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MEASURING FINANCIAL INTEGRATION: EVIDENCE FROM TEN INDUSTRIES IN A "US-EMERGING WORLD"

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ABSTRACT

This chapter measures financial integration in 10 industries over 4 different periods. We use two robust measures of integration: (i) the Pukthuanthong and Roll (2009)'s multi-factor R-*square and (ii) the Volosovych (2011)'s integration index. Both measures, based on PCA, indicate that the difference between the level of integration over the period 2009−2012 ("Post-Lehman" era) and the level of integration over the period 1994−1998 ("Post-Liberalizations" era) is relatively high. In addition, the level of financial integration across international equity markets decreased during the late 1990s. This suggests that de jure integration does not necessarily improve de facto integration. Overall, our findings give rise to a "diversification benefits-insurance benefits trade-off."*

INTRODUCTION

Changes in the degree of integration across international equity markets affect cross-country diversification benefits as well as households consumption-smoothing motive. On the one side, higher levels of financial integration tend to decrease international portfolio diversification benefits. In other words, highly integrated international financial markets induce strong positive cross-country equity return correlations, and, therefore, lower diversification benefits (Donadelli, 2013; Goetzmann, Li & Rouwenhorst, 2005; Kearney & Lucey, 2004, among others). On the other side, a higher level of integration across international equity markets improves risk-sharing. In other words, highly integrated financial markets allow for larger insurance benefits, and therefore, improve households consumption smoothing (Colacito & Croce, 2013; Jappelli & Pistaferri, 2011; Suzuki, 2014, among others). In addition, financial integration provides short- and long-run welfare benefits (Colacito & Croce, 2010).

For all these reasons, the evolution of the global integration process has received an enormous amount of attention in the literature, much of it devoted to assessing a range of possible integration measures.[1] However, the debate on the proper measure of integration is still open. In fact, the literature provides a large number of integration measures. Traditional proxies to measure integration include barriers to international investments (e.g., legal restrictions), price-based measures, quantity-based measures, cointegration- and correlation-based measures. Price-based measures are based on the interest parity or purchasing parity conditions. The literature refers to this as "direct measures" in that they invoke the law of one price, that is, assets with identical cash flows should command the same return. As known, the law of one price holds only in equilibrium. Therefore, it does not specify the process toward the equilibrium. It turns out that it cannot provide a full description of the integration process (Lewis, 1999; Tesar & Werner, 1995). Quantity-based measures rely on the stocks of external assets and liabilities and the international capital flows' volume (i.e., they rely on the concept of international capital market completeness). The literature refers to this as "indirect measures."[2] Cointegration measures try to capture the degree of integration across markets by means of short- and long-run linkages (Aggarwal, Lucey, & Muckley, 2004; Arshanapalli & Doukas, 1993; Chan, Gup & Pan, 1992, 1997; Gallagher, 1995; Gilmore & McManus, 2002; Hatemi-J, 2012; Kasa, 1992; Kenourgios & Samitas, 2011; Manning, 2002; Voronkova, 2004, among others). Correlation-based measures examine international equity markets integration from the perspective

of changes in the level of co-movements between their returns over time (Bekaert, Hodrick, & Zhang, 2009; Chambet & Gibson, 2008; Kuper & Lestano, 2007; Quinn & Voth, 2008; Yang, 2005; Yu, Fung, & Tam, 2010, among many others).[3] Other measures instead rely on the time-varying nature of equity risk premia (Bekaert & Harvey, 1995; de Jong & de Roon, 2005; Donadelli & Prosperi, 2012; Panchenko & Wu, 2009).

Nevertheless, the degree of robustness of all these measures has recently been questioned (Bekaert et al., 2009; Carrieri, Errunza, & Hogan, 2007; Pukthuanthong & Roll, 2009; Volosovych, 2011; Yu et al., 2010). It is also worth noting that there is no a general consensus on whether advanced and emerging equity markets are fully integrated as well as on the shape of the financial integration process (Bekaert, Harvey, Lundblad, & Siegel, 2011). In other words, the empirical evidence on financial integration is mixed. We stress that this is motivated by several factors. First, some empirical studies have been conducted in a static context. This does not allow for a full understanding of the evolution of the level of integration across international stock markets. Second, most of the existing empirical studies have employed pre-2005 data. However, international stock markets have been heavily influenced by the emerging systemic banking crisis of the late 1990s and early 2000s. Third, other studies have focused only on the dynamics of the financial integration process across countries belonging to the same region. Fourth, there is a high degree of heterogeneity (across existing studies) in the set of countries employed to examine both global and regional financial integration. This might produce different financial integration patterns. Last, as mentioned above, existing works have employed different approaches to measure integration. This chapter improves the existing literature in four main directions.

First, we take a step back from the more traditional measures. To this end, we employ two newly introduced robust integration measures: (i) the Pukthuanthong and Roll (2009)'s alternative measure and (ii) the Volosovych (2011)'s integration index. Both measures rely on the principal component analysis (PCA). The first integration measure is represented by the adjusted *R*-square obtained from a multi-(*artificial*) factor model.[4] In the spirit of Pukthuanthong & Roll (2009), as global risk factors, we use the first ten principal components extracted from a set of 39 regional industry portfolio excess returns. The second measure is represented by the proportion of total variation in individual excess returns explained by the first principal component.

Second, in contrast to existing empirical studies, we do not focus on the level of financial integration across equity markets belonging to the same

regions (Claus & Lucey, 2012; Hatemi-J, 2012; Kenourgios & Samitas, 2011; Kim, Kim, & Wang, 2006; Phylaktis & Ravazzolo, 2002; Schotman & Zalewska, 2006; Volosovych, 2011; Voronkova, 2004; Yu et al., 2010; among others). Our sample includes 20 emerging equity markets and, as benchmark, the equity market of the United States.

Third, to capture the dynamics of the financial integration process, both integration measures are computed in four "ad-hoc" periods: (I) January 1994−December 1998, namely, the "Post-liberalizations" era; (II) January 1999−December 2003, namely, the "Post-Crises" era: (III) January 2004− December 2008, namely, the "Rising Rates" era; and (IV) January 2009−July 2012, namely, the "Post-Lehman" era.

Fourth, differently from previous studies, which have mainly focused on national equity markets (i.e., country equity indices), in this chapter the national market (in each region or country) is divided in 10 different industries. Therefore, financial integration is measured in 10 different industrial equity markets: Basic Materials, Consumer Goods, Consumer Services, Financials, Healthcare, Industrials, Oil & Gas, Technology, Telecommunications, and Utilities. The choice of using industry level data is motivated by several factors: (i) it allows to capture shocks in specific industries (e.g., IT bubble); (ii) it allows to examine whether there is hetero-geneity in the integration dynamics across industries, thus, to exploit cross-industry diversification benefits; (iii) it reflects standard financial industry's investment strategies focusing on sector rather than country equity indices (e.g., a private/institutional investor might be interested in investing only in stocks belonging to specific sectors).

