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International diversification with frontier markets ☆

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ABSTRACT

We provide an analysis of frontier market equities with respect to world market integration and diversification. Principal component results reveal that frontier markets exhibit low levels of integration. In contrast with developed and emerging markets, frontier markets offer no indication of increasing integration through time. Furthermore, individual frontier market countries do not exhibit consistent rates of changing integration. Structural break tests identify breakpoints in integration, as well as integration dynamics across countries. We show that frontier markets have low integration with the world market and thereby offer significant diversification benefits.

1. Introduction

We study the potential diversification benefits of frontier markets by measuring integration dynamics, as well as analyzing frontier market exchange-traded funds (ETFs). Frontier markets are smaller, less accessible, yet still investable countries in the developing world; the median market capitalization of frontier markets within our sample reached US$12.89 billion at the end of 2009. When their capital and liquidity increase, frontier markets may be reclassified as emerging markets. This designation originated in the 1990s, when Standard and Poor's (S&P) started to track a representative index of frontier markets, then became prominent in 2007 when S&P launched its Select and Extended Frontier Indexes.[1] To reflect growing investor interest in these markets, MSCI also launched a Frontier Markets Index late in 2007. Recently, frontier market mutual funds and ETFs also have emerged.[2]

Despite the significant attention to frontier markets among the investment community, very little research includes them. Frontier markets may offer promising diversification benefits; for example, Speidell and Krohne (2007) document low correlations between frontier and developed market equities. Jayasuriya and Shambora (2009) study diversification benefits across market classifications and consider optimal portfolios of developed, emerging, and frontier markets. They find improved portfolio risk and returns when investors diversify their portfolio into six frontier markets. Cheng, Jahan-Parvar, and Rothman (2009) use variations of the CAPM to

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[1] According to Kim (2010), MSCI has returns for frontier markets that go back to May 2002, while S&P's Frontier Index (which excludes the Gulf countries) extends back to 1996.

[2] On March 17, 2008, Barclays Global Investors (BGI) launched the BGI Frontier Markets Fund, which invests in 16 frontier markets and benchmarks against the MSCI Frontier Markets Index. Franklin Templeton Investments introduced its Templeton Frontier Markets Fund, the first actively managed, US-registered frontier market fund, on December 9, 2008. Deutsche Bank launched the first frontier market ETF in Europe in early 2008. The Bank of New York Mellon created its frontier market ETF in June 2008.

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study nine emerging and frontier equity markets within the Middle East and North African region. They find that most markets within their sample exhibit low levels of integration, but they also find that both global and local risks are priced.

To enhance understanding of frontier markets, we conduct several analyses across frontier market countries, as well as across broad frontier market indexes that include up to 25 frontier market countries. Constructing these broad frontier market indexes strengthens our results by providing a lengthy sample period and minimizing country-specific noise. This analysis therefore details the relations among small and illiquid markets worldwide.

In contrast to our study, most research on international market integration and diversification focuses on developed and emerging market asset classes. For example, Solnik (1974) argues that international diversification is beneficial on the basis of cross-market correlations. Odier and Solnik (1993) find that despite increasing informational integration across markets and greater correlation during volatile periods, overall international correlations remain low, so international diversification is still beneficial. In their study of diversification benefits, Driessen and Laeven (2007) consider developed and emerging markets and emphasize diversification benefits for local investors. They find that international diversification is most beneficial for emerging market investors. However, focusing on downside risk and allowing for conditional correlations, You and Daigler (2010) find little evidence of international diversification benefits. Recently, Rua and Nunes (2009) use wavelets to study cross-market correlations within developed markets and find that the US and UK stock markets exhibit the highest comovement across time while the Japanese market shows a low degree of comovement with other major stock markets.

From an asset-allocation perspective, cross-market correlations are clearly informational, but Carrieri, Errunza, and Hogan (2007) argue that they do not provide a complete and accurate measure of diversification benefits or overall integration. They provide the example of Zimbabwe, in which a high correlation between the worldwide price of copper and the national market does not indicate a highly integrated capital market. Pukthuanthong and Roll (2009) also consider cross-market correlations inadequate as measures of integration. Varying market sensitivities to international factors can lead to low correlations, despite high levels of integration. Furthermore, integration varies through time, and tends to increase for many countries, though some specific countries become less integrated over time (Pukthuanthong and Roll, 2009). Bekaert et al. (2007) propose the use of global growth opportunities to measure market integration with price-to-earnings ratio comparisons, as an alternative to correlation-based measures.

We apply Pukthuanthong and Roll's (2009) measure of integration to broad market classification indexes and find that developed and emerging markets exhibit significant exposure to the world market factor. However, there is little evidence of integration between frontier market indexes and this factor. For developed and emerging market indexes, levels of integration increase significantly through time; the broad frontier market indexes in contrast offer no evidence of increasing integration. We also extend Pukthuanthong and Roll's (2009) approach that measures integration through time. Specifically, we allow for structural breaks in a time-trend model and apply our proposed method to a sample of frontier market countries. For any given country, breakpoint tests indicate the calendar month in which the level of integration shifts or the rate of integration changes. Therefore, this approach can measure integration dynamics, both before and after the breakpoint. For example, Romania joined the European Union (EU) in January 2007; the breakpoint results indicate a significant increase in integration in February 2007. Whereas few frontier markets exhibit a significant and constant rate of changing integration, when we allow for structural breakpoints, we discover significant integration dynamics (both increasing and decreasing), before or after an identified breakpoint, that vary across countries. The overall results suggest that frontier markets exhibit low levels of world market integration, even after allowing for structural breaks. Thus, frontier market risk may be largely diversifiable.

In a mean-variance analysis across market classification indexes, we find strong diversification benefits exist from including frontier market equities, especially in the form of significant risk reduction. This result is robust both with and without short-selling constraints, indicating that investors likely can achieve similar levels of expected return with lower risk by including frontier market equities. Out-of-sample performance tests and the analysis of ETFs further confirm these diversification benefits.

This study offers three main contributions. First, the results provide empirical evidence about the level of integration and diversification benefits for a complete set of frontier markets, unlike existing studies that focus on a subset (e.g., Cheng, Jahan-Parvar, and Rothman, 2009; Jayasuriya and Shambora, 2009). Although Speidell and Krohne (2007) examine all potential frontier markets, their analysis is limited to cross-market correlations. Because this measure may not be the best indicator of integration, their results are far from conclusive. Second, structural breakpoint models identify calendar dates that correspond to shifts in the integration process and thus extend Pukthuanthong and Roll's (2009) regressions of world market integration. Third, analyzing frontier markets provides insights into international diversification with respect to country factors and geographical diversification, which are relevant topics in recent literature. For example, Bekaert, Hodrick, and Zhang (2009) find that country factors dominate industry factors in international diversification, and Baele and Inghelbrecht (2009) show that geographical diversification continues to offer results superior to those obtained through industry diversification.

