned.

Keywords International stock market comovements · International portfolio diversification · Global financial cycle · Monetary policy independence · Financial stability

JEL Classification F3 · G1 · O1

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1 Introduction

The more a country's stock market is integrated with foreign markets, the more likely the country's stock prices will respond to global factors (GFs), and the more the behaviour of domestic economic entities will be affected by non-domestic circumstances. This passive response of stock prices is referred to hereafter as the *dependence on global factors* (DGF). This article investigates the developments and determinants of national DGFs for 37 advanced and emerging countries during 1996–2015. This investigation contributes towards the literature on financial globalisation in general because it stands out against a broad period background of globalisation when "it is generally believed that increased capital market integration should go hand-in-hand with increased cross-country correlation" (Bekaert et al. 2009, p. 2591). The synchronisation of stock price changes across countries is "a key topic in finance studies, as it has important implications for asset allocation, risk management, and international diversification" (Chuluun 2017, p. 53).

The investigation appears to be informative also for policy makers in monetary authorities. Over the last decade, global financial market comovement has attracted much interest in international finance literature because some costs to the comovement due to monetary policy spillovers from the United States (U.S.) have become more discernible (Passari and Rey 2015). One obvious lesson of the global financial crisis in 2008 is that financial instability can have negative effects on economic activity. "(Where experts) need to make more progress is the links among monetary policy, international capital flows, and domestic financial fragility" (Rajan 2018, p. 22, terms in parentheses added by the author).

This need is addressed in a global financial cycle hypothesis. Rey (2013, 2016), Passari and Rey (2015), and Coeurdacier et al. (2015) (i) claim that a global financial cycle has synchronised international capital movements and asset price changes across countries (ii) regard two factors—global investors' risk preference and global uncertainty—as the GFs driving that cycle, and (iii) argue that these two factors are affected by U.S. monetary policy. Bekaert et al. (2013) find that those two GFs are reflected well in the Chicago Board Option Exchange Volatility Index (VIX), the implied volatility of U.S. stock prices.

To add on the literature, this article makes various types of contributions. The first type is in the context of empirical finance research on international stock market comovements; to be specific, pinning down previously-accumulated mixed evidence for how national DGFs have changed over time. "Appendix A" is a literature survey. A recent seminal study, Bekaert et al. (2009), finds that there is no evidence of an upward trend in national DGFs of 23 developed countries over the period 1980–2005, except for European stock returns.[1] I measure a country's DGF with an indicator for how much the country's stock market is integrated with the world market. This measurement is proposed by Pukthuanthong and Roll (2009) that take corrective measures to gauge national DGFs more flexibly in the spirit of arbitrage

[1] In the case of Bekaert et al. (2009), a national DGF is inter-country correlations of market index returns as well as those explained by changes in the returns' responsiveness to GFs.

pricing theory (APT) and to cover more countries than Bekaert et al. (2009). Pukthuanthong and Roll (2009) apply a multi-factor model to national stock returns and then define a national DGF as the percentage of total variation in national stock returns accounted for by latent GFs gained with the principal component (PC) analysis. Pukthuanthong and Roll (2009) report an upward trend for the simple average of national DGFs of 81 countries, including emerging ones as well, from the 1960 to 2007. I analyse the presence and mode of time-trends in individual countries' DGFs by referring to a recent period after the 2008 crisis and using a time-series econometric method.

The second type of contribution is a methodological one; that is, verifying the realism of national DGFs measured with the Pukthuanthong and Roll's (2009) method in two ways. One is to check the correlation between PC-based latent GFs and potentially reasonable indicators for GFs and that between the latent GFs and GFs gauged within a different theoretical framework of the extended Capital Asset Pricing Model of Fama and French.[2] The other way is to examine data-based linkages of national DGFs with diversification effects for a global stock portfolio with reference to the Sharpe ratio.

The third and last type of contribution is made towards a specific strand of the literature on the driving forces behind national DGFs. Increases of the responsiveness of European stock prices to U.S. stock prices would be a consequence of the integration of financial markets rather than the integration of real business (Baele and Soriano 2010). Beine and Candelon (2011) and Chuluun (2017) investigate determinants of national stock returns' DGFs: a DGF tends to be larger in a country in which international trade and finance are more open.[3] This article adds on that strand by conducting an unprecedented test at a global level on one of the policy implications of the global financial cycle hypothesis, with reference to national DGFs. It is a dilemma between international capital mobility and monetary policy independence. This dilemma referred to hereafter as the *Rey-type dilemma* puts the Mundellian trilemma into question by asserting that, given the influence of GFs on domestic financial stability, "letting the exchange rate float may not be enough to insulate the domestic economy, even if it is a large economy, from global factors and permit monetary policy independence" (Rey 2016, p. 7), and therefore "independent monetary policies are possible if and only if the capital account is managed, directly and indirectly" (Rey 2013, p. 287). The dilemma can read that, regardless of the foreign exchange (FX) regime, short-term interest-rate policy (SIRP) in a country cannot influence domestic financial asset prices without controlling the country's capital account or intercepting the financial market from the GFs.

[2] Agur et al. (2018) estimate common factors for emerging sovereign bond markets by making a factor analysis and examine the correlation between such GFs and potentially reasonable indicators for GFs.

[3] In the case of Beine and Candelon (2011), a national DGF is a country's pairwise stock-return correlations adjusted for the boosting effect of high volatility. In the case of Chuluun (2017), a national DGF is the stock-return correlation between a national market index and a world portfolio. She finds that the DGF tends to be higher in a country occupying a more central position in its networks of international trade and finance.

Table 1 This table reports per cent cumulative eigenvalues of the first and second principal components for foreign capital flows to emerging countries by capital type

Sample periods of time	# of observations	Portfolio stocks (SI)	Portfolio bonds (BI)	Bank loans (BL)
2004Q1–2015Q4	48	97.4%	56.0%	91.7%

Notes are as follows: firstly, all kinds of foreign capital flows are relative to nominal GDPs; secondly, see "Appendix D" for the sources of data; and lastly, the sample countries differ by capital type. 22 emerging countries for SI and BI, including Argentina, Brazil, Bulgaria, Chile, Colombia, Costa Rica, Hong Kong, India, Indonesia, Kazakhstan, South Korea, Mauritius, Mexico, Peru, the Philippines, Poland, Romania, Russia, South Africa, Thailand, Turkey, and Ukraine. 29 emerging countries for BL, including Argentina, Bolivia, Brazil, Bulgaria, Chile, Colombia, Costa Rica, Georgia, Guatemala, Hong Kong, India, Indonesia, Jamaica, Kazakhstan, South Korea, Kyrgyz Republic, Malaysia, Mauritius, Mexico, Paraguay, Peru, the Philippines, Poland, Romania, Russia, South Africa, Thailand, Turkey, and Ukraine

The Rey-type dilemma merits examination for national DGFs because a country's stock market is of great importance to its economic growth and financial stability, to which controlling the country's capital account has conflicting implications. On the one hand, doing so runs the risk of impeding the development of its financial markets, which would have, in the long run, benefited domestic economic growth (Levine 1997, 2002). In a better destination country in international portfolio diversification, increasing investments by foreign investors can contribute towards pushing up the country's GDP growth rates by reducing the financing constraints for domestic companies (Bekaert et al. 2005).

Controlling foreign investors' investing in local stocks, on the other hand, might make monetary authorities worry less about future sudden stops of their investments, accordingly sudden drops of stock prices, due to changes in the GFs which are uncontrollable for the authorities. In fact, the international movement of foreign capital is under the strong influence of GFs. U.S. monetary policy and VIX are determinants of foreign capital flows to individual countries (IMF 2016; Hoggarth et al. 2016) and those of sudden large-scale changes in international capital movements in individual countries (Forbes and Warnock 2012). Table 1 shows results of PC analyses of foreign capital flows to different emerging countries, including foreign investors' portfolio-stock investment flows over national GDPs (SI) during 2004–2015. The percentage of SI's total variance accounted for by two unidentified GFs—the first and second PCs—is almost full: 97%. In analysing the relevance of the Rey-type dilemma to national DGFs, I place a separate focus upon the aftermath of the 2008 crisis, in which national monetary authorities were troubled with sudden changes in domestic asset prices due to GFs.

The methodology of this article consists of three steps. The first is to measure the DGFs for the 37 sample countries during 1996–2015, by referring to four latent GFs. Although their detailed account is beyond the scope of this article, all of them are informative proxies for GFs because each of them has statistically significant correlations with a number of data-based and meaningful indicators for GFs. Two of them, specifically, are likely to have reflected mainly information that affects U.S. and Chinese stock prices, respectively. National

DGFs changed over time and differed with each other. The sample-period average of a global DGF—the simple average of all national DGFs—is substantial: 56%. Its peak was 71% in 2008.

The second step is to analyse the presence and mode of time-trends in national DGFs by country and by country group. This step finds an upward trend in the global DGF. The global positive trend found by Pukthuanthong and Roll (2009) up to 2007 is likely to have persisted for another 8 years beyond the 2008 crisis. The step also finds "upward trends" in national DGFs for 23 out of the 37 sample countries, whilst finding "downward trends" in national DGFs for seven advanced countries. Different country-group DGFs—the simple averages of group member countries' DGFs—showed similar behaviours over time: credible evidence of a global financial cycle. National DGFs increased more rapidly in emerging countries than in advanced ones. In all sample years, nevertheless, country-group DGFs were smaller for emerging countries than for advanced ones. The former countries would be more attractive than the latter countries as an investment destination for international diversification gains. This is in line with the fact that the Sharpe ratio improved by adding emerging countries to an international portfolio consisting of only advanced countries over the sample period.

The third step of the methodology is to make a panel data regression so as to identify the driving forces behind national DGFs during 2001–2015. The forces were country-specific heterogeneities and time-varying factors. Factors contributing towards enhancing a country's DGF are the liberalisation of the country's international trade, capital account, and FX market, as well as the size of its stock market which is smaller compared to foreign investors' investments. As far as short-term interest-rate differentials with respect to the U.S. are concerned, the Rey-type dilemma is confirmed over not only the sample period but also in the run-up to the 2008 crisis, and it is disconfirmed over the crisis period 2007–2009 when reducing the openness of capital accounts and the flexibility of FX rates contributed towards preventing national DGFs from rising.

This article proceeds as follows. Section 2 explains the choice of sample countries, the selection of national stock price indices, and the specification of national DGFs. Section 3 estimates national DGFs and examines the presence and mode of trends in individual countries' DGFs and grouped national DGFs. Section 4 constructs a panel-data regression model for national DGFs and reports the regression results. Section 5 concludes.

2 Measuring national DGFs

This three-part section measures DGFs (dependence on global factors) of national stock returns. The first subsection discusses countries' stock market indices used. The second subsection discusses how to estimate national DGFs by applying two types of multi-factor models. The last subsection selects one of these two models.

2.1 National stock prices

I start by supposing a global stock investor who rolls over a one-week U.S. dollar debt and manages a GDP-weighted sum of 37 national stock indices quoted in U.S. dollars, without hedging FX fluctuation risks. Allocation rates to member countries change every year.

The investor's dataset includes national stock prices on a weekly basis over the period 1996–2015, covering 37 advanced and emerging countries; in alphabetical order; Argentina (ARG), Australia (AUS), Austria (AUT), Belgium (BEL), Brazil (BRA), Canada (CAN), China (CHN), Denmark (DNK), Finland (FIN), France (FRA), Germany (DEU), Greece (GRC), Hong Kong (HKG), India (IND), Indonesia (IDN), Ireland (IRL), Italy (ITA), Japan (JPN), Malaysia (MYS), Mexico (MEX), the Netherlands (NLD), New Zealand (NZL), Norway (NOR), the Philippines (PHL), Portugal (PRT), Russia (RUS), Saudi Arabia (SAU), Singapore (SGP), South Africa (ZAF), South Korea (KOR), Spain (ESP), Sweden (SWE), Switzerland (CHE), Thailand (THA), Turkey (TUR), the United Kingdom (GBR), and the United States (USA). This sample includes 24 developed countries and areas, 23 of which are also analysed by Bekaert et al. (2009). In addition to these countries, the sample includes 13 emerging countries belonging to the Group of Twenty (G20) and/or the Executives' Meeting of East Asia and Pacific Central Banks (EMEAP), an Asia and Pacific forum. The sum of the sample countries' GDPs accounted for 87.5% of world GDP in 2015.

I outline here the basis on which the hypothetical global investor has selected national stock indices; "Appendix B" lists their names. To best reflect fundamentals of national stocks, she chooses an index consisting of broadly tradable shares; e.g., Standard and Poor's 500 rather than the Dow Jones Industrial Average for USA. When such a broad index is unavailable, she uses a benchmark market index that consists of fewer equities. When such a second-best index is young with limited historical data, she uses an alternative market index, such as Morgan Stanley Capital International (MSCI) country indices. She does not consider stock markets for start-up companies, which seem to have poor market liquidity. Prices of the selected stock indices are converted into U.S. dollars with reference to FX rates in the markets.