To the best of our knowledge, there is in the literature only one other study by Donadelli & Persha (2014) that covers such an extensive range of emerging markets as well as industry equity market indices. In addition, this is the first study that measures the level of integration in 10 different industrial equity markets across countries via two newly introduced robust integration measures: (i) the Pukthuanthong and Roll (2009)'s multi-factor R-square and (ii) the Volosovych (2011)'s index of integration.

The main results of this chapter can be summarized as follows. First, our empirical findings suggest that the level of integration in the aftermath of the Lehman Brothers' collapse (i.e., 2009−2012) is higher than the level of integration in the aftermath of equity market liberalizations (i.e., 1994−1998). This result holds across industries and suggests that de jure integration does not necessarily improve de facto integration (see also Claus & Lucey, 2012; Donadelli, 2013). Second, we observe that, in most

industries, financial integration slows down between the first and second eras. We argue that this drop has been mainly caused by the presence of systemic banking crisis across emerging economies in the late 1990s. We stress that both measures produce similar "industry-by-industry" integration patterns, that is, "Volosovych (2011) meets Pukthuanthong and Roll (2009)". Third, we observe that financial integration grows faster as financial and trade openness grow faster.[5] We conclude by arguing that the empirical findings of this chapter give rise to a "diversification benefits-insurance benefits trade-off." On the one side, the increasing degree of integration in all industries across international economies reduces both cross-country and cross-industry diversification benefits. On the other side, the higher level of integration produces a more efficient international risk-sharing environment, that is, improves consumption smoothing (i.e., insurance benefits against bad times). In addition, the relatively high level of financial integration observed in the last two periods suggest that a financial autarky regime or a one-traded bond world embodied in standard international business cycle models might represent an unrealistic international capital markets structure.[6]

The rest of the chapter is organized as follows. The section "Data Description and Summary Statistics" describes the data. The section "On the Financial Integration Measures" presents the employed methodology. The section "Results" examines the evolution of the financial integration process. The section 5 "Concluding Remarks" concludes.

DATA DESCRIPTION AND SUMMARY STATISTICS

Industry Equity Indices

This study employs monthly industry equity indices for 20 emerging equity markets, namely, Argentina, Brazil, Chile, China, Colombia, Czech Republic, India, Israel, Hungary, Mexico, Malaysia, Pakistan, Peru, Philippines, Poland, Russia, Sri Lanka, Taiwan, Thailand, and Turkey. These markets are classified as emerging because of their low- or middle-income and low investable market capitalization/GDP ratio status (see International Finance Corporation [IFC], 1999). As representative developed market, we use monthly data for the United States. The US stock market is included here because it represents the largest stock market in the world, it is a

leading indicator of international equity market returns' movements, and it may be expected to have strong effects on emerging equity markets (Donadelli & Persha, 2014; Donadelli & Prosperi, 2012; Graham, Kiviaho, & Nikkinen, 2012; Hatemi-J, 2012; Narayan & Narayan, 2012). We employ monthly data instead of weekly or daily data to avoid a set of common high-frequency data issues: (i) presence of zero returns, (ii) noise, and (iii) non-synchronicity. Our sample goes from December 1993 to July 2012. All industry equity market indices are obtained from level 2 of Datastream Global Equity Indices (DGEI) database. In this dataset, stock data are classified by industry and sector type. For example, *financials* is an industry within which a number of sectors are included such as *banks*, *life assurance*, and *real estate*. Level 2 of DGEI divides the market into the following 10 industries: Basic Materials, Consumer Goods, Consumer Services, Industries, Health Care, Financials, Oil & Gas, Technology, Tele-communications, and Utilities.[7] To get a homogeneous dataset, all indices are total return indices (TRIs) denominated in US dollars. Equity indices expressed in this form include reinvested dividends, retain only US inflation (i.e., no currency risk), and are widely used in the international finance literature (Bilson, Brailsford, & Hooper, 2001; Chambet & Gibson, 2008; de Jong & de Roon, 2005; Donadelli & Persha, 2014; Donadelli & Prosperi, 2012; Ferson & Harvey, 1994; Grootveld & Salomons, 2003; Harvey, 1995; Lee, Chen, & Chang, 2013; Pukthuanthong & Roll, 2009; Yu et al., 2010, among many others).

Regional Industry Portfolios and Excess Returns

In line with standard asset management strategies, we focus on three regional equally weighted industry equity indices, namely, Asia, Eastern Europe and Middle East, and Latin America, and on the US industry equity indices. Regional industry portfolios are constructed according to the geographic distribution reported in Table 1. Formally,

$$\text{RIEI}_{R,t}^{i} = \sum_{n=1}^{N} w_n \text{DGEI}_{n,t}^{i} \qquad (1)$$

where $\text{DGEI}_{n,t}^{i}$ is the DGEI of industry i in country n at time t, $w_n = 1/N$ denote weights, and N represents the total number of countries in each regions R (for the United States, $N = 1$). Notice that data for some

Table 1. Geographic Distribution of the Countries in the Sample.

Asia	EU + ME	Latin America	Advanced
China	Czech Republic	Argentina	United States
India	Hungary	Brazil	
Malaysia	Israel	Chile	
Pakistan	Poland	Colombia	
Philippines	Russia	Mexico	
Sri Lanka	Turkey	Peru	
Taiwan			
Thailand			

industries are not available since December 1993. As industry data become available a specific country n is added to the portfolio.

Regional industry equity excess returns are computed as follows,

$$\text{ExR}^i_{R,t} = \left(\frac{\text{RIEI}^i_{R,t}}{\text{RIEI}^i_{R,t-1}} - 1 \right) - R_{f,t} \qquad (2)$$

where $R_{f,t}$ is the one-month Treasury-bill rate. Our aggregation strategy gives rise to 39 excess returns.[8] These regional industry equity excess returns represent the most important elements of our analysis. The analysis is based on four different sub-periods: (I) January 1994−December 1998, namely, the "Post-liberalizations" era; (II) January 1999−December 2003, namely, the "Post-Crises" era; (III) January 2004−December 2008, namely, the "Rising Rates" era; and (IV) January 2009−July 2012, namely, the "Post-Lehman" era.[9] The choice of these four specific sub-periods is motivated by two main factors. First, each sub-period includes emerging or US financial shocks that have heavily affected international equity markets. In the spirit of Bloom (2009), we rely on uncertainty shocks. Second, shocks are heterogeneous across periods. While the first two sub-periods have been mainly characterized by financial shocks in emerging countries, sub-periods III and IV are mainly driven by US/EU financial shocks. The post-liberalizations sample is aimed at capturing the degree of financial integration in industrial equity markets across countries in the aftermath of the emerging equity market liberalizations of the late 1980s and early 1990s.[10] The second era allows to measure integration in the aftermath of the systemic banking crisis in Indonesia, Malaysia, Philippines, and Thailand.