The remainder of this paper is organized as follows. In the next section, we detail the data and sample. Section 3 presents the market integration analysis and Section 4 analyzes the diversification benefits of frontier markets. We conclude in Section 5.

2. Data

Our study presents an analysis across market classifications: namely, developed, emerging, and frontier. We utilize daily data for the MSCI All Country World Index, which

Table 1
Country-specific summary statistics and sample period.

This table reports summary statistics covering the country-specific frontier indexes within the sample. *First* and *Last* refer to the months in which a given country enters and exits the sample, while *n* documents the number of daily return observations. R_i represents the daily return for country *i*, in percentage form.

Country	*First*	*Last*	*n*	*Mean*(R_i)	*Var*(R_i)	*Min*(R_i)	*Max*(R_i)
Argentina	08/1993	10/2009	4037	0.008	2.383	−33.650	17.790
Bahrain	01/2000	10/2009	1435	0.047	0.680	−7.906	3.737
Botswana	01/1996	10/2009	3127	0.069	1.505	−12.557	36.756
Bulgaria	11/2000	10/2009	2286	0.090	2.036	−21.504	20.857
Croatia	01/1997	10/2009	3205	0.038	1.970	−13.855	16.961
Estonia	06/1996	10/2009	3392	0.036	1.813	−21.979	12.385
Ghana	01/1996	10/2009	2816	−0.048	1.235	−10.186	21.616
Jamaica	01/1996	10/2009	1289	−0.029	2.487	−23.353	36.241
Jordan	01/1989	10/2009	5197	0.029	1.195	−20.541	19.965
Kenya	02/1990	10/2009	4638	−0.001	1.792	−49.330	48.606
Kuwait	01/1995	10/2009	3807	0.038	1.086	−24.606	25.628
Lebanon	04/2000	10/2009	304	−0.113	2.100	−10.213	9.536
Lithuania	01/2000	10/2009	2402	0.063	1.410	−13.475	11.084
Mauritius	01/1996	10/2009	1367	0.037	1.438	−8.465	16.252
Nigeria	07/1995	10/2009	3440	0.048	1.263	−10.438	10.274
Oman	11/1996	10/2009	3290	0.034	1.246	−14.832	24.040
Pakistan	01/1989	10/2009	4820	0.031	1.735	−12.167	12.791
Romania	10/1997	10/2009	3071	−0.001	2.113	−12.719	11.592
Saudi Arabia	01/1998	10/2009	2134	0.059	1.612	−13.488	16.014
Slovenia	01/1994	10/2009	4030	0.032	1.404	−11.685	11.943
Sri Lanka	10/1990	10/2009	4262	0.019	1.142	−14.002	11.875
Trinidad and Tobago	01/1996	10/2009	2058	0.032	1.253	−8.224	15.515
Tunisia	01/1998	10/2009	3028	0.042	0.677	−6.358	4.714
Ukraine	02/1998	10/2009	2037	−0.010	3.159	−28.780	57.904
United Arab Emirates	06/2005	10/2009	997	−0.063	2.342	−17.273	10.981

includes developed and emerging markets, the MSCI World Index, which is comprised of developed markets (henceforth, the MSCI Developed Markets Index), as well as the MSCI Emerging Markets Index. The sample includes returns to 25 country-specific frontier market indexes. We select frontier market countries according to the MSCI classification. Data for Kazakhstan, Serbia, Qatar, and Vietnam are not available, so these countries are excluded from the sample. Botswana, Ghana, Jamaica, and Saudi Arabia are included within the sample, as the addition of these countries to the MSCI Frontier Markets Index is under consideration. Although per capita GDP may be relatively high in some countries, the frontier market classification also considers the level of development within capital markets, market liquidity, and investment restrictions. Following Pukthuanthong and Roll (2009), we choose the total return index for each country, when available. Finally, all returns and values are denominated in US dollars, based on the Datastream exchange rate facility.

Daily return data from Datastream are used to create the frontier market sample. The specific countries included, as well as dates of coverage are detailed in Table 1. There are cases in which reliable observations do not exist for every point within the coverage period; therefore, Table 1 lists the total number of valid observations for each country in the sample. The frontier market sample is used to construct equal-weighted and value-weighted frontier market indexes. To provide a lengthy sample for analysis, the sample begins January 1989, and countries are added to the sample as data become available. As a result, the frontier indexes consist of a small number of countries during the early years of the sample.[3] However, coverage increases as the sample progresses. With regard to data issues relating to stale prices raised by Pukthuanthong and Roll (2009), following their approach, we eliminate observations for a given country if the price index does not change. Finally, we eliminate a small number of frontier market observations by limiting our sample to only days for which we have observations for the MSCI World Index.

Constructing the value-weighted index is relatively difficult and requires a certain degree of estimation. First of all, market capitalization data are not readily available for every observation for every country. Further, the periodicity of market capitalization is longer than that of the return series. In the cases in which we do not have a fresh observation of market capitalization, we use the most recent available observation.[4] In some instances there are no reliable market capitalization data for a country, nor any reliable lagged observations. In these cases, the given country's market capitalization is set equal to the median level of all frontier market countries within the sample at that point in time.

[3] Subsample analysis, as well as analysis across countries, confirm that our results are not driven by the early sample in which relatively few countries enter the index.

[4] We use the most recent available market capitalization observation, rather than estimate market capitalization based on subsequent returns and the previous observation, as this approach would miss any additions or deletions from the index.

Appendix A provides macro-economic variables for the frontier market sample. Some countries in the sample are relatively developed in terms of GDP per capita. For example, in 2008 GDP per capita was $27,019 and $17,454 for Slovenia and Estonia, respectively. These countries are included within the frontier market classification because they are too small to be considered emerging markets. Slovenia's market capitalization was $12.14 billion and Estonia's market capitalization was only $1.70 billion in 2009. In terms of market capitalization, Saudi Arabia's $318.74 billion and the United Arab Emirates (UAE)'s $109.61 billion are higher than the market capitalization of some emerging markets such as Egypt and Peru. However, these two countries are considered frontier markets because they have recently become open to international investors as investment restrictions have loosened. In fact, all six countries of the Gulf Cooperation Council (Bahrain, Kuwait, Qatar, Oman, Saudi Arabia, and UAE) are considered frontier markets.