As detailed in "Appendix B", the weekly excess returns accruing from investing in individual national stocks are the weekly changes in dollar-based prices of those stocks minus U.S. dollar one-week interest costs. The weekly excess return accruing from the hypothetical stock portfolio is the GDP-weighted average of the country-specific excess returns.

The global investor believes that using a world stock portfolio that consists of both advanced and emerging countries, and which also covers Asia, Africa, and Latin America as well, can help take full account of information incorporated into stock price changes in all parts of the globe.

Finally, for allocation rates in the hypothetical stock portfolio, the global investor does not use market capitalisation weights due to the nature of data availability.[4] Using national GDPs as weights instead helps not only to take appropriate account of the size of national economies, but also to avoid any potential bias caused by using the values of country-specific market capitalisations as weights. As argued by Blackburn and Chidambaran (2011), using market capitalisation values as weights has the risk of disproportionally weighting countries with highly-capitalised stock markets, including financial superpowers such as USA, as well as city-economies functioning as international financial centres like HKG and SGP.

2.2 Estimating national DGFs

2.2.1 Basic policy

Following Pukthuanthong and Roll (2009), the hypothetical global investor gauges countries' DGFs at the end of a sample year by using historical weekly data for that year. A country's DGF is the percentage of total variation in its stock excess returns accounted for by four GFs (global factors). The percentage is a $\mathrm{R}^2_{\mathrm{adj}}$ of the following four-factor model estimated every sample year:

$$ER_{i,t} = \beta_{i0} + \beta_{i1}GF1_t + \beta_{i2}GF2_t + \beta_{i3}GF3_t + \beta_{i4}GF4_t + e_{i,t}, \quad (1)$$

where t is a weekly point in time, ER_i is country i's stock excess return, $GF1$–$GF4$ are the GFs considered, β_is are coefficients, and e is assumed to be independent and identically normally distributed. "Appendix B" shows a calculation formula and descriptive statistics of ERs. Because of the assumption that there are no omitted variables correlating with GFs, estimated β_is are free of omitted-variable biases. How to obtain the GFs and why there are four will be discussed later.

The $\mathrm{R}^2_{\mathrm{adj}}$ of Eq. (1) is written as:

$$\mathrm{R}^2_{\mathrm{adj}}i = 1 - \left\{ \sum_{t=1}^{n} \acute{e}^2_{i,t} \Big/ \sum_{t=1}^{n} \left(ER_{i,t} - \overline{ER}_i\right)\left(ER_{i,t} - \overline{ER}_i\right) \right\} \times \{(n-1)/(n-4)\} = R\_DGF_{i,t}, \quad (2)$$

where $\acute{e}$ is estimated residuals, $\overline{ER}$ is the mean, n is the number of observations, and 4 is the number of GFs. This formulation of R_DGF is superior in that it avoids technical difficulties with inter-country correlation coefficients, which have been used for measuring DGFs as mentioned in the previous section and surveyed in "Appendix A". Firstly, a correlation coefficient between two countries' ERs tends to decrease due to the non-proportional differences in β_is for their counterpart GFs. Secondly, this tendency becomes prominent as the number of GFs increases.

[4] Firstly, the selected national stock price indices do not allow accurate comparisons of national stock market capitalisations because not all of them are broad market indices and they are constructed in different ways. Secondly, it is not possible to use identical indices for all sample countries. For example, MSCI country indices do not cover some of the 13 emerging countries, nor do they have sufficient long-term historical data.

Lastly, to interpret an upward trend in the correlation coefficient as an increasing comovement, it is necessary to assume that the volatility of *e* is zero. In this regard, *R_DGF* is able to increase "over time even if factor exposures (β_is) or factor volatilities decrease rather than increase, as long as country-specific residual volatility is not zero" (Pukthuanthong and Roll 2009, p. 218, terms in parentheses added by the author).

I make ordinary least squares (OLS) estimations of Eq. (1) with around 52 weekly observations every sample year for all individual sample countries. Based upon Eq. (2), I gain one *R_DGF* for one sample country every sample year.

2.2.2 Specifying GFs in two ways

In traditional finance theory, there are two kinds of multi-factor models, depending on views on explanatory factors of securities' returns and the associated risk premiums (Zhou 1999). I use a model which can explain national *ER*s better, or a model that reports larger *R_DGF*s.

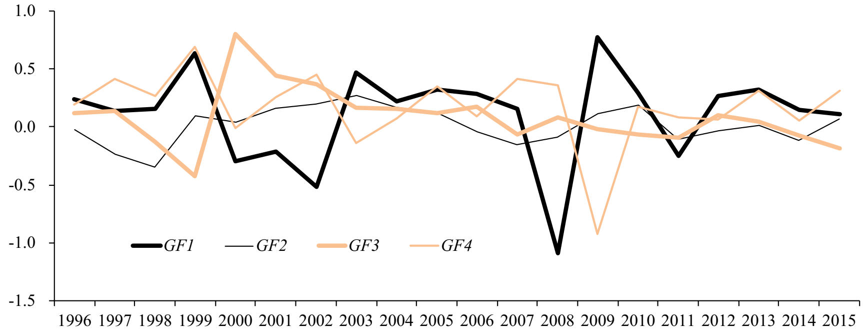
The first model regards the factors as being latent, as in models of APT (arbitrage pricing theory) demonstrated by Ross (1976). The PC (principal component) analysis, a method often used with APT based models, specifies GFs by using PCs of countries' *ER*s (Chamberlain and Rothschild 1983; Connor and Kirajczyk 1988). In the spirit of an APT based model, Pukthuanthong and Roll (2009) regard GFs as being latent and use PCs of sample countries' *ER*s as *GF*s. To be specific, Pukthuanthong and Roll's (2009) *GF*s are the first ten PCs whose percent cumulative eigenvalues are around 90%. In my case, using the first four PCs meets this criterion.[5] I obtain the four *GF*s by conducting PC analyses every sample year by use of weekly data of all individual sample countries' *ER*s weighted by their own GDP percentage shares. I use the GDP percentage shares as weights because they are used as allocation rates to individual countries in the hypothetical global stock portfolio. When constituents are not equally weighted in a portfolio, treating them equally has the risk of coming up with biased PCs (Brown 1989). Notably, Pukthuanthong and Roll (2009) treat sample countries equally in obtaining their *GF*s; that is, they seem to implicitly assume a portfolio consisting of member countries with same allocation rates. This assumption, however, does not match the hypothetical portfolio under study. Another difference from Pukthuanthong and Roll's (2009) computation is that they use out-of-sample PCs whilst I use in-sample PCs for two reasons. One is that, as mentioned above, the hypothetical global investor can use historical weekly data at the end of a sample year when estimating countries' DGFs for the year. The other reason is that in-sample PCs are exactly orthogonal, a desirable aspect in making

[5] The percent cumulative eigenvalues for the first four PCs are 89.8%, 90.8%, 94.3%, 94.7%, 95.9%, 96.7%, 96.5%, 95.4%, 93.8%, 92.3%, 91.4%, 93.2%, 95.0%, 95.0%, 94.1%, 94.0%, 92.3%, 89.2%, 91.7%, and 96.9% in each year over the period 1996–2015, respectively. The remainders are the collective impact of other 33 PCs from the fifth one to the 37th one. Because their eigenvalues are very puny or almost zero, those remainders are interpreted as negligible.

(1) APT-based *GF* s

	GF1	*GF2*	*GF3*	*GF4*
Mean	0.000	0.000	0.000	0.000
SD	0.008	0.004	0.002	0.002
Median	-0.001	0.000	0.000	0.000
Max	0.057	0.015	0.013	0.010
Min	-0.036	-0.018	-0.009	-0.006

(2) Fama-Fench model based *GF* s



	GF1	*GF2*	*GF3*	*GF4*
Mean	0.110	0.016	0.083	0.175
SD	2.219	0.967	1.021	1.892
Median	0.257	0.058	0.050	0.309
Max	10.407	4.061	8.720	10.222
Min	-18.928	-4.949	-4.202	-14.776

Fig. 1 This figure plots annually-averaged *GF1–GF4* of weekly frequency. Their descriptive statistics are based on those on a weekly basis over the sample period 1996–2015: the number of observations is 1043

OLS estimations of Eq. (1).[6] Finally, the upper panel of Fig. 1 plots *GF1–GF4* on an annually-averaged basis. It also shows their descriptive statistics as well as annually-averaged values.

[6] Pukthuanthong and Roll (2009) obtain ten PCs in a year for multiplying countries' stock returns in the year by eigenvectors (factor loadings) gained for the returns in the previous year. The resulting PCs are not exactly orthogonal; that is, there is a risk of multicollinearity. In this regard, Pukthuanthong and Roll (2009) argue that they separately find the correlations amongst their ten PCs too mild to make the risk serious.

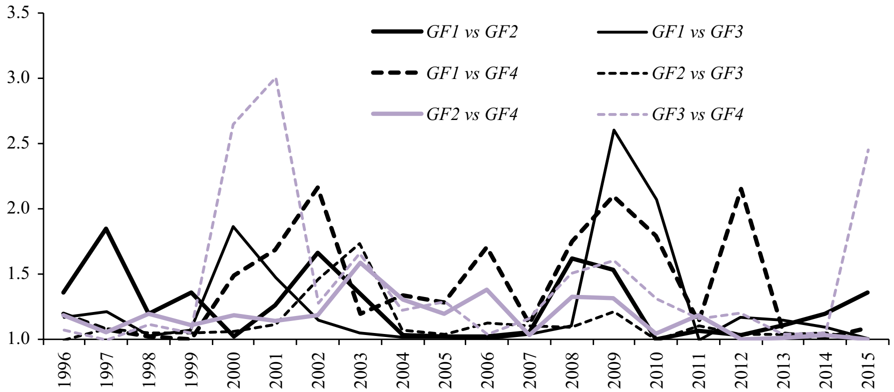


Fig. 2 This figure plots VIFs (variance-inflation factors) amongst four *GF*s in the Fama–French model. A VIF is defined as $1/\{1 - (\text{correlation coefficients})^2\}$. The VIFs are calculated every sample year using weekly data of *GF*s. All the VIFs are much smaller than 10, the criterion proposed by Snee and Marquardt (1984), defining negligible risk of multicollinearities caused by *GF*s

The second model specifies *GF*s with data-based and meaningful indicators, as in the extended Capital Asset Pricing Model of Fama and French (1993, 1998, 2012). I follow Fama and French (2012); that is, the four *GF*s are the market, size, value, and momentum factors.[7] *GF1* is the market factor that comprehensively controls for changes in factors which commonly affect all national stock prices, including changes in world business climate, global uncertainty, global risk appetite, etc. *GF2* is the size factor representing the anomaly that smaller capitalised national stocks tend to yield larger returns in the future. *GF3* is the value factor representing the anomaly that there are fundamentally cheaper national stocks which tend to produce larger returns in the future. *GF4* is the momentum factor representing the anomaly that rising national stocks tend to yield larger returns in the future.

Applying a world Fama–French model, I specify *GF*s as follows. A proxy for *GF1* is the averages of those 37 national stock indices' excess returns with weights of nominal GDPs. This weighting method is used for the reasons given above.

To control for *GF2*, *GF3*, and *GF4*, I refer to Fama and French (2012) who make a market-capitalisation weighted sum of liquid stock prices in 23 advanced countries and calculate widely-used indicators for the three anomalies without regard to their nationalities. Because of the nature of data availability, I am unable to calculate such indicators by nationality, with reference to the 37 constituent national stock indices.[8] Specifically, from Kenneth R. French's digital data

[7] I look at these four conventional factors here in order to equalise the number of GFs with the APT-based model. By analysing numerous individual stocks' excess returns across 49 countries over the period 1981–2003, Hou et al. (2011) report that the cash-flow-to-price factor is a GF of great explanatory power. In my case, indicators representing this factor are not available for some of sample years and national stock indices.

[8] For example, regarding *GF3*, price-book value ratios are not available for all sample years and national stock indices.