The third sub-period allows to measure integration in a period characterized by a sharp increase in international trade, financial linkages and fed funds rate levels.[11] The last period is employed to capture financial integration in the aftermath of the Lehman Brothers' collapse, an era characterized by high economic policy uncertainty both in the United States and Euro Area (see Baker, Bloom, & Davis, 2013; Donadelli & Persha, 2014). Uncertainty shock dates are reported in Fig. 1.[12]

Summary statistics, computed over the full period and over the four sub-periods, suggest that: (i) emerging equity markets tend to deliver higher average excess returns than the US equity market; (ii) the performance of emerging industrial equity markets have been heavily affected by the systemic banking crisis of the late 1990's; (iii) the subprime crisis has mainly affected the performance of the US equity market (see also Donadelli & Persha, 2014).[13]
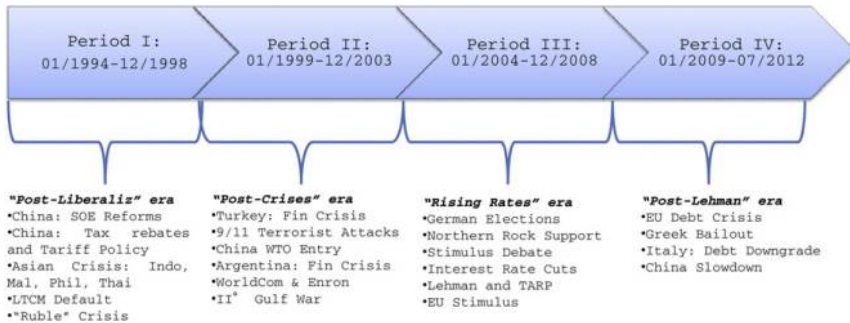
Fig. 1. Sub-Periods and Uncertainty Shocks. *Key events* (date): Trade world concerns (Jan95); financial deregulation in China and state-owned enterprises reforms (Apr95); tax rebates and tariff policy in China (Sep95); systemic banking crisis in Indonesia, Malaysia, Philippines, and Thailand (Jan98); Russian financial crisis (Aug98); LTCM default (Sep98); financial crisis in Turkey (Nov00); US terrorist attacks (Sep01); China is a new WTO member (Dec01); debt crisis in Argentina (Dec01); US accounting scandals (Jul02); II Gulf War (Feb03); German federal election (Sep05); Northern Rock financial support stimulus (Aug07); stimulus debate and large interest rate cuts (Dec07); Lehman Brothers Chapter 11 and Troubled Asset Relief Program (Sep08); EU recovery plan for growth and jobs (Nov08); EU Sovereign Debt Crisis (2009:IVQ); Greek government requested an initial loan of €45 billion from the EU and IMF (Apr10); Standard and Poor's downgraded Italian debt from A+ to A (Aug11); China slowdown fears and disorderly political transition (May12).

ON THE FINANCIAL INTEGRATION MEASURES

Correlation-Based versus PCA-Based Measures: A Review

As discussed in the introduction of this chapter, most studies have examined integration across international equity markets by means of correlation-based or cointegration-based measures.[14] While it is popularly agreed that correlation is one of the most important element of the mean-variance optimization process, the debate on whether correlation might be used as proxy to measure integration is still open. Bekaert et al. (2009) confirm that correlations are important ingredients in the analysis of international diversification benefits and global market integration. However, they argue that correlations neither measure international diversification benefits nor global market integration. Other international finance works raise "robustness issues." Wilcox (2005) and Huber and Ronchetti (2009) argue that the sample correlation is not a robust statistics in the presence of outliers or a heavy-tailed distribution. Other studies suggest that the presence of conditional heteroskedasticity of market returns as well as the hypothesis that cross-country market return correlations depend on market volatility might lead to biased conclusions about integration (Boyer, Gibson, & Loretan, 1999; Forbes & Rigobon, 2002; Longin & Solnik, 2001). Volosovych (2011) points out that a high correlation of economic or financial series cannot be used as evidence of substantial integration. His measure, based on PCA, accounts for both country-specific and global shocks as well as is immune to outliers. Pukthuanthong and Roll (2009) argue that the cross-country correlation of equity index returns do not represent a robust measure of integration. In particular, they show that two countries can be highly integrated even if their equity market returns are negatively correlated. This occurs because of countries' sensitivities to common global factors are different. In other words, perfect integration implies that a set of common factors explains 100% of the broad index returns in both countries, but if country indices differ in their sensitivities to these factors, they do not exhibit perfect correlation. Similarly, Yu et al. (2010) argue that the concept of integration is based on whether the markets are affected by common factors rather than the price convergence.

PCA: The "Multi-Factor" R-Square and the "1st Component"

The PCA is a non-parametric empirical strategy used to reduce the original dimension of a set of variables. Its ultimate goal is to capture common

features across variables variations. In practice, the PCA transforms an original set of variables into a new subset of variables. These transformed variables, namely principal components, are represented by linear combinations of the original set of variables, and are aimed at capturing a large part of the variation in the original set of variables. Formally, let X be a vector of p variables x variables, $x_1, x_2, ..., +x_p$. Then, a linear combination of these variables can be represented as follows:

$$Z = \Omega \cdot X \tag{3}$$

where the first row in Eq. (3) takes the form $z_1 = w_{11}x_1 + w_{12}x_2 + \cdots + w_{1p}x_p$, and Ω is the loading-matrix. Weights in Ω are obtained in a way to guarantee the maximum sample variance of z_1. The first principal component, z_1, is represented by a linear function that has the maximum possible variance. The second principal component, z_2, is the linear function with maximum possible variance subject to being uncorrelated with the first principal components, and the third principal component, z_3, is the linear function with maximum possible variance subject to being uncorrelated with the first and the second principal components, and so on. Principal components can be extracted by using either the covariance matrix or the correlation matrix. It is standard practice to use the covariance matrix when the variable scales are similar and the correlation matrix when variables are expressed in different scales. By using the correlation matrix, data are standardized. Theoretically, if all the employed series are expressed in the same scale (e.g., equity asset returns), then a correlation-based PCA might throw out a relevant amount of information. However, if the covariance matrix is used, the variables with the highest variance tend to dominate the first principal component. To overcome this issue, we employ the correlation matrix.[15]