3. Market integration analysis

3.1. Principal component (PC) analysis

We examine the extent to which frontier markets are integrated within the global market. Pukthuanthong and Roll (2009) consider levels of world integration across a broad sample of developed, emerging, and frontier countries. Specifically, they regress daily country index returns on their global PCs. To apply their methodology to frontier market countries, as well as broad frontier market indexes, we obtain the PC data up until 2007 from Pukthuanthong and Roll and construct PCs for 2008 and 2009. Table 2 presents results for the MSCI World Index, which represents developed markets, the MSCI Emerging Markets Index, and the broad frontier market indexes. With this approach, the adjusted *R*-square measures the proportion of an index's return that is explained by global factors, while the coefficient on the first PC is comparable to the loading on a global market factor. As the PCs are mutually orthogonal, interpretation of the remaining coefficient estimates is not straightforward and consequently the remaining parameter estimates are not reported. Results from the principal component regressions are presented in columns 2 and 3 of Table 2. To provide a comparison across the PC approach and standard correlations as a measure of integration, Table 2 also reports cross-index correlations and associated *p*-values, in the final four columns of the table. Panel A presents results from the full sample, while the remaining panels present subsample analyses, with sample periods denoted in the panel headings.

Results in Table 2 show a striking lack of world market integration across the frontier indexes, despite high levels of integration for the developed and emerging market indexes. In Panel A, the adjusted *R*-square from the PC regressions are −0.0003 and 0.0049 for the frontier value-weighted and equal-weighted indexes, respectively. The corresponding values are 0.4399 and 0.6244 for the emerging market and developed market indexes, respectively. The adjusted *R*-square measures indicate that the PCs explain very little of the variation in frontier market returns, despite the evidence that they explain a large portion of emerging and developed market return variation. Coefficients for the global market factor are large in magnitude and highly significant based on the emerging and developed market indexes. However, the coefficient estimate for the value-weighted frontier index is insignificant. While the global market factor parameter estimate is significant based on the equal-weighted frontier index, it is small in magnitude. Comparable parameter estimates for the developed and emerging market indexes are both over 20 times larger in magnitude. In short, the developed and emerging market indexes exhibit high levels of world market integration, while the evidence suggests frontier markets are not integrated.

Pukthuanthong and Roll (2009) argue that the PC approach provides a better analysis of world market integration, relative to the common correlation approach. Carrieri, Errunza, and Hogan (2007) also discuss the drawbacks from using cross-market correlations as a measure of integration. The final four columns in Table 2 show comparable results and inference across the PC measure and the correlation approach with respect to the level of developed and emerging market integration. Both PC regressions and correlation results suggest that developed and emerging markets exhibit a high degree of world market integration. Further, with respect to levels of integration throughout the sample, both the PC approach and correlations indicate a small degree of integration for frontier markets. For example, the coefficient estimate on the first PC is insignificant for the value-weighted index, and the correlation between the value-weighted index and the world market, although significant, is only 0.04. The PC results show a positive and significant coefficient on the first PC for the frontier equal-weighted index; however, the coefficient of 0.08 is small in magnitude. The correlation across the equal-weighted frontier index and the all country index of 0.06 also indicates some level of positive, but marginal integration. We believe the magnitude of integration is likely best described by the PC results, as explained by Pukthuanthong and Roll (2009).

The broad frontier indexes include data from each frontier market when data become available. Consequently, coverage of the indexes is thin during the early sample periods. Subsample results provide analyses in early years, as well as during more recent periods, which include many frontier equity markets. For example, 20 of the 25 frontier market countries are included within the broad indexes by January 2000. Results in Panel C of Table 2, covering the 10 years from January 2000 through October 2009, confirm the analysis based on the entire sample discussed above. Specifically, both broad frontier market indexes exhibit small or insignificant parameter estimates for the world factor. In addition, adjusted *R*-square measures are very close to zero. These results contrast the large and significant world market factor coefficients, as well as large adjusted *R*-square measures for the developed and emerging market indexes. Finally, Panels D through G contain subperiod results across approximate 5-year periods. Panel H contains results from the final 2 years of the sample period to measure any changes in the global market during the subprime mortgage crisis, which represents a very unique sample. The results in Panels D through G confirm the discussion above, in that the PC results indicate little integration across frontier market indexes with the world market.

Table 2
PC results and correlations across market classification indexes.

This table reports measures of world market integration. Entries under the *PC1* and *Adjusted* R^2 headings correspond to the coefficient estimate on the first principal component, along with the associated *p*-value, and the adjusted *R*-square from the Pukthuanthong and Roll (2009) principal component approach, which regresses index returns on 10 global factors. The final four columns report cross-index correlations of daily returns and associated *p*-values for the given indexes. Subsamples are denoted in each panel.

Index	*PC1*	*Adjusted* R^2	*MSCI All Country*	*MSCI Developed*	*MSCI Emerging*	*Value-weighted frontier index*
Panel A: 1989–2009						
MSCI Developed	1.6962	0.6244	0.9824			
	(0.000)		(0.000)			
MSCI Emerging	1.8900	0.4399	0.6310	0.5967		
	(0.000)		(0.000)	(0.000)		
Value-weighted frontier index	0.0327	−0.0003	0.0381	0.0417	0.0507	
	(0.532)		(0.005)	(0.002)	(0.000)	
Equal-weighted frontier index	0.0802	0.0049	0.0569	0.0573	0.1008	0.6732
	(0.008)		(0.001)	(0.000)	(0.000)	(0.000)
Panel B: Subsample 1 (1989–1999)						
MSCI Developed	1.5540	0.5578	0.9764			
	(0.000)		(0.000)			
MSCI Emerging	1.8100	0.2993	0.5017	0.4716		
	(0.000)		(0.000)	(0.000)		
Value-weighted frontier index	0.0089	−0.0013	0.0047	0.0110	−0.0171	
	(0.908)		(0.804)	(0.557)	(0.364)	
Equal-weighted frontier index	0.0768	0.0072	0.0212	0.0256	0.0116	0.7184
	(0.137)		(0.259)	(0.174)	(0.536)	(0.000)
Panel C: Subsample 2 (2000–2009)						
MSCI Developed	1.7288	0.7449	0.9854			
	(0.000)		(0.000)			
MSCI Emerging	1.8534	0.5515	0.7063	0.6682		
	(0.000)		(0.000)	(0.000)		
Value-weighted frontier index	0.0459	0.0004	0.0679	0.0688	0.1159	
	(0.512)		(0.001)	(0.001)	(0.000)	
Equal-weighted frontier index	0.0944	0.0000	0.0889	0.0860	0.1840	0.6152
	(0.013)		(0.000)	(0.000)	(0.000)	(0.000)
Panel D: Subsample 3 (1989–1993)						
MSCI Developed	1.5150	0.6332	0.9570			
	(0.000)		(0.000)			
MSCI Emerging	1.3820	0.1994	0.3896	0.3787		
	(0.000)		(0.000)	(0.000)		
Value-weighted frontier index	0.0674	0.0036	0.0178	0.0295	−0.0283	
	(0.553)		(0.524)	(0.291)	(0.311)	
Equal-weighted frontier index	0.1220	0.0136	0.0130	0.0205	−0.0274	0.8421
	(0.203)		(0.640)	(0.464)	(0.327)	(0.000)
Panel E: Subsample 4 (1994–1998)						
MSCI Developed	1.5770	0.7099	0.9964			
	(0.000)		(0.000)			
MSCI Emerging	2.1310	0.4243	0.6226	0.5684		
	(0.000)		(0.000)	(0.000)		
Value-weighted frontier index	0.0017	−0.0068	−0.0115	−0.0084	−0.0204	
	(0.990)		(0.679)	(0.762)	(0.464)	
Equal-weighted frontier index	0.0470	0.0014	0.0358	0.0366	0.0514	0.6231
	(0.485)		(0.199)	(0.189)	(0.065)	(0.000)
Panel F: Subsample 5 (1999–2003)						
MSCI Developed	2.1180	0.6594	0.9979			
	(0.000)		(0.000)			
MSCI Emerging	1.9220	0.4353	0.5426	0.5094		
	(0.000)		(0.000)	(0.000)		
Value-weighted frontier index	0.1740	0.0040	0.0556	0.0526	0.0616	
	(0.048)		(0.046)	(0.058)	(0.027)	
Equal-weighted frontier index	0.0601	−0.0023	0.0445	0.0408	0.0932	0.3948
	(0.152)		(0.110)	(0.143)	(0.001)	(0.000)
Panel G: Subsample 6 (2004–2007)						
MSCI Developed	1.6070	0.7317	0.9902			
	(0.000)		(0.000)			
MSCI Emerging	2.5980	0.7182	0.7411	0.6769		
	(0.000)		(0.000)	(0.000)		
Value-weighted frontier index	−0.1410	0.0101	−0.0279	−0.0223	−0.0640	
	(0.316)		(0.369)	(0.474)	(0.039)	