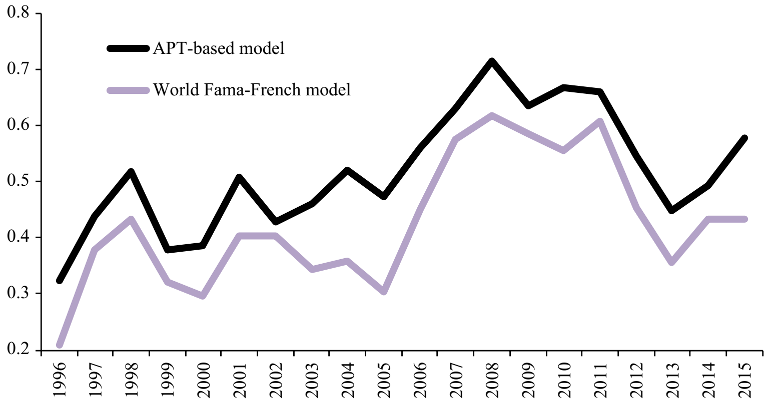


Fig. 3 This figure plots global DGFs obtained by estimating the APT-based and Fama–French models. These global DGFs are the simple averages of national DGFs, or *R_DGF*s defined in Eq. (2)

library,[9] for *GF2* I use *SMB* (the difference between the returns on diversified portfolios of small stocks and big stocks), and for *GF3*, I use *HML* (the difference between the returns on diversified portfolios of high book-to-market stocks and low book-to-market stocks) in *Fama/French Global 5 Factors [Daily]*. For *GF4*, I also use *WML* (the difference between the returns on diversified portfolios of the top-30% strong stocks and the bottom-30% weak stocks) in *Global Momentum Factor (Mom) [Daily]*.

The lower panel of Fig. 1 shows Fama–French model-based *GF1–GF4* with descriptive statistics of them. *GF1* occasionally appears to be negatively correlated with *GF3* and positively correlated with *GF4*. As shown in Fig. 2, I investigate the multicollinearity that could occur amongst *GF*s by calculating the variance-inflation factors (VIFs) for them according to Snee and Marquardt (1984), and I find all VIFs too small to cause multicollinearity.

2.3 Comparing two kinds of national DGFs

I close Sect. 2 by discussing which multi-factor model is better for national DGFs, the APT-based or the Fama–French model. Figure 3 plots the simple averages of national *R_DGF*s gained by estimating the two models. Strikingly, these two global DGFs change very similarly. The APT-based one is larger in all sample years than the Fama–French model-based one. Therefore, I analyse the APT-based national DGFs in the following sections.[10]

9 http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/.

10 Given space constraints, I present only two observations on the results of 740 plain OLS estimations of Eq. (1) for each of the APT-based model and the Fama–French model. In the following recitation, (i) italic numbers refer to the APT model, (ii) numbers with single quotation marks refer to the Fama–French model, and (iii) the ten per cent significance level is applied. The two observations are as follows. Firstly, on the above-assumed normality of *e*, the Jarque–Bera test does not reject null hypotheses that *e*s have the normalities in *571* or '496' regressions, but the tests do in *169* or '244' regressions. The rejec-

A precise explanation of APT-based *GF1–GF4* is that they are effective GFs which are uncorrelated with each other. Any reasonable indicators for GFs, such as VIX, U.S. monetary policy, and energy prices, are more-or-less correlated with each other in reality. One of *GF1–GF4*, or *GF3* for example, could represent factors of different countries in different sample years. Identifying APT-based *GF1–GF4* with specific indicators could be wide of the mark. Be that as it may, approximating *GF1–GF4* in some way could contribute towards enhancing the realism of national DGFs gained by using them as regressors. "Appendix C" makes analyses of APT-based *GF1–GF4*, including their correlations with Fama–French model-based *GF1–GF4*. It shows that APT-based *GF1–GF4* are informative proxies for GFs because each of them has statistically significant correlations with a number of data-based and meaningful indicators for GFs. It also shows that APT-based *GF1* and *GF2* are likely to have reflected mainly information affecting U.S. and CHN stock prices, respectively.

3 Developments of national DGFs

This four-part section looks into the developments of DGFs (dependence on global factors) of national stock returns. The first subsection observes individual countries' estimated DGFs. The second subsection constructs a regression model to investigate the presence and mode of trends in the DGFs. The third section explains regression results. The last subsection makes numerical experiments on diversification effects by calculating the Sharpe ratios of different international stock portfolios.

3.1 Individual and grouped national DGFs based upon the APT

Figure 4 plots *R_DGF*s by country, and by country-group. They are defined in Eq. (2). The country groups are: all sample countries (ALL), advanced countries (AD), emerging countries (EM), European countries (EU), and Asia Pacific small countries (AP small). The last group consists of 9 of 11 countries whose central banks belong to the above-mentioned EMEAP consisting of JPN, AUS, NZL, KOR, HKG, SGP, CHN, IDN, MYS, THA, and PHL. AP small excludes JPN and CHN. Figure 5 shows the sample-period averages of the individual and grouped national DGFs.

Footnote 10 (continued)
tions take place more frequently in emerging countries than in advanced ones. Although the rejection ratios—*22.8%* or '33.0%'—appear to insufficiently low, I do not think that the ratios prevent me from using the APT-based and Fama–French models to gauge national DGFs. This is because the normality assumption does not directly affect their size (although its collapse affects the statistical significance of estimated βs). Lastly, very small negative R^2_{adj}s are gained in *22* or '30' regressions. These R^2_{adj}s appear irregular because a R^2_{adj} is interpreted here as the percentage of non-diversifiable systematic risks in total risks of *ER*. Therefore, I regard the negative R^2_{adj}s as 0.

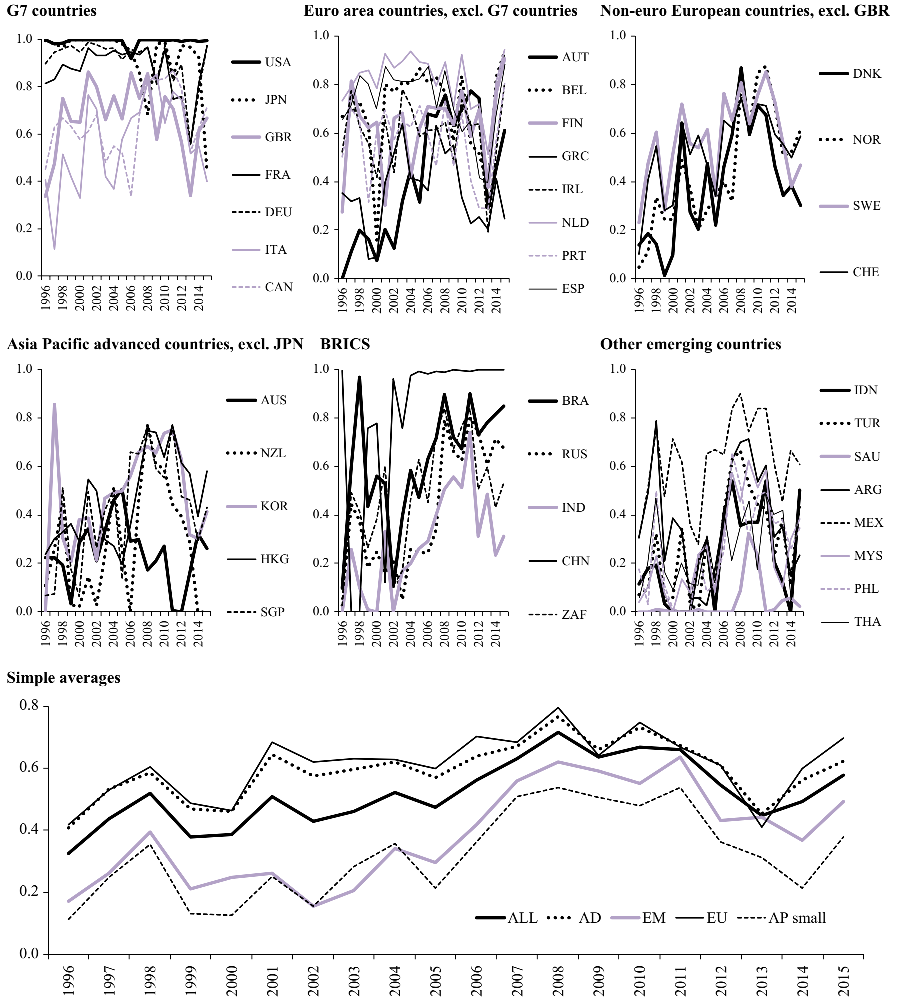


Fig. 4 This figure plots the APT-based *R_DGF*s by country and by group. Notes are as follows: firstly, a national DGF at τ (a yearly point in time) is a *R_DGF* defined in Eq. (2), or a R^2_{adj} gained by estimating Eq. (1) for individual sample countries with around 52 weekly observations; secondly, ALL stands for all sample countries, AD for advanced countries, EM for emerging countries, EU for European countries, and AP small for Asia Pacific small countries (EMEAP countries, excluding JPN and CHN); and lastly, the distinction between advanced and emerging countries is based upon the International Monetary Fund's *World Economic Outlook*

Six observations arise from Figs. 4 and 5. Firstly, different country-group DGFs have changed in a similar fashion over time: a visualisation of a global financial cycle.

Secondly, these DGFs reached their peaks in 2008, in line with Berger and Pukthuanthong's (2012) finding that the risk of market crash tends to increase following the enhancement of a Pukthuanthong and Roll (2009)-type DGF.

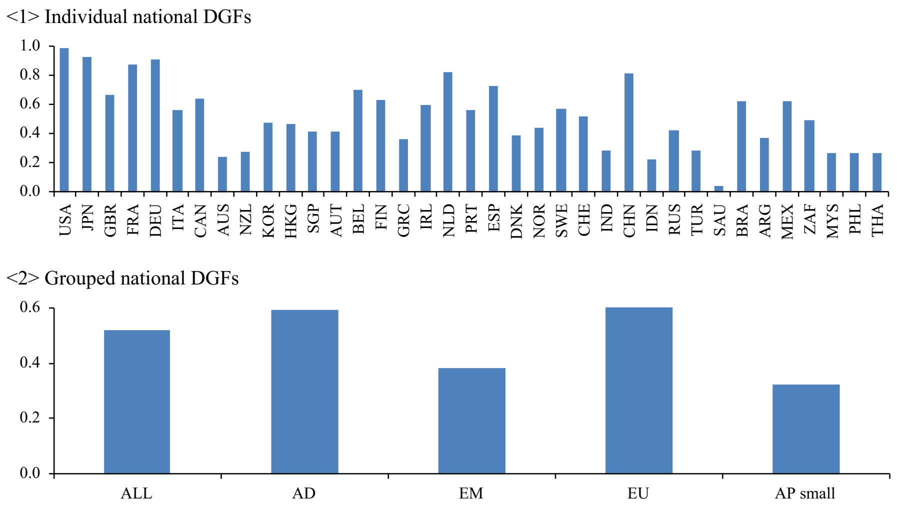


Fig. 5 This figure plots 1996–2015 averages of APT-based *R_DGF*s by country and by group. Notes are as follows: firstly, ALL stands for all sample countries, AD for advanced countries, EM for emerging countries, EU for European countries, and AP small for Asia Pacific small countries (EMEAP countries, excluding JPN and CHN) for EMEAP countries, excluding JPN and CHN; and lastly, the distinction between advanced and emerging countries is based upon the International Monetary Fund's *World Economic Outlook*

Thirdly, national DGFs have been larger in AD than in EM, suggesting that stock markets are likely to have been integrated more with the world market in advanced countries than in emerging ones.

Fourthly, the differences between these two DGFs have reduced over time, suggesting that the stock market integration is likely to have proceeded more rapidly in emerging countries than in advanced ones.

Fifthly, the EU's DGF has for many years been larger than other country groups' DGFs, suggesting that European stock markets are likely to have been the most integrated with the world market.

Lastly, a handful of economic powers have large DGFs. Especially, USA's DGF looks almost constant and slightly less than one in all sample years whilst so does CHN's DGF after 2005. This evokes a subtle aspect of *GF*s. Since *GF*s are obtained from my PC analyses, using national GDP-weighted *ER*s (stock excess returns), *ER* of a larger-economy country has greater potential to affect *GFs*. Regressing a larger-economy country's *ER* on such *GFs* could have a larger risk of endogeneity.[11] I regard this risk as negligible. Not only because the Wu-Hauman statistics

[11] Pukthuanthong and Roll (2009) exclude a sample country in making the PC analyse to estimate GFs for the country. Such exclusion would be beneficial in hedging the risk of endogeneity. Their GFs are not common to sample countries, and they seem not to find a huge DGF for U.S. stock returns. However, I believe that GFs should be common to all sample countries. In addition, it would be more likely that the method fails to grasp true GFs when a sample country is a country whose asset prices are more relevant to GFs, like asset prices in oil-exporting countries and the sole key-currency country, or the U.S.

to investigate the endogeneity of USA and CHN's *ER*s with respect to *GF1–GF4* every year over the sample period reject the risk in 67 cases of 80 cases for USA and in 74 cases of 80 cases for CHN.[12] But also because an observation that a number of small-economy countries, especially European ones, have considerably large DGFs may serve as counter-evidence for that risk. Consequently, I consider USA and CHN's stock returns to be good proxies for GFs for which I control with the four *GF*s. To be on the safe side, I will drop USA and CHN from the sample in Sect. 4 that investigates the determinants of national DGFs.