The "Multi-Factor R-Square"

The adjusted R-square measures how well equity market excess returns can be explained by common factors. In other words, global integration relies on whether the equity markets are affected by common risk factors rather than the equity price index convergence. In this chapter, global risk factors are represented by artificial risk factors. In the spirit of Pukthuanthong & Roll (2009), the first 10 principal components, which generally capture 90% of excess returns' variation, are our artificial risk factors.[16] In this exercise, principal components are extracted from the dataset composed by

39 regional portfolio industry excess returns (see "Data Description and Summary Statistics"). To capture changes in the level of integration in all industrial equity markets, the analysis is carried out in period I, II, III, and IV. Therefore, as in Pukthuanthong & Roll (2009),[17] principal components are extracted in different sub-periods.[18] Details on the proportion of total variation in individual excess returns explained by each principal component in each sub-period are presented in Table 2. The adjusted R-square,

Table 2. PCA: Sub-Period Results.

Number	Value	Difference	Prop	Cum Value	Cum Prop
Panel A: PCA (Sample: 1994M01–1998M12)					
1	15.78	11.13	0.40	15.78	0.40
2	4.65	1.02	0.12	20.44	0.52
3	3.64	0.19	0.09	24.07	0.62
4	3.45	2.05	0.09	27.52	0.71
5	1.39	0.15	0.04	28.91	0.74
6	1.24	0.26	0.03	30.16	0.77
7	0.99	0.09	0.03	31.14	0.80
8	0.89	0.02	0.02	32.04	0.82
9	0.87	0.24	0.02	32.91	0.84
10	0.63	0.04	0.02	33.54	0.86
Panel B: PCA (Sample: 1999M01–2003M12)					
1	16.63	12.46	0.43	16.63	0.43
2	4.17	0.70	0.11	20.80	0.53
3	3.47	0.62	0.09	24.27	0.62
4	2.85	1.36	0.07	27.12	0.70
5	1.49	0.37	0.04	28.62	0.73
6	1.12	0.07	0.03	29.74	0.76
7	1.05	0.09	0.03	30.78	0.79
8	0.96	0.21	0.02	31.74	0.81
9	0.75	0.06	0.02	32.49	0.83
10	0.68	0.06	0.02	33.17	0.85
Panel C: PCA (Sample: 2004M01–2008M12)					
1	27.86	25.42	0.71	27.86	0.71
2	2.44	0.97	0.06	30.31	0.78
3	1.47	0.50	0.04	31.78	0.81
4	0.97	0.16	0.02	32.74	0.84
5	0.81	0.09	0.02	33.55	0.86
6	0.72	0.18	0.02	34.27	0.88
7	0.54	0.12	0.01	34.81	0.89
8	0.42	0.01	0.01	35.23	0.90
9	0.40	0.05	0.01	35.63	0.91
10	0.36	0.02	0.01	35.99	0.92

Table 2. (*Continued*)

Number	Value	Difference	Prop	Cum Value	Cum Prop
Panel D: PCA (Sample: 2009M01–2012M07)					
1	27.17	24.55	0.70	27.17	0.70
2	2.61	0.90	0.07	29.78	0.76
3	1.71	0.55	0.04	31.49	0.81
4	1.16	0.28	0.03	32.65	0.84
5	0.88	0.24	0.02	33.53	0.86
6	0.64	0.08	0.02	34.17	0.88
7	0.56	0.01	0.01	34.73	0.89
8	0.55	0.11	0.01	35.28	0.90
9	0.44	0.02	0.01	35.72	0.92
10	0.42	0.05	0.01	36.14	0.93

Notes: This table reports the results of the PCA. PCA results are reported for each sub-period: (I) January 1994–December 1998 (Panel A); (II) January 1999–December 2003 (Panel B); (III) January 2004–December 2008 (Panel C); and (IV) January 2009–July 2012 (Panel D).

which serves as measure of integration, is obtained from standard OLS estimations. According to our aggregation strategy, the adjusted R-square is estimated for each industry (i) in each region. Formally,

$$\text{ExR}_{R,t}^{i,\text{I}} = \alpha_{R,t}^{i,\text{I}} + C_{1,t}^{\text{I}} + C_{2,t}^{\text{I}} + C_{3,t}^{\text{I}} + C_{4,t}^{\text{I}} + C_{5,t}^{\text{I}} + C_{6,t}^{\text{I}} + C_{7,t}^{\text{I}} + C_{8,t}^{\text{I}} + C_{9,t}^{\text{I}} + C_{10,t}^{\text{I}} + \varepsilon_{R,t}^{i,\text{I}}$$

$$\text{ExR}_{R,t}^{i,\text{II}} = \alpha_{R,t}^{i,\text{II}} + C_{1,t}^{\text{II}} + C_{2,t}^{\text{II}} + C_{3,t}^{\text{II}} + C_{4,t}^{\text{II}} + C_{5,t}^{\text{II}} + C_{6,t}^{\text{II}} + C_{7,t}^{\text{II}} + C_{8,t}^{\text{II}} + C_{9,t}^{\text{II}} + C_{10,t}^{\text{II}} + \varepsilon_{R,t}^{i,\text{II}}$$

$$\text{ExR}_{R,t}^{i,\text{III}} = \alpha_{R,t}^{i,\text{III}} + C_{1,t}^{\text{III}} + C_{2,t}^{\text{III}} + C_{3,t}^{\text{III}} + C_{4,t}^{\text{III}} + C_{5,t}^{\text{III}} + C_{6,t}^{\text{III}} + C_{7,t}^{\text{III}} + C_{8,t}^{\text{III}} + C_{9,t}^{\text{III}} + C_{10,t}^{\text{III}} + \varepsilon_{R,t}^{i,\text{III}}$$

$$\text{ExR}_{R,t}^{i,\text{IV}} = \alpha_{R,t}^{i,\text{IV}} + C_{1,t}^{\text{IV}} + C_{2,t}^{\text{IV}} + C_{3,t}^{\text{IV}} + C_{4,t}^{\text{IV}} + C_{5,t}^{\text{IV}} + C_{6,t}^{\text{IV}} + C_{7,t}^{\text{IV}} + C_{8,t}^{\text{IV}} + C_{9,t}^{\text{IV}} + C_{10,t}^{\text{IV}} + \varepsilon_{R,t}^{i,\text{IV}}$$

$$(4)$$

where $\text{ExR}_{R,t}^{i,j}$ is the regional industry portfolio excess return in period j, $\alpha_{R,t}^{i,j}$ are constants, $C_{1,t}^{j}, \ldots, C_{10,t}^{j}$, are the first ten principal components extracted in each sub-period j, and $j = \text{I, I, III, IV}$.