Table 2 (*continued*)

Index	*PC1*	*Adjusted R^2*	*MSCI All Country*	*MSCI Developed*	*MSCI Emerging*	*Value-weighted frontier index*
Equal-weighted frontier index	0.0821	0.0090	0.0680	0.0634	0.0464	0.4141
	(0.063)		(0.028)	(0.041)	(0.135)	(0.000)
Panel H: Subsample 7 (2008–2009)						
MSCI Developed	1.7208	0.7664	0.9970			
	(0.000)		(0.000)			
MSCI Emerging	2.6112	0.7303	0.8236	0.7774		
	(0.000)		(0.000)	(0.000)		
Value-weighted frontier index	−0.1006	0.0211	0.4815	0.4472	0.6370	
	(0.228)		(0.000)	(0.000)	(0.000)	
Equal-weighted frontier index	0.0865	0.0104	0.5506	0.5135	0.7152	0.9021
	(0.049)		(0.000)	(0.000)	(0.000)	(0.000)

With the exception of the final 2 years of our sample, overall the correlation results are consistent with the PC results, and suggest little integration across the broad frontier indexes with the world market. Correlations across the frontier indexes and the all country, developed, and emerging market indexes are all less than 0.1 in Panels B through G, with the exception of the 2000–2009 subsample presented in Panel C, in which the correlation between frontier market indexes and emerging markets is marginally greater than 0.1. However, correlations presented in Panel H for the 2008–2009 subsample are large in magnitude. Correlations with the all country index are 0.48 and 0.55 for the value-weighted and equal-weighted frontier indexes, respectively. This result is consistent with Ang and Bekaert (2002) and Longin and Solnik (2001), who find that correlations tend to increase during bear markets. Further, Forbes and Rigobon (2002) show that correlations are biased upwards given heteroskedasticity and periods of increasing volatility.

Results in Table 2 analyze integration of broad frontier market indexes and provide a measure of integration across market classifications. The results indicate that the countries contained within the frontier classification appear largely segragated from world capital markets. To expand this analysis, we present similar results across country-specific frontier market indexes in Table 3.

The country-specific analysis finds very little evidence of frontier market integration. The parameter estimate on the first PC is less than 0.002 for each of the 25 frontier countries. Comparable estimates from Table 2 equal 1.70 for the developed markets index, and 1.89 for the emerging markets index. The adjusted *R*-square measure from the PC analysis is greater than 0.05 for only four countries, Argentina, Croatia, Estonia, and Lithuania, and in these cases, still less than 0.10. For comparison, the adjusted *R*-squares are 0.62 for the developed markets index, and 0.44 for the emerging markets index.

Daily return correlations in Table 3 provide little evidence of high integration across frontier and developed markets.[5] No frontier country exhibits a correlation with the world or developed markets index that is greater than 0.3, and only five countries exhibit correlations in excess of 0.2. Although 13 of the 25 frontier countries exhibit correlations that are greater than 0.1, the overall conclusion based on the correlation approach is that frontier market countries tend to exhibit a low level of world market integration, consistent with the PC results.

3.2. Time-varying integration

Levels of world market integration likely vary through time. For example, Carrieri, Errunza, and Hogan (2007) indicate that world market integration tends to increase. However, they also find reversals in levels of integration. Bekaert, Harvey, and Lumsdaine (2002) estimate structural break models to identify periods of segmentation and integration. They discuss that integration may be a gradual process and often occurs after dates of official liberalization. To consider trends within the level of frontier market integration, we follow Pukthuanthong and Roll (2009) and regress the adjusted *R*-square from the PC analysis on a simple time-trend. Initially, we estimate the PC model based on subsequent 6-month calendar periods from January 1989 through October 2009, and then regress the adjusted *R*-square measure from each 6-month regression on a time-trend. Results are reported in Panel A of Table 4. The remaining panels detail results based on bimonthly *R*-square regressions. To compare results across the PC and correlation approaches, columns 3 and 4 contain results from regressing correlations computed across the given index and the all country world index from either 6-month or 2-month intervals, as indicated in the panel heading, on a simple time-trend, in the same fashion as the PC approach.

The time-trend parameter estimates in Panel A of Table 4 are positive and highly significant for the developed and emerging market indexes, while corresponding estimates are insignificant based on the frontier market indexes. Emerging and developed markets exhibit

[5] Daily correlations may be small, even across active developed markets, as information is released during a calendar day after easterly markets have closed, and consequently incorporated in these markets on the following day. However, our broad frontier indexes mitigate this concern somewhat, as the broad frontier market indexes span multiple time zones. We thank the referee for this explanation.

Table 3
PC results and correlations across country-specific indexes.

Entries within the first four columns of the table represent the correlation of daily returns and the associated *p*-value for the given country and market classification index. Entries within the final two columns correspond to the coefficient on the first principal component, *PC1*, along with associated *p*-value, and adjusted *R*-square from the Pukthuanthong and Roll (2009) principal component approach, which regresses index returns on 10 global factors. The sample period is from 1989 to 2009.