3.2 A time-trend model

I investigate the presence and mode of trends in individual and grouped national DGFs. Specifically, I estimate the following equation:

$$L\_DGF_{\tau} = a_c + a_{TT} TT_{\tau} + e_{\tau}, \tag{3}$$

where *L_DGF* is the generalised logit-transformation of the square root of *R_DGF*. The logit-transformation is applied in order to transform its range [0, 1] to [0, +∞]. That is,

$$L\_DGF_{\tau} = \ln\left\{\left(1 + \sqrt{R\_DGF_{\tau}}\right)/\left(1 - \sqrt{R\_DGF_{\tau}}\right)\right\}. \tag{4}$$

As for Eq. (3), τ is a yearly point in time, a_c is a constant term, and a_{TT} is a coefficient, *TT* is a time-trend term, and *e* is residuals which denote the deviations of *DGF* from the trend. *TT* is a straight line increasing by one from one as τ goes by, and therefore a_{TT} is a coefficient showing the presence and mode of a time trend.

I estimate Eq. (3) using the OLS method and investigate the stationarity of estimated *e* ($\hat{e}$) with the Augmented Dickey–Fuller (ADF) test. In general, the OLS estimation does not come up with normally-distributed residuals when the dependent variable is a logit-transformed variable. Beyond this, if the order of integration is zero for $\hat{e}$, or $\hat{e}$ is stationary, then the OLS method produces asymptotically efficient estimates, whilst if the order of integration is one for $\hat{e}$, OLS estimates in the differenced regression will be asymptotically efficient (Canjels and Watson 1997). If $\hat{e}$ is not stationary in Eq. (3), I will proceed to estimate the following equation using the OLS method and investigate the stationarity of residuals with the ADF test:

$$\Delta L\_DGF_{\tau} = a_c + \mathring{a}_{TT} TT_{\tau} + \dot{e}_{\tau}, \tag{5}$$

[12] To be specific, I assume that instrument variables for *GF*s at *t* are *ER* at $t-1$ and their own *GF*s at $t-1$; for example, $GF2_{t-1}$ and USA's ER_{t-1} for $GF2_t$. As mentioned above, *GF1–GF4* are exactly orthogonal with each other. I regress individual *GF*s on their instruments every year over the 20-year sample period and gain counterpart 80 residuals for each of USA and CHN. By repeatedly adding as a regressor one of the residuals in Eq. (1), I gain 80 augmented equations for each country. As a result of the OLS estimations of them, a null hypothesis that one of the added regressors is exogenous in its augmented equation cannot be rejected in only 13 and 6 regressions for USA and CHN, respectively.

Table 2 Results of estimating Eq. (3) ($L\_DGF_\tau = C + a_{TT}TT_\tau + e_\tau$), and Eq. (5) ($\Delta L\_DGF_\tau = C + \mathring{a}_{TT}TT_\tau + \dot{e}_\tau$)

[Individual national DGFs: G7 countries]

		USA	JPN	GBR	FRA	DEU	ITA	CAN
Eq. (3)	a_{TT}	– 0.141	– 0.262	– 0.001	– 0.010	– 0.069	0.047	0.041
	ADF	<3> – 4.069 ***	<1> – 2.230	<1> – 1.884	<1> – 1.697	<1> – 2.409	<1> – 1.945	<3> – 3.338 **
Eq. (5)	ADF	–	<1> – 2.798 *	<1> – 3.464 **	<1> – 1.823	<1> – 2.4408	<1> – 4.210 ***	–

[Individual national DGFs: other euro area countries]

		AUT	BEL	FIN	GRC	IRL	NLD	PRT	ESP
Eq. (3)	a_{TT}	0.105	0.025	0.037	0.003	– 0.002	– 0.009	– 0.008	– 0.030
	ADF	<1> – 1.630	<1> – 1.845	<1> – 3.490 **	<3> – 1.095	<1> – 3.345 **	<1> – 1.856	<1> – 2.170	<1> – 1.817
Eq. (5)	ADF	<1> – 3.846 **	<1> – 2.175	–	<1> – 1.801	–	<1> – 4.598 ***	<1> – 1.931	<1> – 1.877

[Individual national DGFs: other advanced countries]

		AUS	NZL	KOR	HKG	SGP	DNK	NOR	SWE	CHE
Eq. (3)	a_{TT}	– 0.013	– 0.009	0.036	0.057	0.060	0.064	0.098	0.036	0.049
	ADF	<1> – 2.523	<1> – 1.856	<1> – 1.859	<1> – 2.196	<1> – 1.389	<1> – 1.444	<5> – 3.291 **	<1> – 1.463	<1> – 1.656
Eq. (5)	ADF	<1> – 3.900 ***	<1> – 4.598 ***	<1> – 4.612 ***	<1> – 2.365	<1> – 3.986 **	<1> – 3.614 **	–	<1> – 3.142 **	<1> – 2.970 *

[Individual national DGFs: BRICS]

		IND	CHN	RUS	BRA	ZAF
Eq. (3)	a_{TT}	0.079	0.398	0.103	0.071	0.069
	ADF	<5> – 3.375 **	<1> – 3.644 **	<4> – 3.051	<3> – 1.926	<4> – 3.058
Eq. (5)	ADF			<1> – 4.095 ***	<1> – 6.291 ***	<1> – 5.056 ***

[Individual national DGFs: other emerging countries]

		IDN	TUR	SAU	ARG	MEX	MYS	PHL	THA
Eq. (3)	a_{TT}	0.044	0.053	0.029	0.003	0.040	0.057	0.057	0.032
	ADF	<1> – 2.603	<1> – 1.662	<1> – 3.466 **	<3> – 3.944 ***	<5> – 1.803	<1> – 1.801	<1> – 2.409	<1> – 2.449
Eq. (5)	ADF	<1> – 3.555 **	<1> – 3.168 **	–	–	<5> – 3.908 ***	<1> – 2.987 *	<1> – 3.914 ***	<1> – 4.571 ***

[Grouped national DGFs: Simple averages]

		ALL	AD	EM	EU	AP small
Eq. (3)	a_{TT}	0.031	–0.003	0.080	0.021	0.013
	ADF	<1> – 2.054	<1> – 2.108	<4> – 4.496 ***	<1> – 1.976	<1> – 1.517
Eq. (5)	ADF	<1> – 4.112 ***	<5> – 3.930 ***		<1> – 2.219	<1> – 3.089 **

The number of observations is 20 for all estimations. Notes are as follows: firstly, ADF tests conducted here are based on the Dickey–Fuller regressions including intercepts but not trends; secondly, figures in <> represent the degree of lags, chosen by the Schwarz Bayesian Criterion amongst lags up to five; thirdly, ***, **, and * stand for 1%, 5%, and 10% statistical significances, respectively. Critical values proposed by Cheung and Lai (1995) are used; fourthly, white-on-black country names indicate that their DGFs are judged to have downward trends; fifthly, shaded country names indicate that their DGFs are judged *not* to have trends; sixthly, ALL stands for all sample countries, AD for advanced countries, EM for emerging countries, EU for European countries, and AP for Asia Pacific countries; and lastly, the distinction between advanced and emerging countries is based upon the International Monetary Fund's *World Economic Outlook*

where Δ stands for the first difference, $\mathring{a}_{TT}$ is a coefficient, $\dot{e}$ denotes the deviations of ΔL_DGF from the trend, and other variables and notations are the same as in Eq. (3).

3.3 Estimation results

Table 2 shows the results of estimating Eq. (3) for all individual and grouped national DGFs and Eq. (5) for relevant DGFs.

As for individual sample countries, firstly, I find upward trends for 23 countries, including all of the emerging countries. Amongst the 23 DGFs, CHN's DGF has a much steeper slope than do other DGFs. Secondly, I find downward trends for USA, JPN, GBR, IRL, NLD, AUS, and NZL. Notably, USA's DGF is not constant after applying a logit-transformation to it. Amongst these seven countries, USA and JPN's DGFs have much steeper slopes than do other DGFs, whilst the negative slopes of other countries' DGFs are very gentle. Lastly, I find no trends for FRA, DEU, BEL, GRC, PRT, ESP, and HKG. Amongst the 14 countries whose DGFs do not have upward trends, nine countries are European.

As for country groups, I find (i) upward trends for ALL, EM, and AP small, (ii) a downward trend for AD, and (iii) no trend for EU. Pukthuanthong and Roll (2009) also find an upward trend in a DGF at a global level by analysing many more than 37 countries until 2007. The upward trend found for ALL suggests that an upward trend should be likely to have persisted for another 8 years beyond the 2008 crisis. Both the upward trend for EM and the downward trend for AD are in line with the above-mentioned observation: emerging countries' DGFs have been catching up with those of advanced countries. As shown by the by-country results above, CHN led this catch-up process, and USA and JPN were the major sources of the downward trend for AD. Such a downward trend is not found by Barari et al. (2008) and Bekaert et al. (2009), both of which report no trends in these cases. The result (iii) above—no trend for EU—is different from Bekaert et al.'s (2009) finding of an upward trend for European countries. These differences can be attributed mainly to three factors. One is the difference in the end of a sample period of time: 2005 in their cases and 2015 in mine. The second is the difference in the range of sample countries, which may affect values of GFs: only advanced countries in their case whilst emerging countries are added in mine. The final factor is in the measurement of national DGFs, as discussed in the previous section.

3.4 Numerical experiments on diversification effects

To see whether DGFs measured by Pukthuanthong and Roll's (2009) method are useful for making decisions on stock investments, I place a focus upon the Sharpe ratio: the return of an investment compared to its risk. A country's Sharpe ratio here is a time-period average of the country's *ER* over a time-period standard deviation of that. In the case of a portfolio of different countries, I apply this formulation to GDP-weighted member-countries' *ER*s; namely, I use the countries' GDP percentage shares as allocation rates in the portfolio. The Sharpe ratios over the period 1996–2015 for the country-groups are as follows: 0.043 for ALL, 0.035 for AD, 0.070 for EM, 0.041 for EU, and 0.028 for AP small. By the formulation, there is not necessarily a definitive linkage between the Sharpe ratios and the DGFs. In fact, the

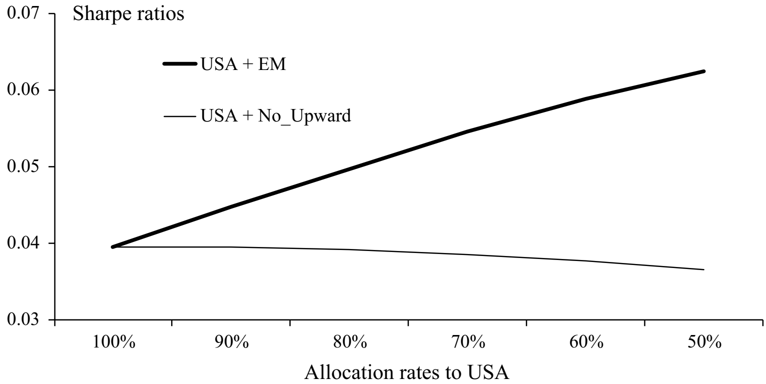


Fig. 6 This figure plots the Sharpe ratios to two types of portfolios. Notes are as follows: firstly, the Sharpe ratio is the 1996–2015 average of *ER*s (excess returns) over the 1996–2015 standard deviation of *ER*s for country groups and U.S.; secondly, a country-group *ER* is the GDP-weighted average of group member countries' *ER*s; thirdly, EM stands for emerging countries whilst No_Upward stands for countries whose DGFs are not upward-trended; and lastly, the distinction between advanced and emerging countries is based upon the International Monetary Fund's *World Economic Outlook*

sample-period averages of the country-groups' DGFs are as follows: 0.519 for ALL, 0.592 for AD, 0.383 for EM, 0.610 for EU, and 0.329 for AP small. Nevertheless, the data-based association between the two indicators seems to still merit examination for diversification effects, which I define here as a rise in the Sharpe ratios.

I undertake two tasks here. The first is to look into the presence and mode of a trend in the Sharpe ratios of the global portfolio (ALL). I deal with the question here: Did the upward trend in ALL's DGFs result in a decline of diversification effects gained from the global stock portfolio? It appears that such a decline matches with a downward trend in ALL's Sharpe ratios. To be specific, I calculate ALL's Sharpe ratios every year over the sample period. Then, I regress the annual ratios on *C* and *TT* as in the above-conducted time-trend analyses. As a result, I find that the ratios are not trended.[13]

The second task is to examine diversification effects gained by expanding the coverage of investment destination countries. I start with a U.S. alone portfolio (USA). Then, I add different country-groups to USA, to gain the following portfolios: (i) all advanced countries (AD), (ii) USA plus emerging countries (USA + EM), and (iii) both advanced and emerging countries (ALL), and (iv) USA plus countries whose DGFs do not have upward trends (USA + No_Upward), including 14 advanced countries as mentioned above.