The "1st Principal Component"
As discussed in Volosovych (2011), in a PCA-based analysis, the "1st principal component" captures most of the variation of the original data. Therefore, if international equity markets are highly integrated, the

proportion of total variation in individual excess returns explained by the first component should be close to one.

To be consistent with the previous analysis, we first compute the integration index by using all the 39 regional portfolio industry excess returns. This gives rise to a "global measure of integration." We then extract the principal component at the industry level, that is, we compute the level of integration in each industry (in each period) in a "1st principal component" context. In order to have more than four series per industry (i.e., the four regional industry portfolio excess returns), we use data at the country level. To have a homogeneous dataset, we select only those countries for which industry data are available since December 1993.[19] As for the adjusted *R*-square, the "1st principal component" is extracted in period I, II, III, and IV.[20]

RESULTS

Evidence from the "Multi-Factor R-*Square"*

Fig. 2 reports the evolution of financial market integration in each industry across regions. The integration index is captured by the adjusted *R*-square of a multi-(*artificial*) factor regression. As discussed in the section "On the Financial Integration Measures," the 10 artificial global risk factors are represented by the first 10 principal components extracted from the set of variables composed by our 39 regional portfolio industry excess returns. The analysis is conducted for each period and for each region. The average level of integration (in each industry) is then represented by the average adjusted *R*-square, that is, in each sub-period the adjusted *R*-square is averaged across the four regions (Asia, Eastern Europe + Middle East, Latin America, United States). Results suggest that the average percentage of variation in regional industry excess returns explained by the first 10 principal components (i.e., *R*-square) in periods III and IV is higher than the percentage explained in the period I (on average, 0.9 vs. 0.8). In other words, the level of financial integration across regions in each industry sharply increased during the last 5−10 years. At the country level, Pukthuanthong & Roll (2009), Yu et al. (2010), and Donadelli (2013) obtain similar results. It is also worth noting that, in most industries, the level of financial integration in the "Post-Liberalizations" era (i.e., first sub-period) is higher than in the "Post-Crises" era (i.e., second sub-period). Exceptions are the technology and telecommunications industries.[21] We argue that the dynamics
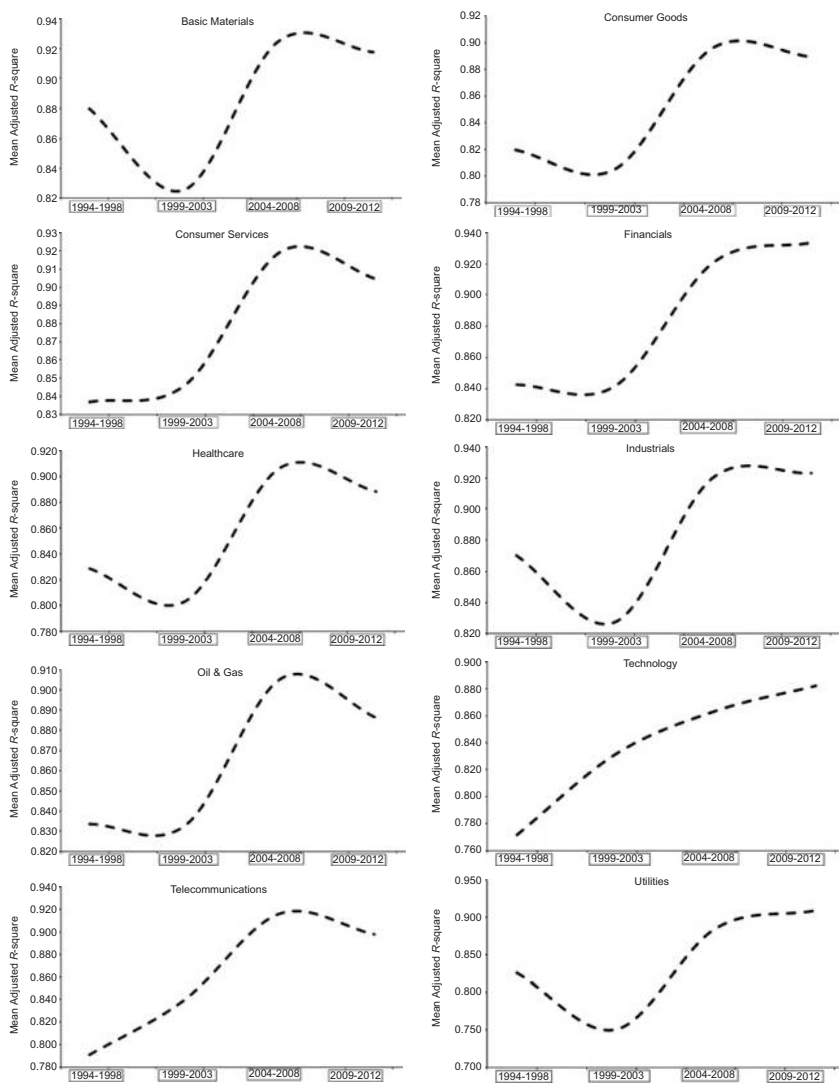
Fig. 2. Indicator of Global Market Integration by Industry: The "Multi-Factor *R*-Square." *Notes*: This figure reports the adjusted *R*-square estimated for each industry in each individual region, and then averaged across regions (Asia, Eastern Europe and Middle East, Latin America, and the United States). The adjusted *R*-square from a regression of industry index excess returns on global risk factors captures financial market integration. Global risk factors (in each period) are represented by the first 10 principal components. Principal components are extracted as described in the section "Evidence from the "Multi-Factor *R*-Square."" Principal components are extracted using monthly data over historic sub-periods. Sub-periods are defined as in Fig. 1. Regional industry equally weighted portfolios are constructed as defined in Eq. (1). Adjusted *R*-squares are obtained via standard OLS estimations. Constant is included. Standard errors are Newey & West (1987, 1994). The full sample goes from January 1994 until July 2012.

of financial market integration between the first and second sub-period has been mainly driven by the presence of systemic banking crisis across emerging economies in the late 1990s (see Fig. 1). It turns out that financial market integration tends to be stronger during recession periods.