	MSCI all countries	*MSCI developed*	*MSCI emerging*	*Frontier value-weighted*	*PC1*	*Adjusted R^2*
Argentina	0.1689	0.1655	0.1396	0.2554	0.0017	0.0603
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	
Bahrain	0.0159	0.0006	0.0866	0.0719	0.0001	0.0003
	(0.548)	(0.981)	(0.001)	(0.007)	(0.082)	
Botswana	0.1144	0.1025	0.1710	0.0336	0.0004	0.0232
	(0.000)	(0.000)	(0.000)	(0.060)	(0.000)	
Bulgaria	0.1593	0.1442	0.2152	0.1894	0.0007	0.0284
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	
Croatia	0.2759	0.2602	0.2678	0.1953	0.0015	0.0837
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	
Estonia	0.1381	0.1295	0.1604	0.1673	0.0011	0.0780
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	
Ghana	0.0160	0.0183	0.0098	0.0501	0.0001	0.0047
	(0.396)	(0.333)	(0.602)	(0.008)	(0.198)	
Jamaica	0.0470	0.0415	0.0603	0.0354	0.0000	0.0014
	(0.092)	(0.136)	(0.030)	(0.204)	(0.577)	
Jordan	0.0505	0.0468	0.0691	0.1735	0.0003	0.0092
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	
Kenya	0.0273	0.0217	0.0486	0.0553	0.0001	0.0005
	(0.063)	(0.140)	(0.001)	(0.000)	(0.202)	
Kuwait	0.0633	0.0572	0.0897	0.1122	0.0000	0.0024
	(0.000)	(0.000)	(0.000)	(0.000)	(0.319)	
Lebanon	0.2650	0.2443	0.3563	0.1252	0.0001	−0.0017
	(0.000)	(0.000)	(0.000)	(0.029)	(0.205)	
Lithuania	0.2533	0.2314	0.2957	0.1876	0.0008	0.0594
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	
Mauritius	0.0997	0.0819	0.1380	0.0406	0.0001	0.0001
	(0.000)	(0.002)	(0.000)	(0.134)	(0.013)	
Nigeria	−0.0084	−0.0076	0.0005	0.0267	0.0008	0.0005
	(0.623)	(0.655)	(0.978)	(0.117)	(0.027)	
Oman	0.0888	0.0786	0.1656	0.0846	0.0000	−0.0018
	(0.000)	(0.000)	(0.000)	(0.000)	(0.822)	
Pakistan	0.0260	0.0281	0.0457	0.2948	0.0003	0.0053
	(0.071)	(0.052)	(0.002)	(0.000)	(0.001)	
Romania	0.2447	0.2283	0.2721	0.1460	0.0006	0.0260
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	
Saudi Arabia	0.1030	0.0936	0.1192	0.4200	0.0000	−0.0006
	(0.000)	(0.000)	(0.000)	(0.000)	(0.722)	
Slovenia	0.1813	0.1678	0.2012	0.6366	0.0005	0.0270
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	
Sri Lanka	0.0413	0.0381	0.0737	0.0492	0.0001	−0.0001
	(0.007)	(0.013)	(0.000)	(0.001)	(0.014)	
Trinidad and Tobago	0.0015	0.0026	0.0053	−0.0007	0.0001	0.0016
	(0.947)	(0.907)	(0.810)	(0.976)	(0.096)	
Tunisia	0.1507	0.1412	0.1563	0.2580	0.0003	0.0261
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	
Ukraine	0.1118	0.0952	0.1450	0.1043	0.0001	0.0127
	(0.000)	(0.000)	(0.000)	(0.000)	(0.600)	
United Arab Emirates	0.2496	0.2256	0.3526	0.1659	0.0002	0.0047
	(0.000)	(0.000)	(0.000)	(0.000)	(0.465)	

increasing world market integration, but no such trend exists within frontier markets. Interestingly, the PC approach is able to capture changing levels of integration that are not captured by the simple correlation approach. For example, across the entire sample period, the PC approach indicates that developed markets become increasingly integrated, while the corresponding estimate based on correlations is insignificant. The results in this section further compliment the earlier findings in that not only do frontier markets exhibit low levels of overall integration, but these levels do not appear to increase through time.

The bimonthly regression subsample analyses presented in Panels B through H also show several interesting results. First, the time-trend is significant and positive based on the equal-weighted frontier index during the 1994 through 1998 sample period presented in Panel F. However, no other subsample provides significant estimates for either frontier markets index. Further, in unreported results based on monthly regressions, the time-

Table 4
Integration through time across market classification indexes.

This table presents results from regressing calendar-period integration measures on a time-trend variable. Entries under the *PC* and *Correlation* headings present results using the *R*-square from the Pukthuanthong and Roll (2009) principal component approach, and the correlation of daily returns for the given index with the MSCI All Country World Index, respectively, as the measure of calendar-period integration. The calendar-period integration measures are formed with 6-month periods in Panel A, and with 2-month periods in the remaining panels. Entries under the *Time* heading present parameter estimates for the time-trend variable and the associated *p*-value, while entries under the *Adjusted* R^2 heading represent the adjusted *R*-square from the regression of the calendar-period integration measure on time. Subsample periods are denoted in the panel headings.