As the Sharpe ratios for USA, AD and ALL are 0.040, 0.035, and 0.043, respectively, over the period 1996–2015, adding advanced countries to USA resulted in a decrease of the ratio whilst adding both advanced and emerging countries resulted in an increase of the ratio. This suggests a contrast that emerging countries should

[13] The estimates to *TT* and *C* are 0.00 and 0.08, respectively. The ADF test statistic to the residiaul is −3.20 whose *p* value is 0.05. This suggests that ALL's Sharpe ratios should have a horizontal trend.

be likely to have been attractive as a destination in international portfolio diversification whilst so should not be advanced ones.

I look into the second-type portfolio ((ii): USA + EM) and the fourth-type portfolio ((iv): USA + No_Upward), so as to answer the question: Is the contrast attributable to the average level of added countries' DGFs or to the presence of an upward trend therein? The previous subsection shows that advanced countries tend to have non-trended large DGFs whilst emerging ones tend to have upward-trended small DGFs. For the two types of portfolios, I assume different allocation rates to USA: 90%, 80%, 70%, 60%, and 50%. The remainder allocation rates, for example 20% in the case of 80% to USA, are those to a counterpart country-group whose member countries are weighted by their own GDP percentage shares. Figure 6 plots the Sharpe ratios by portfolio and by allocation rate to USA. The ratios for the portfolio (ii) above rapidly increase as allocation rates to USA decrease, confirming again that emerging countries are attractive investment destinations. The ratios for the portfolio (iv) above decrease very mildly as allocation rates to USA decrease. This is in line with the above-mentioned result of AD because all of the No_Upward countries are advanced ones.

Thus, the average level of added countries' DGFs affected the Sharpe ratios more than the presence of an upward trend in that level. The next section investigates determinants of the levels of national DGFs.

4 Determinants of national DGFs

This three-part section investigates the relevance of the global financial cycle hypothesis to DGFs (dependence on global factors) of national stock returns by conducting panel-data regressions. The first subsection constructs a baseline regression equation and gives a brief account of data. The second subsection discusses the estimation results and does three kinds of robustness-checks. The last subsection extends the baseline regression equation to test the Rey-type dilemma.

4.1 A baseline model and data

By the construction of a national DGF, differences in individual countries' DGFs across countries and those over time are determined by country-specific factors which are omitted variables collectively carried by e (residuals) in Eq. (1). These factors are assumed not to be correlated with GFs (global factors). As mentioned in Sect. 1, the previous studies, which measure a national DGF in different methods, find that it tends to be larger in a country with greater openness of international trade and finance. I interpret this finding as meaning that international trade and finance help domestic economic activities to be subject to GFs. A baseline model is:

$$L\_DGF_{i,\tau} = h_0 C + h_1 TO_{i,\tau} + h_2 CAC_{i,\tau-1} + h_3 FXV_{i,\tau} + h_4 Size_{i,\tau} + IE_i + \varepsilon_{i,\tau}, \quad (6)$$

where *L_DGF* is the national DGFs that Sect. 3 measures by applying the APT-based model and defining with Eq. (4), i stands for individual sample countries, τ stands for a yearly point in time, C is one (a constant term), hs are coefficients, *TO*, *CAC*, *FXV*, and *Size* are regressors explained later, IE_i stands for i's *heterogeneities* incorporated into omitted variables and unobservable factors, and ε is residuals. Meanwhile, time effects common to all sample countries (is) in individual sample years (τs) are not needed because, in Eq. (1), *GF*s (proxies for GFs) include such common effects.

Depending on the presence and character of *IE*s, Eq. (6) should take one of three potential forms: firstly, a pooling model represented by dropping *IE*s from Eq. (6); secondly, a fixed-effect model, or Eq. (6) in which *IE*s are country-specific constants; and lastly, a random-effect model, or Eq. (6) in which *IE*s are country-specific stochastic variables. I specify it by following a conventional procedure detailed in "Appendix E".[14]

The four regressors are the following. *TO* is an institutional factor representing the openness of international trade. It is *Index of Trade Freedom* that The Heritage Foundation calculates for individual countries by considering tariffs, taxes, and bans. As lager *TO* suggests more open international trade, I expect its estimate ($\hat{h}_1$) to be positive.

CAC is an institutional factor representing capital account closedness. It is an index constructed by Fernández et al. (2016) who review the presence of capital control measures for individual countries on both inflows and outflows. This index runs from zero through one, with zero meaning a fully-open capital account. I expect *CAC*'s estimate ($\hat{h}_2$) to be negative. Notably, *CAC* refers to a previous point in time ($\tau - 1$), in order to avoid statistical problems caused by a potential endogeneity that a country's larger DGF could encourage its authority to regulate foreign investors for domestic financial stability.

FXV deals with a built-in character of the DGFs. A national DGF is based upon changes in stock prices converted into U.S. dollars with reference to FX (foreign exchange) rates. A country's FX rates fluctuate in response to GFs and affect the country's stock prices in U.S. dollars. It is necessary to control for the exposure of a country's FX market to these FX effects. I do so with *FXV*, an indicator for the variability of FX rates. It is zero for countries without floating FX rate regimes and, for those with such regimes, the rates' coefficient of variation. As *FXV* tends to be a larger in a country whose FX market is more sensitive to the FX effects, I expect its estimate ($\hat{h}_3$) to be positive.

Because the global financial cycle hypothesis appears to suppose that foreign stock investors access a country's stock market in response to GFs, their behaviours

[14] When either a fixed-effect model or a random effect model is selected, it is necessary to deal with four potential irregular aspects of residuals (ε) so as to gain asymptotically consistent estimates ($\hat{h}$s): firstly, cross-section heteroskedasticity; secondly, period heteroskedasticity; thirdly, contemporaneously correlation; and lastly, serial correlation. These can reduce the reliability of the results of t-tests on the estimates. The first and second aspects could be acute for my dependent variables (*L_DGF*s) because they are logit-transformed variables (Kataoka 2005). The third and fourth aspects appear to be irrelevant when τ refers to a short period of time.

would be more likely to affect the price of a country's stocks when the country's stock market is smaller in comparison with their investment flows.[15] To control for such an impact of the flow size on the prices, *Size* is the ratio of $|SI|$ to the market capitalisation of all stocks listed, where *SI* is foreigners' portfolio-stock investment flows mentioned in Sect. 1. An estimate ($\hat{h}_4$) to *Size* should be positive.

I use an unbalanced panel dataset that includes 35 sample countries over the period 2001–2015. I exclude USA and CHN because, as discussed in Sect. 3, their DGFs (*R_DGF*s) are close to one very often in that sample period. Potential distortions caused by this might merit beforehand elimination. "Appendix D" details the definitions and sources of all data.

4.2 Estimation results

I estimate Eq. (6) by using a generalised least squares (GLS) method. As shown in the upper panel of "Appendix E", I select the random-effect model: *IE*s are country-specific stochastic variables. The result is:

$$L\_DGF_{i,\tau} = 0.629 + 0.019^{***}TO_{i,\tau} - 0.841^{**}CAC_{i,\tau-1} + 0.042^{***}FXV_{i,\tau} + 0.199^{***}Size_{i,\tau}$$
$$\left(\#\, of\ observations = 463,\ R^2_{adj} = 0.05\right) \tag{7}$$

where the superscripts ***, **, and * stand for 1%, 5%, and 10% statistical significances, respectively, and the p values for the estimates are the averages of two cases (εs): (i) those based upon White standard errors which adjust for ε's potential cross-section heteroskedasticity and contemporaneously correlation; (ii) those based upon White standard errors which adjust for ε's potential period heteroskedasticity and serial correlation. (See note in "Appendix E" for details.) All of the regressors gain statistically significant estimates whose signs are the same as expected above.

I do three kinds of robustness-checks for Eq. (7). The first is to address the risk of spurious regression. My panel-data regression could be at this risk for two reasons: firstly, as found in Sect. 3, most of national DGFs are trended; and secondly, there could be upward trends in *TO* amid the expansion of international trade. To respond to the spurious regression risk, I conduct a panel co-integration analysis of Eq. (6), by assuming that some of the dependent and independent variables are integrated of order one. By running the auxiliary regression for each i with Pedroni's (1999) method, I find the stationarity of the residuals (εs).[16]

[15] Transaction costs can give rise to illiquidity discounts on asset prices, or illiquidity premia on asset returns (Amihud and Mendelson 1991; Lo et al. 2004). A more liquid financial asset can be bought and sold in the market with a relatively small impact on its market price. The size of a financial market is one of conventionally-used indicators for the market liquidity.

[16] *C* is dropped from Eq. (6). The order of lag(s) is one, selected by the Schwarz Bayesian Criterion. The ADF statistic for a within-dimension is −4.439 (p value: 0.000) while the ADF statistic for a between-dimension is −5.436 (p value: 0.000). The null hypothesis that there is no co-integration can be rejected. The number of observations used is 1500.

I also explicitly control for a trend component of the dependent variable by extending Eq. (6) as follows:

$$L\_DGF_{i,\tau} = h_{TTi}TT + h_1 TO_{i,\tau} + h_2 CAC_{i,\tau-1} + h_3 FXV_{i,\tau} + h_4 Size_{i,\tau} + IE_i + \varepsilon_{i,\tau}, \quad (8)$$

where *TT* is a time trend, estimates (*h*s) have subscript *i*, and *IE* remains. Equation (8) allows for heterogeneous intercepts (*IE*) and trend coefficients ($h_{\mathrm{TT}i}$) across countries. Using Pedoroni's (1999) method, I find the stationarity of the residuals (εs) again.[17] Consequently, the first robustness-check suggests that Eq. (7) should not be a spurious relationship but a long-term stable relationship, beyond the fact that *L_DGF*s are logit-transformed variables.

The second robustness-check is to estimate Eq. (6) by using sample countries in inclusive of USA and CHA. As shown in the lower panel of "Appendix E", I select the random-effect model. The GLS estimation result is below:

$$L\_DGF_{i,\tau} = 0.905 + 0.020^{***}TO_{i,\tau} - 0.740^{*}CAC_{i,\tau-1} + 0.037^{*}FXV_{i,\tau} + 0.219^{***}Size_{i,\tau} \left(\#\, of\ observations = 489,\ R^2_{adj} = 0.03\right) \quad (9)$$

where the superscripts ***, **, and * stand for 1%, 5%, and 10% statistical significances, respectively, and the p-values for the estimates are the averages of two cases (εs) as in the case of the baseline estimation above. All of the regressors gain statistically significant estimates whose signs are the same as expected above.

The last robustness-check is to address the risk of multicollinearity amongst the independent variables. My panel-data regression could be at this risk due to *TO* and *FXV* which are level-variables. I find that all of the VIFs between *TO* and *FXV* for all sample countries should be too small to cause multicollinearity.[18]

Thus, national DGFs gauged by Pukthuanthong and Roll's (2009) method tend to be larger in a country with greater openness of international trade and finance, in line with the previous studies. The DGFs also tend to be larger in a country whose FX rates are more flexible and stock market is smaller in comparison with the flows of foreigners' inbound investments.

4.3 An extension for the Rey-type dilemma

With aim at testing the Rey-type dilemma, I add regressors to Eq. (6). I interpret here the dilemma as arguing that, regardless of the FX regime, SIRP (short-term

[17] The order of lag(s) is one, selected by the Schwarz Bayesian Criterion. The ADF statistic for a within-dimension is −4.087 (*p* value: 0.000) while the ADF statistic for a between-dimension is −5.923 (*p* value: 0.000). The null hypothesis that there is no co-integration can be rejected. The number of observations used is 1500.

[18] I calculate the VIFs between *TO* and *FXV* by using annual data over the period 1996–2015 for all sample countries. A VIF is defined as $1/\{1-(\text{correlation coefficients})^2\}$. Suffice it here to report that all of the VIFs are much smaller than 10, the criterion proposed by Snee and Marquardt (1984), defining negligible risk of multicollinearities caused by *TO* and *FXV*.

interest-rate policy) in a country cannot influence domestic stock prices without controlling the country's capital account. I regard Eq. (6) as controlling for the FX regime with *FXV*. I prepare four variables as follows.

If SIRP creates country-specific changes in a country's stock prices, SIRP will be implied to be a negative determinant of the country's DGF: a disconfirmation of the monetary policy dilemma. The dilemma appears to concern well a specific case where a monetary authority conducts SIRP to affect foreigners' investments. To address this case, I add as a regressor $SIRP^{w.r.t.\ USA}$—short-term interest-rate differentials with respect to the U.S. The dilemma may also relate to a general case where a monetary authority conducts SIRP to affect domestic economy and prices. $SIRP^{real\ gap}$ is a common indicator for such a domestic impact of SIRP—"real short-term interest-rate gaps" (Woodford 2003). I calculate these gaps by subtracting natural interest rates—hypothetical interest rates that are neutral to business climate—from real short-term interest rates. I approximate these two rates in a simple way due to the nature of computability and data-availability for all sample countries.[19] Short-term interest rates are one-year yields on sovereign bonds denominated in local currencies. Larger absolute values of $SIRP^{w.r.t.\ USA}$ and $SIRP^{real\ gap}$ represent more impactful SIRP.