Evidence from the "1st Principal Component": Volosovych (2011) Meets Pukthuanthong and Roll (2009)

Fig. 3 reports the percentage of variance explained by the first principal components across the 39 regional industry excess returns. In this exercise, the first principal component represents the first global risk factors in Eq. (4). Therefore, values reported in Fig. 3 correspond to entries in Table 2 (see first line (column 4) in Panels A−D). Not surprisingly, we find that the level of global integration in the "Rising Rates" and "Post-Lehman" eras is higher than in the "Post-Liberalizations" and "Post-Crises" eras. It is also worth noting that financial market integration raised by 30% between the second and third sub-periods.
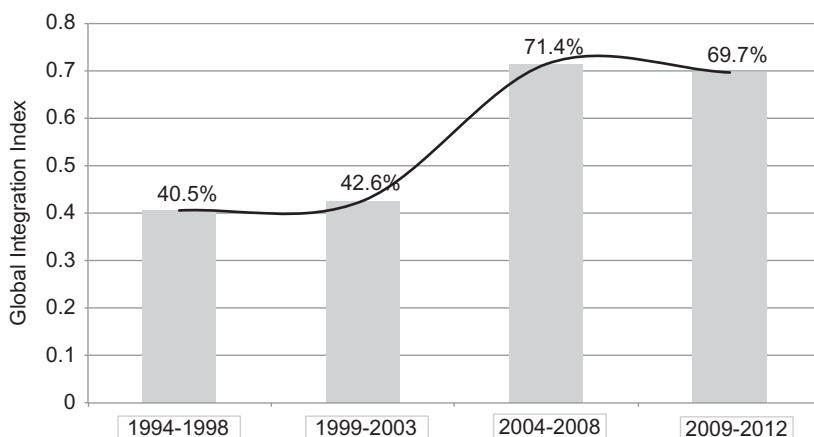

Fig. 3. Global Financial Integration Index: The "1st Component." *Notes*: This figure reports the proportion of total variation in individual excess returns explained by the first principal component. The principal component, which corresponds to the first global risk factors in Eq. (4), is extracted from the set of data composed by the 39 regional industry portfolio excess returns. Principal components are extracted using monthly data over historic sub-periods.

Fig. 4 reports the evolution of the financial integration index in the 10 industrial equity markets. As in Volosovych (2011), market integration is captured by the proportion of variation in individual excess returns explained by the first principal component. As discussed in the section "PCA: The "Multi-Factor R-Square" and the "1st Component,"" to have a larger set of variables for each industry, we use industry equity indices at the country rather than regional level. As for the adjusted R-square, the percentage of variation explained by the first principal component is estimated in each sub-period. Overall, we find that the adjusted R-square and the proportion of variation explained by the first principal component follow similar patterns. It turns out that the common principal component approach of Pukthuanthong and Roll (2009) and the first principal component approach of Volosovych (2011) give rise to similar financial integration patterns. We find differences only in their order of magnitude. However, if the adjusted R-squared is obtained from a multi-factor regression with only three or four global risk factors, then the two measures (i.e., the two percentages) do not display only similar patterns, but also similar values. In this case the adjusted R-square is significantly lower (see Pukthuanthong & Roll, 2009).[22]

Market Openness versus Financial Integration

The evidence provided so far shows that the last two eras are characterized by a higher proportion of equity market returns' variation explained by common global risk factors (i.e., higher adjusted R-square) as well as by a larger proportion of variation attributed to a single important factor than ever before. Results suggest also that financial market integration sharply increased over the period 2002−2008. This can be informally observed also by looking at the evolution of the mean adjusted R-square (see right-hand side of Fig. 4) reported in Pukthuanthong & Roll (2009). Using country equity market indices, Donadelli (2013) finds a similar result. Both the international finance and international business cycle literature have shown that much of the increase in the level of global market integration might be attributed to an increase in the degree of trade and financial openness (Colacito & Croce, 2013; Donadelli, 2013; Imbs, 2006; Pretorius, 2002, among others). Fig. 5, which plots the evolution of the total value of WORLD stocks traded (black line) and international trade of goods and services (gray line) over the period 1995−2012, confirms these findings. In particular, it shows that the 2002−2008 period has been characterized by a
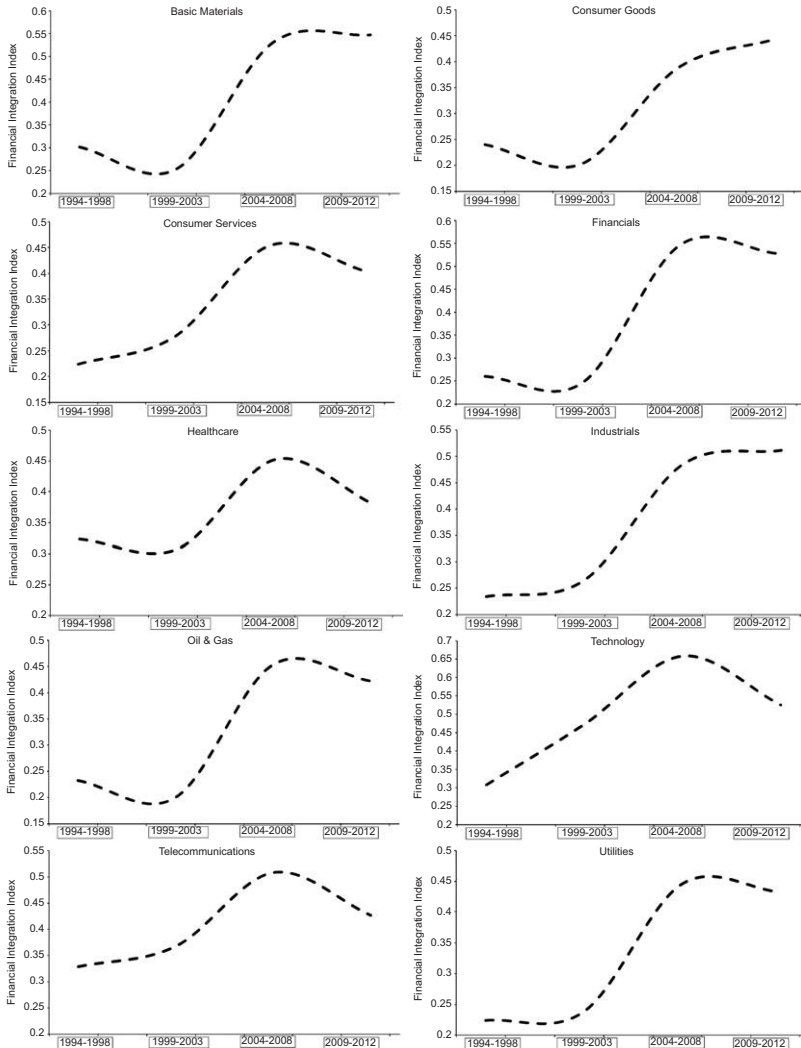
Fig. 4. Indicator of Global Market Integration by Industry in Four Different Periods: The "1st Component." *Notes*: Market integration in each industrial equity market is captured by the proportion of total variation in individual industry equity excess returns explained by the first principal component. The number of countries included to extract the first principal component corresponds to the number of industry equity indexes available since December 1993 (see note 15). The first principal component is extracted over period I, II, III, and IV.
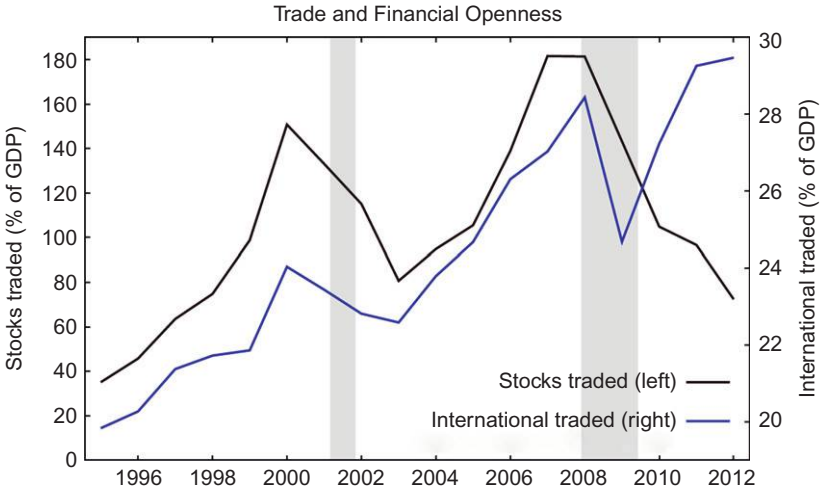
Trade and Financial Openness