	PC		*Correlation*	
Index	*Time*	*Adjusted* R^2	*Time*	*Adjusted* R^2
Panel A: 1989–2009 Sample with six-month regressions				
MSCI Developed	$2.16*10^{-3}$	0.2183	$-9.86*10^{-6}$	−0.0250
	(0.003)		(0.984)	
MSCI Emerging	$1.78*10^{-2}$	0.6423	$1.17*10^{-2}$	0.4799
	(0.000)		(0.000)	
Value-weighted frontier index	$-3.71*10^{-4}$	0.0003	$3.79*10^{-3}$	0.0801
	(0.395)		(0.039)	
Equal-weighted frontier index	$-7.08*10^{-5}$	−0.0251	$4.87*10^{-3}$	0.1525
	(0.967)		(0.006)	
Panel B: 1989–2009 Sample with bimonthly regressions				
MSCI Developed	$6.64*10^{-4}$	0.0512	$-1.02*10^{-4}$	0.0021
	(0.010)		(0.263)	
MSCI Emerging	$6.72*10^{-3}$	0.4734	$3.96*10^{-3}$	0.3573
	(0.000)		(0.000)	
Value-weighted frontier index	$-8.14*10^{-5}$	−0.0082	$1.02*10^{-3}$	0.0369
	(0.763)		(0.018)	
Equal-weighted frontier index	$-3.05*10^{-4}$	−0.0063	$1.27*10^{-3}$	0.0510
	(0.577)		(0.007)	
Panel C: Bimonthly regressions with subsample 1 (1989–1999)				
MSCI Developed	$1.23*10^{-3}$	0.0599	$3.81*10^{-4}$	0.0228
	(0.010)		(0.118)	
MSCI Emerging	$5.08*10^{-3}$	0.1142	$5.53*10^{-3}$	0.1591
	(0.005)		(0.001)	
Value-weighted frontier index	$-7.59*10^{-4}$	−0.0071	$1.82*10^{-4}$	−0.0152
	(0.516)		(0.866)	
Equal-weighted frontier index	$5.96*10^{-4}$	−0.0110	$9.29*10^{-4}$	−0.0041
	(0.612)		(0.395)	
Panel D: Bimonthly regressions with subsample 2 (2000–2009)				
MSCI Developed	$-3.49*10^{-4}$	−0.0156	$-8.38*10^{-4}$	0.1471
	(0.707)		(0.002)	
MSCI Emerging	$5.86*10^{-3}$	0.3642	$5.03*10^{-3}$	0.3264
	(0.000)		(0.000)	
Value-weighted frontier index	$-1.31*10^{-3}$	−0.0019	$2.99*10^{-3}$	0.0630
	(0.295)		(0.031)	
Equal-weighted frontier index	$1.60*10^{-4}$	−0.0236	$4.62*10^{-3}$	0.1283
	(0.993)		(0.003)	
Panel E: Bimonthly regressions with subsample 3 (1989–1993)				
MSCI Developed	$2.94*10^{-3}$	0.0544	$1.25*10^{-3}$	0.0057
	(0.154)		(0.290)	
MSCI Emerging	$-1.07*10^{-3}$	−0.0345	$1.17*10^{-3}$	−0.0342
	(0.854)		(0.843)	
Value-weighted frontier index	$-8.86*10^{-4}$	−0.0337	$4.36*10^{-3}$	0.0151
	(0.852)		(0.240)	
Equal-weighted frontier index	$-1.74*10^{-3}$	−0.0274	$4.27*10^{-3}$	0.0165
	(0.661)		(0.233)	
Panel F: Bimonthly regressions with subsample 4 (1994–1998)				
MSCI Developed	$3.53*10^{-3}$	0.0844	$4.51*10^{-4}$	0.2117
	(0.003)		(0.006)	
MSCI Emerging	$1.51*10^{-2}$	0.2392	$8.81*10^{-3}$	0.1204
	(0.004)		(0.034)	
Value-weighted frontier index	$6.34*10^{-4}$	−0.0341	$3.12*10^{-3}$	−0.0062
	(0.847)		(0.373)	
Equal-weighted frontier index	$6.41*10^{-3}$	0.0720	$7.03*10^{-3}$	0.1082
	(0.021)		(0.043)	
Panel G: Bimonthly regressions with subsample 5 (1999–2003)				
MSCI Developed	$1.86*10^{-3}$	0.1203	$-1.25*10^{-4}$	0.0693
	(0.011)		(0.086)	
MSCI Emerging	$9.97*10^{-3}$	0.2605	$-1.38*10^{-3}$	−0.0290

Table 4 (*continued*)

Index	PC		Correlation	
	Time	Adjusted R^2	Time	Adjusted R^2
	(0.002)		(0.673)	
Value-weighted frontier index	$3.06*10^{-4}$	−0.0353	$2.48*10^{-3}$	−0.0089
	(0.934)		(0.396)	
Equal-weighted frontier index	$5.41*10^{-4}$	−0.0340	$4.76*10^{-4}$	−0.0350
	(0.818)		(0.893)	
Panel H: Bimonthly regressions with subsample 6 (2004–2009)				
MSCI Developed	$6.63*10^{-4}$	−0.0443	$-1.57*10^{-3}$	0.1033
	(0.625)		(0.034)	
MSCI Emerging	$1.75*10^{-2}$	0.4031	$5.50*10^{-3}$	0.2210
	(0.000)		(0.003)	
Value-weighted frontier index	$-1.39*10^{-4}$	−0.0442	$1.01*10^{-2}$	0.2173
	(0.911)		(0.003)	
Equal-weighted frontier index	$-5.30*10^{-3}$	−0.0130	$1.17*10^{-2}$	0.2369
	(0.485)		(0.002)	

trend coefficient for the value-weighted frontier markets index is negative and marginally significant during the years from 1989 through 1999. Overall, the time-trend and subsample analyses show that frontier market integration is not increasing. Table 4 also shows subsamples in which the MSCI Developed Markets Index does not exhibit a positive trend in integration, consistent with the time-varying world market integration shown by Bekaert and Harvey (1995). Specifically, the time-trend coefficient for the MSCI Developed Markets Index is insignificant based on the 2000 through 2009 sample, presented in Panel D, as well as in the shorter subsamples from 1989 through 1993 and 2004 through 2009, presented in Panels E and H, respectively. Finally, in most cases the PC results are similar to the correlation results, with respect to frontier markets. Both approaches fail to find a significant increase or decrease in world market integration within frontier market indexes during most samples. However, results in Table 2 indicate strong increases in correlations between frontier indexes and the world index during 2008 and 2009. The PC approach does not show a similar pattern. From Table 4, results tend to differ across PC and correlation regressions when the sample includes 2008 and 2009. That is, in those cases correlations tend to increase, while the adjusted *R*-squares from the PC regressions do not. This result suggests the correlation approach is heavily influenced by the extreme observations during the latter sample period.

Fig. 1 plots *R*-square measures from 6-month regressions through time, to detail levels of integration across market classifications. The figure shows that the level of integration for both frontier market indexes remains essentially flat and approximately equals zero, which suggests a constant and low level of frontier market integration throughout the entire sample period. The figure also shows a dramatic time-trend in terms of emerging market integration beginning during the early 1990s. Finally, the level of developed market integration appears high and almost constant throughout the sample. This result helps explain the lack of a time-trend for developed markets shown in the latter subsamples presented in Table 4.

3.3. Country-specific integration and structural break test

To understand country-specific integration through time, we regress the adjusted *R*-squares from the PC analysis on a linear time-trend for each individual country. Table 5 reports parameter estimates of the constant and time-trend from these regressions. Out of the 25 countries, 10 have positive time-trend coefficients, while 15 have negative estimates. However, only three of these estimates are significant at the 5% level. Estonia exhibits increasing integration through time, while integration decreases within Jamaica and Jordan. Considering the estimate of the constant term, Botswana, Ghana, Jamaica, Trinidad and Tobago, Tunisia, and Ukraine all exhibit estimates above 0.3. Therefore, even though the trend is not increasing, these countries exhibit some level of positive world market integration.