To investigate whether the closedness of a country's capital account helps the country's SIRP to be effective, I make either $SIRP^{w.r.t.\ USA}$ or $SIRP^{real\ gap}$ interact with *CAC*. For the interpretability of estimates to the interaction terms, my extension of Eq. (6) looks at two combinations: firstly, $SIRP^{w.r.t.\ USA}$ and its interaction term with *CAC*; and secondly, $SIRP^{real\ gap}$ and its interaction term with *CAC*. The first combination is exemplified as follows:

$$
\begin{aligned}
L\_DGF_{i,\tau} = {} & h_0 C + h_1 TO_{i,\tau} + h_2 CAC_{i,\tau-1} + h_3 FXV_{i,\tau} + h_4 Size_{i,\tau} \\
& + h_5 |SIRP^{w.r.t.\ USA}_{i,\tau}| + h_6 (|SIRP^{w.r.t.\ USA}_{i,\tau}| \times CAC_{i,\tau-1}) + IE_i + \varepsilon_{i,\tau},
\end{aligned}
\tag{10}
$$

where $SIRP^{w.r.t.\ USA}$ will be replaced with $SIRP^{real\ gap}$ in the second combination. In Eq. (10), when *CAC* is zero (country *i*'s capital account is fully open), *CAC* and its interaction term disappear and only $|SIRP^{w.r.t.\ USA}|$ remains. A negative $\hat{h}_5$, if gained, will imply that a country's SIRP should be likely to have created country-specific changes in its stock prices without the help of capital control measures. When *CAC* is a positive number (less than one), a negative $\hat{h}_6$, if gained, will imply that SIRP's DGF-reducing impact should be likely to have been strengthened as the country' capital account is regulated more. Thus, a pair of an insignificant $\hat{h}_5$ and a significantly positive $\hat{h}_6$ can serve as good corroboration for the Rey-type dilemma.

As detailed in "Appendix F", I select the random-effect models for the two combinations. The Rey-type dilemma can be justified for $|SIRP^{w.r.t.\ USA}|$. When $|SIRP^{w.r.t.\ USA}|$ is referred to, $\hat{h}_5$ is statistically insignificant, and $\hat{h}_6$ is statistically significant and negative. By contrast, when $|SIRP^{real\ gap}|$ is referred to, both $\hat{h}_5$ and $\hat{h}_6$

[19] As explained in "Appendix D", natural interest rates are potential growth rates based upon local-currency real GDP, which are gauged by a conventional filtering method. The real short-term interest rates are those on an *ex post* basis: one-year sovereign bond yields minus annual inflation rates.

Table 3 Rolling-regression results of Eq. (9): $L\_DGF_{i,\tau}=h_0C+h_1TO_{i,\tau}+h_2CAC_{i,\tau-1}+h_3FXV_{i,\tau}+h_4Size_{i,\tau}+h_5|SIRP_{i,\tau}^{w.r.t.\ USA}|+h_6(|SIRP_{i,\tau}^{w.r.t.\ USA}|\times CAC_{i,\tau-1})+IE_i+\varepsilon_{i,\tau}$

Regressors		Estimators												
		$\hat{h}_{0,1,\ldots,\text{ or }6}$												
3-year sample periods in or after 2001		2001–03	02–04	03–05	04–06	05–07	06–08	07–09	08–10	09–11	10–12	11–13	12–14	13–15
Constant	*C*	1.929***	2.451***	3.212***	1.192***	0.450	2.100***	2.683***	2.539***	2.534***	2.097	3.536***	3.089**	1.437*
Institutional openness of trade	*TO*	0.01***	−0.004	−0.004	0.011***	0.021***	0.003	−0.002	0.001	0.003	0.001	−0.018***	−0.014	0.003
Capital account closedness	*CAC*	−1.235**	−1.151*	−1.981***	−0.204	0.234	−0.740*	−0.664**	−0.522	−0.607	−0.847	−1.436***	−1.111**	−0.575*
FX rate variability	*FXV*	−0.010	−0.041	−0.096**	0.029	0.050	0.071***	0.039**	0.026	−0.014	0.178***	0.191***	0.147***	0.139***
Flow-size impact	*SIZE*	11.979**	0.757	0.418	0.40***	−0.067	0.29	−0615	0.085*	0.060	−0.136***	−0.483***	−0.257***	−0.248*
Interest-rate differentials (vis-à-vis USA)	|*SIRP*|	**0.108**	**0.187*****	**−0.044**	**−0.006**	**−0.005**	**−0.016**	**0.037**	**0.041**	**−0.013**	**−0.009**	**−0.011**	**0.008**	**0.093**
Interaction term	|*SIRP*|×*FO*	**−0.201*****	**−0.358*****	**0.035**	**−0.136**	**−0.273****	**−0.087**	**−0.162**	**−0.197**	**−0.071**	**−0.074**	**−0.039**	**−0.111*****	**−0.193*****
Individual Effect	*IE*	RE	RE	RE	RE	RE	RE	RE	RE	RE	RE	RE	RE	RE

Table 3 (continued)

Regressors	Estimators												
	$\hat{h}_{0,1,\ldots,\text{ or }6}$												
3-year sample periods in or after 2001	2001–03	02–04	03–05	04–06	05–07	06–08	07–09	08–10	09–11	10–12	11–13	12–14	13–15
R^2_{adj}	0.145	0.241	0.098	−0.015	0.081	0.139	0.056	0.042	0.024	0.133	0.13	0.14	0.11
# of observations	65	69	77	83	91	94	96	95	93	91	86	82	76

Notes are as follows. Firstly, I follow the conventional procedure to specify the type of *IE*. See notes in Appendix Table 9 for details. In the end, I select the random-effect (RE) model here. The RE estimators depend on the Swamy–Arora method which uses residuals gained in the within (fixed-effect) and between-means regressions. Secondly, ***, **, and * stand for 1%, 5%, and 10% statistical significances. White standard errors are used. εs' risks of period heteroskedasticity and contemporaneously correlation are adjusted for are insignificant. This result would be sensitive to the simple formulation of $SIRP^{real\ gap}$. Therefore, it would be too soon to conclude that the real interest-rate gaps in a country cannot affect the country's stock price changes in an internationally-distinct fashion.

Finally, to investigate the sensitivity of statistical significances of $\hat{h}_5$ and $\hat{h}_6$ to the length of time periods, I conduct rolling panel-regressions of random-effect models. The time horizon is three years; that is, I consider 13 periods, including 2001–2003, 2002–2004,…, and 2013–2015. Based upon White standard errors adjusting for ε's potential cross-section heteroskedasticity and contemporaneously correlation, a pair of an insignificant $\hat{h}_5$ and a significantly positive $\hat{h}_6$ is gained for $|SIRP^{w.r.t.\ USA}|$ in four periods, including 2001–2003, 2005–2007, 2011–2014, and 2012–2015, as summarised in Table 3.

5 Concluding remarks

The findings corroborate a notation that different countries' stock markets are in a global financial cycle. The sample-period (1996–2015) average of a global DGF (dependence on global factors)—the simple average of all national DGFs—is substantial: 56%. There were upward trends in the DGFs for many countries as well as in the global DGF, suggesting the progress of stock market integration globally. An indication of the global financial cycle is that different country-group DGFs showed similar behaviours.

By analysing national DGFs, I find that national stock markets were more greatly integrated with the world market in advanced countries than those in emerging ones. I argue that emerging countries are more attractive destinations in international portfolio diversification—an argument supported by the fact that the Sharpe ratio improved by adding emerging countries to an international portfolio consisting of advanced countries. The stock market integration, however, happened more rapidly in emerging countries than in advanced ones. Such a catch-up by emerging countries accompanied their liberalisation of international trade, capital accounts, and FX markets, as well as a slow growth in the size of domestic stock markets compared to foreigners' investments.

When a country's monetary authority needs to reduce the country's DGF for domestic financial stability, the authority may be able to do so by closing the country's capital account and making its FX rates inflexible. As far as short-term interest-rate differentials vis-a-vis the U.S. are concerned, the Rey-type dilemma is confirmed over the sample period. So is it in the run-up to the 2008 crisis but not during the crisis.

Restrictive measures on a country's capital account and FX regime presumably have a negative side-effect of preventing financial markets from developing in the country. How specific restrictive measures have worked in individual countries merits closer examination from a longer-term perspective. Apart from such measures, one of the findings is that growing domestic investors should contribute towards reducing a national DGF by diminishing the size impact of foreigners' investments on market prices.

Finally, this article closes with two caveats. Firstly, the findings cannot be generalised fully, because they are gained through the lens of a realistic and very specific global investor investing in 37 countries' stock market indices by using the GDP percentage shares as allocation rates. Although I believe that such a GDP-based allocation is the best benchmark, changing the allocation rates will affect, to some extent, measurements of both GFs and national DGFs. Lastly, the implications for monetary policy independence could be sensitive to the simple formulation of real short-term interest-rate gaps and to the coarse content of the indicator for regulations on foreign stock investors. The latter indicator tells just whether or not there are regulations on foreign stock investors. To my knowledge, internationally-comparable indicators for the strictness of the regulations are not available. In this connection, using a particular method to estimate the impact of weekly changes in (i) controls on overall capital outflows and inflows and (ii) macroprudential measures related to international transaction for 60 countries over the period 2009–2011, Forbes et al. (2015) show that the capital control measures were less capable than the macroprudential measures in terms of achieving intended objectives. Beyond these caveats, this study, hopefully, will serve as a good initial step for the further research on the international stock market comovements and the global financial cycle hypothesis.

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Appendix A: A brief survey of empirical studies on the DGFs

To justify the potential gains to investors from international diversification, early financial articles investigate the inter-temporal stability of bilateral correlation coefficients amongst major countries. Watson (1978, 1980) and Meric and Meric (1989) support this stability whilst Maldonado and Saunders (1981) do not. Beyond this disagreement, Forbes and Rigobon (2002) demonstrate that simple correlation coefficients can be biased, resulting in the false appearance of correlation during periods of high volatility. With a computational method of adjusting for such a bias, they find that there was no significant increase in many unconditional cross-country correlation coefficients of national stock markets even in times of crises, including the 1987 U.S. crash, the 1994 Mexican crisis, and the 1997 Asian crisis.

Testing for changes in a cointegrating vector for pairs of national stock indices also deals with correlations between two countries' stock prices. Based upon a constant correlation GARCH model, Longin and Solnik (1995) report that the hypothesis of a constant conditional correlation is rejected. Based upon a dynamic conditional correlation GARCH model, Barari et al. (2008) show that estimated dynamic conditional correlations in stock returns between the U.S. and other G7 countries are clearer for iShares than for national stock market indices, but they do not discover an upward trend over the period 1996–2005. Although they find an increasing statistical significance for cointegration amongst G7 countries since 2001, it is impossible to establish different degrees of association for a cointegration because it is binary (Croux et al. 2001); in other words, a more statistically significant cointegration between two variables does not necessarily mean a stronger correlation between the two.

Bekaert et al. (2009) obtain a similar result for 23 developed stock markets over the period 1980–2005: there is no evidence of an upward trend for national DGFs, except for the European stock markets. They analyse inter-country correlations of market index returns as well as those explained by changes in the returns' responsiveness to GFs (global factors)—the betas (βs) that the authors estimate by applying both APT-based and Fama–French-type multi-factor models.

Two articles challenge Bekaert et al. (2009). Blackburn and Chidambaran (2011) warn that using a market-capitalisation-weighted average of national stock markets as a world stock portfolio has the risk of disproportionally weighting countries with highly-capitalised stock markets, including financial superpowers such as USA, as well as city-economies functioning as international financial centres such as HKG and SGP. Looking at the same 23 stock markets used by Bekaert et al. (2009), Blackburn and Chidambaran (2011) make a canonical correlation analysis in order to retrieve comoving components from pairs of national stock returns. They define the components as common factors to the pairs. These common factors are a combination of weights which maximises correlation between a weighted-sum of historical data of stock returns in one country and a weighted-sum of those in another country. They gain maximised correlations for one country with respect to other countries individually, and show that, from the mid-1990s through 2010, the average pairwise correlation for individual countries increased, as did the average pairwise correlation amongst all pairs.

Pukthuanthong and Roll (2009) propose a method for gauging national DGFs, by arguing that the analyses of Bekaert et al. (2009) of trends in national DGFs by referring to individual countries' estimates (βs) may be narrow as discussed in Sect. 2 of this article. Pukthuanthong and Roll (2009) apply their method to 81 countries, including developing ones, from the 1960s to 2007, and find an upward trend for the simple average of their DGFs.