Fig. 5.   Financial and Trade Openness. *Notes*: This table reports the evolution of the total value of stocks traded (black line) and international trade of goods and services (gray line) over the period 1995−2012. Both series are measured as percentage of GDP. The stocks traded series is from the World Development Indicators and refers to the total value of shares traded during the period. The international trade (sum of imports and exports) series is from the OECD database. Shaded areas denote official NBER-dated recessions.

steep increase in the level of trade and financial openness.[23] Overall, we find evidence, at the industry level, that financial integration tend to be accompanied by increasing levels of trade and financial openness. In other words, international trade of assets and goods provides a channel for financial integration.

Some Robustness Checks

1. In our analysis, principal components are extracted by employing the correlation matrix. We investigate whether the use of the covariance matrix to extract principal components affects our results. In practice, we re-compute our 10 global risk factors (i.e., the 10 principal components extracted from the set of 39 regional portfolio excess returns) by using the covariance rather than the correlation matrix. We find that the Pukthuanthong & Roll (2009)'s integration measure and the Volosovych

(2011)'s integration index display similar dynamics. We also replicate the exercise in Fig. 4 using the covariance matrix. Needless to say, market integration patterns are similar.

2. Do we really need 10 global risk factors? Do fewer principal components produce similar R-square patterns? To address this issue, we compute the R-square using just the first one and the first three of the ten principal components. Using three factors instead of ten produces a similar integration pattern. However, the R-squares are slightly lower. With one factor, integration patterns are also similar. We just find much lower R-square values. Therefore, factors one through 10 are indeed contributing something to the measured level of integration.

3. Why do we use principal components as global risk factors? Do different global risk factors generate similar results? We have employed principal components rather than other variables to be consistent with the analysis of Pukthuanthong & Roll (2009). However, adjusted R-squares can be obtained also by regressing international equity market returns on standard macroeconomic and financial risk factors (i.e., large market indices, global liquidity measures, US/EU industrial production, economic policy uncertainty index (UI), among many others). For example, Yu et al. (2010) estimate the R-square by regressing Asian stock market returns on the following common components: cross-economy averages of currency return, excess equity return, dividend yield, and forward premia. Similarly, at the industry level, Donadelli & Persha (2014) show that the R-square obtained from a world CAPM (i.e., the world excess return is used as unique global risk factor) is increasing over time. As a robustness check, based on existing empirical works (Bilson et al., 2001; Donadelli & Prosperi, 2012; Ferson & Harvey, 1994), we have re-computed our industry average R-squares by using the following four global risk factors: (i) the world excess returns (WORLD); (ii) the rate of change of the CBOE volatility index (VIX); (iii) the rate of change of the US consumer confidence index; and (iv) the weighted average of the US and EU economic policy UI.[24] Not surprisingly, these four global risk factors provide almost the same integration pattern over time for each industry as we have seen earlier based on principal components. It turns out that the evolution of financial market integration is robust to the choice of factors.

4. The sub-periods employed in our analysis rely on economic, financial or political shocks. Do different sub-periods give rise to different results? To account for this possible issue, we estimate both the "multi-factor R-square" and the "1st principal component" in a rolling-window

framework. In practice, both measures have been re-estimated using a rolling window of 60 months (5 years). We find a very similar pattern for both the adjusted R-square and the proportion of total variation in individual excess returns explained by the first principal component (i.e., the difference between the level of integration in period IV and the level of integration in period I is relatively high).

5. Do a country-level analysis provide similar adjusted R-square patterns? As an additional check, we have used a larger set of industry equity indices. In other words, we have extracted the first ten principal components by using the original set of variables (120 industry equity indices). To have a homogeneous dataset, we have used only those industries (i.e., industry equity indices) for which data are available since December 1993 (see note 15). The excess return of each industry in each country is then regressed on the "new 10 principal components." The adjusted R-square is then averaged across countries. We observe that industry average R-square patterns are similar to those reported in Fig. 2.[25]

6. As benchmark developed market, this chapter employs the United states. What about other developed markets? Using a different market or a portfolio of advanced equity markets, rather than the US market, we obtain similar integration patterns. This is due to the high degree of comovement between the excess return of the US equity markets and the excess return of the other develop equity markets over the four analyzed sub-periods (i.e., the average correlation ranges from a minimum of 0.72 (period I) to a maximum of 0.88 (period IV)).[26]

CONCLUDING REMARKS

This chapter examines the level of integration in 10 industrial equity markets in a "US-Emerging world." Financial integration in each industry is captured via two robust integration measures. The first measure, Pukthuanthong & Roll (2009)'s integration index, is represented by the adjusted R-square of a multi-(*artificial*) factor model. The second measure, Volosovych (2011)'s integration index, corresponds to the proportion of total variation in individual excess returns explained by the first principal component. Our main empirical findings are as follows. First, in each industry, we observe that the level of integration in the aftermath of the Lehman's collapse (i.e., 2009−2012) is higher than in the aftermath of emerging equity market liberalizations (i.e., 1994−1998). Second, we

observe that financial integration slows down between the first and second sub-periods. We argue that this has been mainly caused by the emerging systemic banking crises of the late 1990s. This evidence holds for all industries and is supported by both measures. Therefore, "Volosovych (2011) meets Pukthuanthong and Roll (2009)." Third, we observe that a steep increase in the level of financial integration is associated with a steep increase in the level of trade and financial openness.