The time-trend regressions presented in Table 5 allow integration to change through time. However, this approach fits a constant rate of change throughout the sample for a given country. We extend this model to allow for structural breaks in the level of integration, captured by changes in the constant term in the regression, as well as changes in the rate of integration, captured by changes in the time-trend parameter. World market integration dynamics could vary during certain periods, or exhibit structural breaks, due to changes in regulations, such as investment restrictions or the formation of economic unions like the EU. Quandt-Andrews Breakpoint test identifies unknown structural breakpoints in the time-trend regressions. Tests are conducted separately for a joint breakpoint in the constant and time-trend, breakpoints in the time-trend only, and the constant term only. We report identified breakpoints and the associated *p*-values from each breakpoint test in the final three columns of Table 5. Based on the 10% significance level, integration dynamics within 14 countries exhibit significant structural breaks for at least one of the breakpoint tests. In most cases, the three breakpoint tests identify the same calendar month for a given country. European countries such as Bulgaria, Romania, and Slovenia have

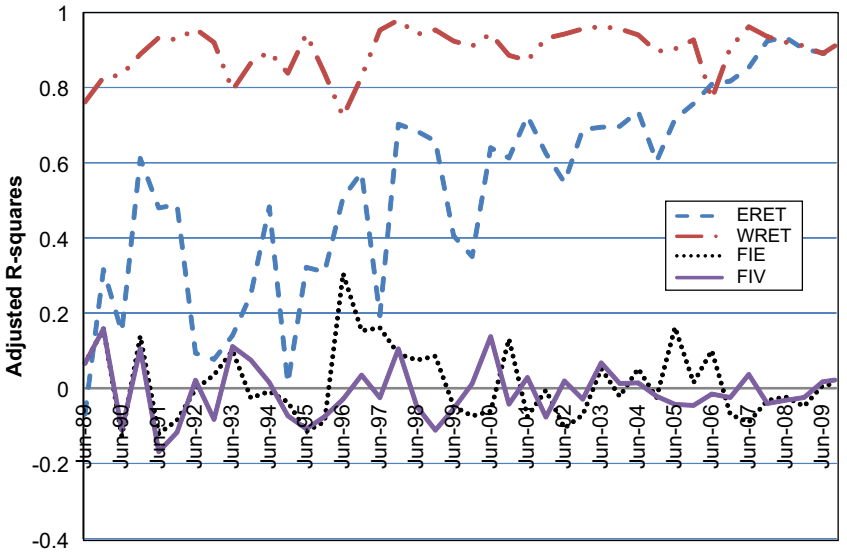

Fig. 1. Global market integration from January 1989 to October 2009. The figure plots adjusted *R*-squares from the Pukthuanthong and Roll (2009) principal component approach in which returns to a market classification index are regressed on 10 global factors. Regressions are based on 6-month calendar periods. FIV is value-weighted frontier index; FIE is equal-weighted frontier index; ERET is MSCI Emerging Markets index; and WRET is MSCI World Index representing developed markets.

structural breakpoints around the end of 2006 to early 2007. Interestingly, joining the EU does not necessarily lead to greater integration. Although both Lithuania and Slovenia joined the EU in 2004, Lithuania's structural breakpoint in November 2004 is not significant. African countries such as Botswana, Ghana, and Trinidad and Tobago exhibit structural breakpoints from 1999 to 2001. Argentina has a breakpoint in 2005, while Saudi Arabia's breakpoint was in 1998.

Augmenting the regression of adjusted *R*-square on time with breakpoint dummy-variables provides estimates of world market integration dynamics. Specifically, for each country, we separately define a variable, $break_t$ that takes the value of zero for all observations prior to the identified breakpoint and the value of one for all subsequent observations. This approach creates the following models in which, both the constant and time-trend change (Eq. (1)), the time-trend changes (Eq. (2)), and the constant changes (Eq. (3)):

$$adjR_t^2 = \alpha_0 + \alpha_1 * break_t + \beta_0 t + \beta_1 t * break_t + e_t, \quad (1)$$

$$adjR_t^2 = \alpha_0 + \beta_0 t + \beta_1 t * break_t + e_t, \quad (2)$$

$$adjR_t^2 = \alpha_0 + \alpha_1 * break_t + \beta_0 t + e_t. \quad (3)$$

The variable $adjR_t^2$ represents the adjusted *R*-square from the PC model during month t, while t is an ordinal time-trend variable. For simplicity, parameter notation is maintained across the three models. Table 6 reports results from the appropriate structural break model for countries in which the Quandt-Andrews Breakpoint test results, presented in Table 5, indicate a significant breakpoint at the 10% level.

Results in Table 6 detail significant dynamics with respect to world market integration that are not apparent in analyses of the entire sample period. Results from the Quandt-Andrews Breakpoint test in Table 5 indicate a significant break in both the constant and time-trend for Slovenia in October 2006. Results that include dummy-variable terms for both the constant and the time-trend are presented in Panel A of Table 6. The β_0 parameter estimate of 0.0033 indicates increasing integration for Slovenia until the identified breakpoint. Following the breakpoint, the parameter estimate of β_1 is -0.0361. As β_1 represents the shift in the slope following the breakpoint, the sum of the two parameters, β_0 and β_1, indicates that the overall rate of integration following the breakpoint is approximately -0.03. Finally, the parameter estimate of α_1 indicates a significant positive shift in the level of integration following the breakpoint. As a whole, the results for Slovenia in Panel A indicate increasing integration until October 2006, at which point the level of integration shifts and the rate of integration decreases.

Panel B of Table 6 details results from Eq. (2) for countries with significant breakpoints in the time-trend parameter. Both Argentina and Romania exhibit insignificant rates of integration prior to their breakpoints. However, the β_1 parameter estimates of 0.0023 and 0.0039 for Argentina and Romania, respectively, indicate increasing integration subsequent to the breakpoint. β_0 parameter estimates for Botswana, Bulgaria, Croatia, Ghana, Saudi Arabia, Slovenia, Trinidad and Tobago, and Ukraine are positive, while estimates of β_1 are negative and approximately equal in magnitude to β_0. Therefore, these countries exhibit increasing integration throughout the early sample, followed by no increasing or decreasing integration subsequent to the breakpoint, as the sum of

Table 5
Frontier market country integration through time.