Appendix B: Countries' stock market indices and descriptive statistics of *ER*s

See Table 4.

Table 4 Countries' *ER*s: market indices used and descriptive statistics

Country names	Stock market indices	Mean	SD	Median	Max	Min
USA	S&P 500	0.001	0.024	0.002	0.120	−0.182
JPN	Tokyo Stock Price Index	0.000	0.028	−0.001	0.125	−0.161
GBR	FTSE All-Share Index	0.001	0.026	0.001	0.107	−0.171
FRA	CAC All-Tradable	0.001	0.032	0.002	0.118	−0.198
DEU	HDAX	0.002	0.035	0.003	0.147	−0.196
ITA	MSCI Italy	0.000	0.035	0.001	0.195	−0.239
CAN	S&P/Toronto Stock Exchange Composite Index	0.001	0.030	0.003	0.161	−0.226
AUS	All Ordinaries Index	0.001	0.020	0.000	0.081	−0.075
NZL	MSCI New Zealand	0.000	0.030	0.002	0.127	−0.225
KOR	Korea Composite Stock Price Index	0.001	0.050	0.003	0.306	−0.405
HKG	Hang Seng Index	0.001	0.034	0.002	0.148	−0.181
SGP	MSCI Singapore	0.000	0.033	0.001	0.203	−0.228
AUT	MSCI Austria	0.000	0.037	0.003	0.207	−0.318
BEL	Belgian All-Share Index	0.002	0.029	0.003	0.121	−0.224
FIN	OMX Helsinki All-Share Index	0.002	0.041	0.003	0.171	−0.220
GRC	Athex Composite Share Price Index	0.000	0.045	0.001	0.261	−0.213
IRL	ISEQ All-Share Index	0.001	0.034	0.003	0.147	−0.252
NLD	AEX	0.001	0.035	0.002	0.149	−0.230
PRT	PSI All-Share Index	0.001	0.029	0.001	0.139	−0.164
ESP	Madrid Stock Exchange General Index	0.001	0.033	0.003	0.117	−0.189
DNK	OMX Copenhagen 20	0.002	0.030	0.004	0.135	−0.222
NOR	OBX	0.001	0.038	0.003	0.210	−0.255
SWE	OMX Stockholm 30	0.001	0.037	0.002	0.213	−0.219
CHE	Swiss Market Index	0.001	0.027	0.001	0.146	−0.230
IND	S&P BSE Sensex Index	0.002	0.037	0.002	0.196	−0.184
CHN	Shanghai Stock Exchange Composite Index	0.002	0.036	0.001	0.173	−0.203
IDN	Jakarta Composite Index	0.002	0.056	0.002	0.584	−0.440
RUS	CS First Boston Russian Stock Market Index	0.004	0.061	0.003	0.407	−0.290
TUR	Borsa Istanbul 100	0.003	0.065	0.004	0.395	−0.484
SAU	Tadawul All-Share Index	0.002	0.032	0.002	0.148	−0.213
BRA	MSCI Brazil	0.002	0.052	0.004	0.292	−0.282
ARG	Argentina Merval Index	0.002	0.051	0.004	0.267	−0.342
MEX	MSCI Mexico	0.002	0.041	0.004	0.253	−0.264
ZAF	FTSE/JSE African All Shares	0.001	0.038	0.003	0.299	−0.186
MYS	FTSE Bursa Malaysia EMAS Index	0.000	0.038	0.001	0.503	−0.276
PHL	PSEi Index	0.001	0.038	0.001	0.212	−0.283
THA	Bangkok SET Index	0.000	0.041	0.003	0.202	−0.239

$ER_{t+1} = ((Stock\ Prices_{t+1}/Stock\ Prices_t - 1) - ((1 + 1\text{-}Week\ Interest\ Rates_t/100)^{7/360} - 1)) \times 100$, where t is a weekly point in time, *Stock Prices* refer to countries' stock indices listed below, and *1-Week Interest Rates* are linearly interpolated with federal funds effective rates and 1-year yields on Treasury bills

Table 5 Eigenvectors (factor loadings) of *GF*1–*GF*5 for USA and CHN by year

1996	*GF1*	*GF2*	*GF3*	*GF4*	1997	*GF1*	*GF2*	*GF3*	*GF4*	1998	*GF1*	*GF2*	*GF3*	*GF4*
USA	−0.93	0.26	−0.13	0.20	USA	0.87	−0.23	0.42	0.05	USA	−0.89	0.15	−0.39	−0.15
CHN	0.05	−0.13	−0.96	−0.20	CHN	−0.03	−0.01	0.03	0.05	CHN	0.00	0.00	−0.01	0.00
1999	*GF1*	*GF2*	*GF3*	*GF4*	2000	*GF1*	*GF2*	*GF3*	*GF4*	2001	*GF1*	*GF2*	*GF3*	*GF4*
USA	−0.93	0.12	0.33	0.05	USA	−0.97	0.14	0.15	−0.03	USA	−0.94	0.12	0.31	−0.02
CHN	0.01	−0.03	−0.03	0.80	CHN	0.01	0.06	−0.03	−0.84	CHN	−0.01	−0.01	0.04	−0.38
2002	*GF1*	*GF2*	*GF3*	*GF4*	2003	*GF1*	*GF2*	*GF3*	*GF4*	2004	*GF1*	*GF2*	*GF3*	*GF4*
USA	−0.92	0.17	0.34	−0.04	USA	−0.88	0.06	−0.44	−0.05	USA	−0.86	0.33	−0.31	−0.04
CHN	−0.01	−0.13	−0.08	−0.95	CHN	0.01	−0.04	−0.06	0.91	CHN	0.00	−0.03	−0.01	0.96
2005	*GF1*	*GF2*	*GF3*	*GF4*	2006	*GF1*	*GF2*	*GF3*	*GF4*	2007	*GF1*	*GF2*	*GF3*	*GF4*
USA	0.91	0.00	0.36	−0.04	USA	−0.81	0.17	0.07	−0.48	USA	−0.87	0.19	0.19	−0.37
CHN	0.06	−0.18	−0.09	0.95	CHN	−0.09	−0.79	0.57	0.03	CHN	−0.15	−0.96	0.22	0.02
2008	*GF1*	*GF2*	*GF3*	*GF4*	2009	*GF1*	*GF2*	*GF3*	*GF4*	2010	*GF1*	*GF2*	*GF3*	*GF4*
USA	−0.87	0.09	−0.24	−0.41	USA	−0.91	0.12	−0.22	−0.27	USA	−0.86	0.29	−0.06	0.25
CHN	0.01	−0.95	−0.18	−0.08	CHN	−0.08	−0.98	−0.13	−0.06	CHN	−0.28	−0.94	0.09	0.01
2011	*GF1*	*GF2*	*GF3*	*GF4*	2012	*GF1*	*GF2*	*GF3*	*GF4*	2013	*GF1*	*GF2*	*GF3*	*GF4*
USA	−0.86	0.16	0.38	0.21	USA	−0.85	0.15	0.20	0.20	USA	−0.87	0.11	0.30	0.33
CHN	−0.14	−0.94	0.04	0.20	CHN	−0.05	−0.96	0.22	0.06	CHN	−0.12	−0.99	−0.05	0.06
2014	*GF1*	*GF2*	*GF3*	*GF4*	2015	*GF1*	*GF2*	*GF3*	*GF4*					
USA	−0.80	−0.33	−0.31	0.18	USA	−0.24	−0.87	0.27	0.28					
CHN	−0.35	0.93	0.00	0.00	CHN	−0.01	−0.07	−0.07	−0.18					

Table 6 Correlation coefficients between *GF1–GF4* and selective indicators

	GF1	*GF2*	*GF3*	*GF4*
%VIX	0.22***	0.02	0.02	0.03
ΔExpUSMP	−0.25***	−0.03	−0.08**	0.07**
%US$	0.29***	0.24***	−0.07**	0.11***
%WTI	−0.17***	−0.09***	0.04	0.01

Notes are as follows. Firstly, the number of observations is 1096, weekly data over the period 1996–2015. Secondly, ***, **, and * stand for 1%, 5%, and 10% statistical significances. Lastly, Appendix Table 8 explains in detail the indicators

Table 7 Correlation coefficients between *GF1–GF4* and F&F-type GFs

	GF1	*GF2*	*GF3*	*GF4*
Market factor	−0.81***	−0.19***	−0.04	0.01
Size factor	0.41***	−0.14***	−0.04	−0.04
Value factor	0.14***	0.00	0.07**	0.02
Momentum factor	0.21***	0.01	−0.08**	−0.01

Notes are as follows. Firstly, the number of observations is 1096, weekly data over the period 1996–2015. Secondly, ***, **, and * stand for 1%, 5%, and 10% statistical significances. Lastly, Appendix Table 8 explains in detail the F&F-type GFs

Appendix C: An overview of APT-based *GF1–GF4*

I briefly make three kinds of analyses of APT-based *GF1–GF4*, to illustrate the realism of national DGFs gained by using them as regressors. First of all, remind the finding that USA's DGF is almost full in all sample years, and so is CHN's DGF after 2005. I understand that these countries' stock returns are good proxies for GFs for which I control with *GF1–GF4*. Looking at Appendix Table 5 which lists eigenvectors (factor loadings) of USA and CHN for *GF1–GF4*, USA has large eigenvectors in absolute value for *GF1* in almost all sample years, suggesting that *GF1* is likely to have mainly reflected information affecting U.S. stock prices. Likewise, CHN has large eigenvectors in absolute value for *GF2* in almost all sample years in and after 2006, suggesting that *GF2* is likely to mainly reflected information affecting Chinese stock prices.

Secondly, Appendix Table 6 shows correlation coefficients between *GF1–GF4* and four indicators suitable for GFs: percentage change in VIX (*%VIX*), the change in the expected average of future U.S. short-term interest rates for ten years ahead (*ΔExpUSMP*), percentage change in effective FX rates of U.S. dollars (*%US$*), and percentage change in West Texas Intermediate crude oil prices (*%WTI*). The frequency of these indicators is weekly. "Appendix D" details their definitions and sources. Looking at the table, *GF1* has statistically significant correlations with all of *%VIX*, *ΔExpUSMP*, *%US$*, and *%WTI*. *GF2* has statistically significant correlations with *%US$* and *%WTI*. *GF3* has statistically significant correlations with Δ*ExpUSMP* and *%US$*. This can be said to *GF4* too.

The last analysis is to consider correlations between APT-model based *GF1–GF4* and Fama–French (F&F) model based ones: the market, size, value, and momentum factors. Appendix Table 7 shows correlation coefficients between the two types of GFs. Looking at the table, APT-model based *GF1* has statistically significant correlations with all of F&F-model based *GF*s, while APT-model based *GF4* has statistically significant correlations with none of them. APT-model based *GF2* has statistically significant correlations with F&F-model based *GF1* (market factor) and *GF2* (size factor). APT-model based *GF2* has statistically significant correlations with F&F-model based *GF3* (value factor) and *GF4* (momentum factor).

Thus, I argue that, although APT-model based *GF1–GF4* are unidentifiable, they are informative proxies for GFs because each of them has statistically significant correlations with a number of data-based and meaningful indicators for GFs.

Appendix D: On data

See Table 8.