Overall, the empirical findings of this chapter give rise to a "diversification benefits-insurance benefits trade-off." On the one hand, a higher level of integration (at the industry and country level) reduces both cross-country and cross-industry diversification benefits. On the other hand, stronger financial market integration produces a more efficient international risk-sharing environment, that is, improves consumption smoothing (i.e., insurance benefits against bad times).

NOTES

1. A survey of this literature can be found in Kearney & Lucey (2004).
2. Indirect integration measures can be found in Portes & Rey (2005) and Bekaert, Harvey, & Lumsdaine (2003).
3. The three-dimensional analysis of wavelet coherency can be included in this class (see Graham, Kiviaho, & Nikkinen, 2012).
4. A similar approach, namely, common component approach, can be found in Yu et al. (2010).
5. See, for details, Pretorius (2002), Imbs (2006), Colacito & Croce (2013), and Donadelli (2013).
6. A two-country model with financial autarky or just one-traded bond can be found in Heathcote & Perri (2002) and Benigno & Thoenissen (2008).
7. DGEI break down into six levels. Level 1 is the Market Index. This covers all the sectors in each region or country. Level 2 divides the market into 10 industries and covers all the sectors within each group in each region or country. Levels 3–6 subdivide the level 2 classifications into sector classifications in increasing detail. *Source*: Datastream.
8. Due to lack in data availability we are not able to build the Latin America Technology Index.
9. Throughout the chapter we use the terms era, sub-period, and period interchangeably.
10. Date of first stock market liberalization (Country): November 1989 (Argentina), March 1988 (Brazil), May 1989 (Chile), April 1991 (China), December 1991 (Colombia), June 1986 (India), June 1987 (Korea), May 1987 (Malaysia), May 1989 (Mexico), May 1986 (Philippines), May 1986 (Taiwan), and January 1988 (Thailand). Further details on equity market liberalization dates can be found in Henry (2000).

11. Note that the fed funds rate moves from 1.00% (as of January, 2004) to 5.26% (as of July, 2007).

12. For additional details on uncertainty shocks, see http://www.policyuncertainty.com.

13. Mean, standard deviation, skewness and kurtosis values, and the Sharpe ratio are available upon request.

14. See, for example, Goetzmann, Li & Rouwenhorst (2005), Obstfeld & Taylor (2003), Quinn & Voth (2008), and Yu et al. (2010), among others.

15. Note that the two approaches give rise to very different results only if variables are expressed in different scales.

16. Yu et al. (2010) use a common component approach to measure financial market integration in Asia. As in Pukthuanthong & Roll (2009), the adjusted R-square obtained from a multi-factor regression serves as measure of integration. In contrast to Pukthuanthong & Roll (2009), the authors do not employ principal components as global risk factors. Instead, they use the following four common factors: cross-economy averages of currency return, excess equity return, dividend yield, and forward premia.

17. Differently from Pukthuanthong & Roll (2009), this chapter employs monthly data and in-sample principal components. In their work, principal components are estimated from returns in the subsequent year, that is, the eigenvectors obtained from the year $t - 1$ covariance matrix are applied to the same set of returns during year t. Overall, they extract principal components for 34 years.

18. Donadelli (2013) extracts the first 10 principal components (i.e., global risk factors) from a set of variables composed by 19 national stock market excess returns over the period January 1988−December 2011, that is, principal components are extracted only once. The 10 global risk factors are then regressed on the country equity index returns in a rolling-window context.

19. List of employed countries to extract the "1st principal component": *Basic Materials* (Argentina, Chile, Colombia, Mexico, China, India, Malaysia, Pakistan, Philippines, Taiwan, Thailand, Czech Republic, Hungary, Israel, Turkey, the United States); *Consumer Goods* (Argentina, Chile, Colombia, Mexico, China, India, Malaysia, Pakistan, Philippines, Sri Lanka, Taiwan, Thailand, Czech Republic, Hungary, Turkey, the United States); *Consumer Services* (Argentina, Chile, Colombia, Mexico, China, Malaysia, Pakistan, Philippines, Sri Lanka, Taiwan, Thailand, Israel, Turkey, the United States); *Financials* (Argentina, Chile, Colombia, Mexico, China, India, Malaysia, Pakistan, Philippines, Sri Lanka, Taiwan, Thailand, Hungary, Israel, Turkey, the United States); *Healthcare* (Chile, India, Pakistan, Thailand, Hungary, Israel, the United States); *Industrials* (Chile, Mexico, Peru, China, India, Malaysia, Pakistan, Philippines, Sri Lanka, Taiwan, Thailand, Czech Republic, Israel, Turkey, the United States); *Oil & Gas* (Argentina, Chile, Colombia, India, Malaysia, Pakistan, Philippines, Thailand, Czech Republic, Israel, Turkey, the United States); *Telecommunications* (Argentina, Chile, Mexico, India, Malaysia, Philippines, Thailand, Israel, Turkey, the United States); *Technology* (India, Thailand, Israel, Turkey, the United States); *Utilities* (Chile, Colombia, India, Malaysia, Pakistan, Philippines, Czech Republic, Turkey, the United States).

20. Using only our four regional portfolios, at the industry level, we obtain almost identical financial integration patterns. We find differences only

in the order of magnitude of the proportion of variation in individual excess returns (in each industry) explained by the first principal component. This is due to a difference in the total number of variables employed in the two original sets.

21. Note that the technology and telecommunications industries display a constantly increasing integration index. This has been driven by the IT bubble (see also Brooks & Del Negro, 2004).

22. Using only the four regional portfolios for each industry (i.e., in each industry the first principal component is extracted by using four regional portfolio industry excess returns), we obtain similar integration patterns. Results are available upon request.

23. Note that (as of December 2001) China became a WTO member. Therefore, China's market openness has influenced global market openness.

24. Details are available upon request but the bottom line is that the results are hardly distinguishable.

25. Compared to the original procedure in which only the 39 regional equity industry excess returns are employed, this procedure produces: (i) a lower proportion of total variance explained by the first 10 principal components and (ii) a slightly lower average R-squares. We stress that the evolution of the integration measure across periods does not changes.

26. However, the US equity market has been used a benchmark in several studies (see Donadelli & Persha, 2014; Graham et al., 2012; Hatemi-J, 2012, among others).

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