Table 8 Definitions and sources of data

Indicators	Notations	Definitions	Sources	Notes
Foreigners' stock-investment flows	*SI*	Foreigners' purchasing of portfolio-stocks minus their selling of the stocks/Nominal GDP	IMF, *Balance of Payments Statistics* (BOPS)	Nominal GDPs are taken from IMF, *World Economic Outlook* (WEO). This is applicable to all indicators divided by nominal GDPs
Foreigners' bond-investment flows	*BI*	Foreigners' purchasing of portfolio-bonds minus their selling of the bonds/Nominal GDP	See the above	See the above
Foreign banks' loan flows	*BLI*	Foreign banks' new loans minus repayment to the banks/Nominal GDP	BIS, Consolidated Banking Statistics	See the above
Excess returns of national stock	*ER*	{(National stock prices at *t*/National stock prices at $t-1$) − 1 week interest rates of US dollar at $t-1$}	Bloomberg	% points. National stock prices are quoted in U.S. dollar. The interest rates are linearly interpolated with FF effective rates and 1-year Treasury bill yields. See Appendix Table 4 for national stock market indices used
Market factor	Fama–French's (FF) *GF1*	GDP-weighted averages of 37 countries' *ER*s	See the above	% points. Nominal GDPs are taken from IMF, WEO. This is applicable to all indicators divided by nominal GDPs
Size factor	FF's *GF2*	A global portfolio is a market-capitalisation weighted sum of liquid corporate stock prices in 23 advanced countries. All stocks are sorted into big and small stocks by market capitalisation. Big stocks are those in the top 90% whilst small stocks are those in the bottom 10%. Stocks in each stock group are sorted into three sub-groups by three ratios gained by dividing (i) market equity, (ii) operating profits, and (iii) changes of total assets by book equity. Stocks in each sub-group are classified into bottom 30%, middle 40%, and top 10%. As a result, big stocks consist of nine portfolios, and so do small stocks. *SMB* is the average excess return on the nine small portfolios minus the average excess return on the nine big portfolios	*Fama/French Global 5 Factors [Daily]*	% points

Table 8 (continued)

Indicators	Notations	Definitions	Sources	Notes
Value factor	FF's *GF3*	*HML* = 1/2 (Excess return on small stocks with bottom-30% book-to-market equity ratios + excess return on big stocks with bottom-30% book-to-market equity ratios) − 1/2 (Excess return on small stocks with top-10% book-to-market equity ratios + excess return on big stocks with top-10% book-to-market equity ratios)	See the above	See the above
Momentum factor	FF's *GF4*	*WML* (the difference between the returns on diversified portfolios of top-30% strong stocks and bottom-30% weak stocks)	*Fama/French Global Momentum Factor (Mom) [Daily]*	See the above
VIX	*VIX*	Chicago Board Option Exchange Volatility Index	See the above.	Appendix Tables 5, 6, and 7 use weekly data
Expectations on U.S. monetary policy for 10 years ahead	*USMP*	Changes in X. X = (Fitted yield on a 10 year zero-coupon bond) − (term premium on a 10-year zero-coupon bond)	The Federal Reserve Board	% points. Weekly data retrieved from Federal Reserve Economic Data (FRED) are used
Energy pirces	*Energy*	Percentage change in value represents the benchmark prices which are representative of the global market. They are determined by the largest exporter of a given commodity. Prices are period averages in nominal U.S. dollars. Index 2005 = 100	IMF	%. Monthly data retrieved from the FRED are used
Institutional openness of trade	*TO*	*Index of Trade Freedom*. A composite measure of the absence of tariff and non-tariff barriers that affect imports and exports of goods and services. Country *i*'s score is written as: $(((T_{max}-T_i)/(T_{max}-T_{min}))\times 100) - NTB_i$, where T_{max} and T_{min} represent the upper and lower bounds for tariff rates (%), T_i represents the weighted average tariff rate (%), and NTB stands for a non-tariff barrier. NTB is 0, 5, 10, 15, or 20: a value dermined using both qualitative and quantitative information on the extensiveness of using non-tariff barriers	The Heritage Foundation	A larger *TO* means a freer trade.

Table 8 (continued)

Indicators	Notations	Definitions	Sources	Notes
Capital account closedness	*CAC*	Index on the presence of regulations on capital inflows and outflows	Fernández et al. (2016)	0 to 1. 1 means full closedness
Foreign exchange rate variability	*FXV*	For countries which employ floating and free floating FX systems, coefficients of variation of FX rates: annual standard deviations/annual averages × 100. These countries include euro-area countries, apart from an original classification by the IMF. 0 for other countries	IMF, *Annual Report on Exchange Arrangements and Exchange Restrictions*. Bloomberg	Weekly data used for FX rates
Flow-size impact	*Size*	($\lvert SI \rvert$/market capitalisation of listed stocks)*100. Both of the numerator and denominator are % of nominal GDP	World Bank, *Global Financial Development Database* (GFDD)	%
Interest-rate differentials	$\lvert SR^{w.r.t.\ USA} \rvert$	Absolute values of spreads vis-a-vis USA on 1-year sovereign bond yields	Bloomberg	% points
Real short-term interest-rate gap	$\lvert SR^{real\ gap} \rvert$	$\lvert$Real short-term interest-rate gaps at t – real short-term interest-rate gaps at $t-1\rvert$. Real short-term interest-rate gaps = Real short-term interest-rates—natural rates. Real short-term interest rates = One-year sovereign bond yields—annual inflation rates. Natural interest rates are potential growth rates based on local-currency real GDP smoothed by applying the Hodrick–Prescott filter with a multiplier of 100	Bloomberg; IMF IFS; World Bank WDI	% points

Appendix E: Detailed results of baseline and alternative estimations

See Table 9.

Table 9 Results of estimating Eq. (6): $L\_DGF_{i,\tau} = h_0C + h_1TO_{i,\tau} + h_2CAC_{i,\tau-1} + h_3FXV_{i,\tau} + h_4Size_{i,\tau} + IE_i + \varepsilon_{i,\tau}$

The specification of *IE*		A: Pooling	B: Fixed effect			C: Random effect	
		No	Yes: Constant			Yes: Stochastic	
Estimation method		OLS	LSDV	Weighted GLS		GLS	
Adjustments on residuals (ε)		–	–	White period	White cross-section	White period	White cross-section
				CSH, PH, & SC are adjusted for.	CSH & CCE are adjusted for.	PH & SC are adjusted for.	CSH & CCE are adjusted for.
Regressors \ Estimators		$\hat{h}$s	$\hat{h}$s	$\hat{h}$s	$\hat{h}$s	$\hat{h}$s	$\hat{h}$s
(1) Baseline estimation results: the number of observations is 463							
Constant	*C*	2.280***	0.523	0.409	0.409**	0.629	0.629
Institutional openness of trade	*TO*	0.002	0.021***	0.021***	0.021***	0.020***	0.020**
Capital account closedness	*CAC*	– 1.554***	– 0.684*	– 0.385	– 0.385	– 0.841**	– 0.841***
FX rate variability	*FXV*	0.050***	0.041***	0.047***	0.047*	0.042***	0.042*
Flow-size impact	*Size*	– 0.315	0.323	0.261***	0.261**	0.199***	0.199***
R_{adj}^2		0.170	0.605	0.810		0.054	
F-test on H_0: Model A is better than Model B		16.337 (*p*-value: 0.000)					
Hausman test on H_0: Model C is better than Model B			3.428 (*p*-value: 0.489)				
(2) Alternative estimation results: the number of observations is 489 (USA and CHN are included)							
Constant	*C*	1.315*	0.911	0.746	0.746	0.905	0.905
Institutional openness of trade	*TO*	0.019**	0.021***	0.021***	0.021***	0.020***	0.020***
Capital account closedness	*CAC*	– 0.531*	– 0.882**	– 0.465	– 0.465*	– 0.740*	– 0.740**
FX rate variability	*FXV*	– 0.066***	0.041**	0.047***	0.047*	0.037***	0.037
Flow-size impact	*Size*	– 0.447	0.295	0.258***	0.258**	0.219***	0.219***
R_{adj}^2		0.045	0.763	0.825		0.028	
F-test on H_0: Model A is better than Model B		42.744 (*p*-value: 0.000)					
Hausman test on H_0: Model C is better than Model B			3.633 (*p*-value: 0.458)				

Notes are as follows. Firstly, I follow the conventional procedure to specify the type of *IE*. I estimate the pooling model using the OLS method, and I estimate the fixed-effect model with the LSDV method. I justify the addition of constant *IE*s by checking with the F-test by how many and how significantly that addition reduces residual squared sums. If the fixed-effect model is selected, then, to compare it with the random-effect model, I test a null hypothesis with the Hausman test that *IE*s are uncorrelated with explanatory variables. Secondly, shading indicates regressors with statistically significant estimators and a specification of *IE* with statistical adequacy. I select the random-effect model. Thirdly, ***, **, and * stand for 1%, 5%, and 10% statistical significances. Lastly, CSH stand for cross-section heteroskedasticity, PH for period heteroskedasticity, SC for serial correlation, and CCE for contemporaneously correlated errors. Using the *EViews 10* statistical software package, I address these potential irregular aspects of residuals ($\varepsilon_{i,\tau}$) with reference to two kinds of adjusted standard errors. *EViews 10*'s option for a panel-data regression, *White period*, is used to gain standard errors adjusted for the risks of PH and SC, with *White cross-section* used to gain those adjusted for CSH and CCE. In estimating the fixed-effect model by GLS, I additionally use the *Cross-section weights* option, which also enables controlling for the risk of CSH. Reed and Ye (2011) demonstrate that estimators gained using the weighted-GLS method together with each of the two options for adjusted standard errors are excellent in terms of the estimators' asymptotical efficiency and the accuracy of confidence intervals across them. The random effect estimators depend on the Swamy-Arora method which uses residuals gained in the within (fixed-effect) and between-means regressions

Appendix F: Detailed results of the extended estimations

See Table 10.

Table 10 Results of estimating an extended Eq. (6): $L\_DGF_{i,\tau} = h_0C + h_1TO_{i,\tau} + h_2CAC_{i,\tau-1} + h_3FXV_{i,\tau} + h_4Size_{i,\tau} + h_5X + h_6(X_{i,\tau} \times CAC_{i,\tau-1}) + IE_i + \varepsilon_{i,\tau}$

(1) $X = |SIRP^{w.r.t.\ USA}|$

The specification of *IE*		A: Pooling	B: Fixed effect			C: Random effect	
		No	Yes: Constant			Yes: Stochastic	
Estimation method		OLS	LSDV	Weighted GLS		GLS	
Adjustments on residuals (ε)		–	–	White period	White cross-section	White period	White cross-section
				CSH, PH, & SC are adjusted for.	CSH & CCE are adjusted for.	PH & SC are adjusted for.	CSH & CCE are adjusted for.
Regressors \ Estimators		$\hat{h}$s	$\hat{h}$s	$\hat{h}$s	$\hat{h}$s	$\hat{h}$s	$\hat{h}$s
Constant	*C*	2.086	0.729	0.729	0.729	0.935	0.935 *
Institutional openness of trade	*TO*	0.003	0.018 ***	0.018 *	0.018 ***	0.015 *	0.015 **
Capital account closedness	*CAC*	– 0.927 ***	– 0.573	– 0.127 *	– 0.127 ***	– 0.569	– 0.569 **
FX rate variability	*FXV*	0.059 ***	0.066 ***	0.066 ***	0.066 **	0.065 ***	0.065 ***
Flow-size impact	*Size*	– 0.289	0.276	0.276 ***	0.276 **	0.157 ***	0.157 **
Interest-rate differentials (vis-à-vis USA)	$\|SIRP^{w.r.t\ USA}\|$	– 0.001	0.011 *	0.011	0.011 **	0.010	0.010
Interaction term	$\|SIRP^{w.r.t\ USA}\| \times CAC$	– 0.106 **	– 0.127 **	– 0.127 *	– 0.127 ***	– 0.122 *	– 0.122 ***
R_{adj}^2		0.193	0.607	0.607		0.087	
F-test on H_0: Model A is better than Model B		14.738 (*p*-value: 0.000)					
Hausman test on H_0: Model C is better than Model B			3.402 (*p*-value: 0.757)				

(2) $X = |SIRP^{real\ gap}|$

The specification of *IE*		A: Pooling	B: Fixed effect			C: Random effect	
		No	Yes: Constant			Yes: Stochastic	
Estimation method		OLS	LSDV	Weighted GLS		GLS	
Adjustments on residuals (ε)		–	–	White period	White cross-section	White period	White cross-section
				CSH, PH, & SC are adjusted for.	CSH & CCE are adjusted for.	PH & SC are adjusted for.	CSH & CCE are adjusted for.
Regressors \ Estimators		$\hat{h}$s	$\hat{h}$s	$\hat{h}$s	$\hat{h}$s	$\hat{h}$s	$\hat{h}$s
Constant	*C*	2.338	1.023	0.971 **	0.971 **	1.223 *	1.223 **
Institutional openness of trade	*TO*	0.002	0.014 ***	0.135 **	0.135 **	0.012 *	0.012 *
Capital account closedness	*CAC*	– 1.939 ***	– 0.940 **	– 0.651 *	– 0.651	– 1.102 ***	– 1.102 ***
FX rate variability	*FXV*	0.050 ***	0.062 ***	0.068 ***	0.068 ***	0.060 ***	0.060 **
Flow-size impact	*Size*	– 0.300	0.285	0.258 ***	0.258 **	0.161 ***	0.161 **
Real short-term interest-rate gap	$\|SR^{real\ gap}\|$	– 0.038 ***	– 0.003	– 0.015 **	– 0.015 ***	– 0.006	– 0.006
Interaction term	$\|SR^{real\ gap}\| \times CAC$	0.141 ***	0.030	0.058 *	0.058 **	0.041	0.041
R_{adj}^2		0.191	0.601	0.549		0.074	
F-test on H_0: Model A is better than Model B		14.378 (*p*-value: 0.000)					
Hausman test on H_0: Model C is better than Model B			5.448 (*p*-value: 0.487)				

The number of observations is 537. Notes are as follows. Firstly, shading indicates regressors with statistically significant estimators and a specification of *IE* with statistical adequacy. I select the random-effect model. The random effect estimators depend on the Swamy–Arora method which uses residuals gained in the within (fixed-effect) and between-means regressions. Secondly, ***, **, and * stand for 1%, 5%, and 10% statistical significances. Lastly, see notes in Appendix Table 9 for other details

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