This table shows frontier market integration through time. Entries under the *Constant* and *Trend* headings present parameter estimates along with associated *p*-values for the intercept and time-trend, respectively, from regressing monthly adjusted *R*-squares based on the Pukthuanthong and Roll (2009) principal component approach on a linear time-trend. Entries under the *Structural break tests* heading present identified breakpoints and associated *p*-values from structural break tests for a changing constant and time-trend, changing time-trend, and changing constant, respectively, based on the Quandt-Andrews Breakpoint test. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	Adjusted R-squares		*Structural break tests*		
Country	*Constant*	*Trend*	*Constant and trend*	*Trend only*	*Constant only*
Argentina	0.1328	0.0010	10/2002	10/2005**	10/2005**
	(0.033)	(0.232)	(0.302)	(0.017)	(0.017)
Bahrain	0.0440	0.0002	7/2001	7/2001	7/2001
	(0.596)	(0.992)	(0.844)	(0.475)	(0.596)
Botswana	0.4037	−0.0012	1/2001	1/2001***	1/2001***
	(0.000)	(0.926)	(0.241)	(0.002)	(0.001)
Bulgaria	0.0037	0.0019	4/2004	12/2006**	10/2003**
	(0.969)	(0.290)	(0.337)	(0.031)	(0.021)
Croatia	0.0302	0.0017	1/2004	10/2005*	10/2005*
	(0.643)	(0.350)	(0.699)	(0.064)	(0.074)
Estonia	0.0697	0.0026	3/2004	3/2004	3/2004
	(0.175)	(0.004)	(0.912)	(0.970)	(0.372)
Ghana	0.3274	−0.0032	1/1999	1/1999***	1/1999***
	(0.000)	(0.202)	(0.124)	(0.000)	(0.001)
Jamaica	0.4045	−0.0034	1/2001	1/2001*	1/2001**
	(0.000)	(0.023)	(0.436)	(0.058)	(0.013)
Jordan	0.1794	−0.0010	1/2007	6/2000	12/2006
	(0.001)	(0.001)	(0.526)	(0.181)	(0.179)
Kenya	0.0536	−0.0007	3/2004	3/2004*	3/2004*
	(0.476)	(0.373)	(0.748)	(0.071)	(0.059)
Kuwait	0.0695	−0.0011	4/2007	8/2003	8/2003
	(0.262)	(0.099)	(0.811)	(0.663)	(0.507)
Lebanon	0.0017	−0.0006	7/2001	11/2006	11/2006
	(0.992)	(0.840)	(0.974)	(0.357)	(0.349)
Lithuania	0.0612	0.0028	7/2007	11/2004	11/2004
	(0.415)	(0.074)	(0.878)	(0.394)	(0.411)
Mauritius	−0.0817	0.0008	5/2003	5/2003	5/2003
	(0.226)	(0.257)	(0.964)	(0.522)	(0.305)
Nigeria	−0.0127	−0.0003	3/2001	3/2001	3/2001
	(0.849)	(0.209)	(0.927)	(0.556)	(0.813)
Oman	0.1003	−0.0006	6/1997	5/2000	4/2005
	(0.165)	(0.116)	(0.942)	(0.944)	(0.913)
Pakistan	0.1155	−0.0009	7/1995	4/2003	7/1995*
	(0.087)	(0.498)	(0.843)	(0.238)	(0.067)
Romania	0.0125	0.0018	11/2006	2/2007**	2/2007**
	(0.858)	(0.103)	(0.539)	(0.013)	(0.014)
Saudi Arabia	0.0422	−0.0002	12/1998	12/1998**	12/1998**
	(0.576)	(0.403)	(0.750)	(0.034)	(0.023)
Slovenia	0.0784	0.0018	8/2006**	10/2006***	10/2006***
	(0.145)	(0.056)	(0.040)	(0.000)	(0.000)
Sri Lanka	0.1997	−0.0014	4/1996	4/1996*	9/1996
	(0.000)	(0.659)	(0.725)	(0.088)	(0.197)
Trinidad and Tobago	0.3446	−0.0030	12/2000	12/2000***	12/2000**
	(0.000)	(0.587)	(0.423)	(0.005)	(0.013)
Tunisia	0.3230	−0.0007	7/2002	7/2002**	7/2002**
	(0.000)	(0.657)	(0.414)	(0.013)	(0.021)
Ukraine	0.3138	−0.0029	1/2001	1/2001**	1/2001**
	(0.000)	(0.272)	(0.585)	(0.025)	(0.021)
United Arab Emirates	0.0149	0.0012	2/2007	2/2007	2/2007
	(0.909)	(0.449)	(0.977)	(0.312)	(0.304)

the two parameters, β_0 and β_1, is approximately zero for each country. Finally, Kenya, Sri Lanka, and Tunisia indicate some level of decreasing integration prior to the breakpoint, followed by no subsequent change in integration.

The intercept in the time-trend regressions indicates levels of integration, rather than rates of change which are captured by the time-trend parameter. Therefore, changes in the constant term indicate shifts in the overall level of integration that occur relatively quickly with respect to time. Results in Panel C of Table 6 indicate positive shifts in integration following the breakpoints for Argentina, Bulgaria, Kenya, Romania, and Tunisia. For example, considering Romania, parameter estimates of α_0, α_1, and β_0

Table 6
Structural break models of world market integration.

The table presents structural break regression results from the model:

$$adjR_t^2 = \alpha_0 + \alpha_1 * break_t + \beta_0 t + \beta_1 t * break_t + e_t,$$

in which $adjR_t^2$ represents the adjusted R-square from the Pukthuanthong and Roll (2009) principal component approach during month t, t is an ordinal time-trend variable, and $break_t$ is a dummy variable taking the value of zero for all observations prior to the identified breakpoint, and taking the value of one otherwise. Quandt-Andrews Breakpoint test identifies significant breakpoints for each country. Panels A–C present parameter estimates for countries with an identified breakpoint in the constant and time-trend, the time-trend only, and the constant only, respectively. Table entries correspond to the given parameter estimate and its associated p-value.

	α_0	α_1	β_0	β_1
Panel A: Breakpoint in constant and time-trend				
Slovenia	−0.0030	5.3198	0.0033	−0.0361
	(0.955)	(0.039)	(0.000)	(0.025)
Panel B: Breakpoint in time-trend				
Argentina	0.2226	–	−0.0008	0.0023
	(0.001)		(0.331)	(0.001)
Botswana	0.2064	–	0.0069	−0.0066
	(0.018)		(0.008)	(0.001)
Bulgaria	−0.1186	–	0.0065	−0.0062
	(0.221)		(0.005)	(0.002)
Croatia	−0.0641	–	0.0041	−0.0027
	(0.366)		(0.001)	(0.004)
Ghana	0.0657	–	0.0179	−0.0187
	(0.479)		(0.001)	(0.000)
Jamaica	0.2607	–	0.0024	−0.0047
	(0.007)		(0.398)	(0.033)
Kenya	0.1692	–	−0.0026	0.0020
	(0.044)		(0.003)	(0.003)
Romania	0.0852	–	0.0000	0.0039
	(0.222)		(0.998)	(0.001)
Saudi Arabia	−0.0734	–	0.0581	−0.0569
	(0.384)		(0.006)	(0.006)
Slovenia	0.0015	–	0.0032	−0.0031
	(0.977)		(0.000)	(0.000)
Sri Lanka	0.3300	–	−0.0066	0.0045
	(0.000)		(0.000)	(0.004)
Trinidad and Tobago	0.1259	–	0.0063	−0.0075
	(0.168)		(0.024)	(0.001)
Tunisia	0.5164	–	−0.0096	0.0072
	(0.000)		(0.000)	(0.000)
Ukraine	0.1318	–	0.0111	−0.0120
	(0.250)		(0.071)	(0.021)
Panel C: Breakpoint in constant				
Argentina	0.2216	0.3692	−0.0007	–
	(0.001)	(0.001)	(0.338)	
Botswana	0.3247	−0.5113	0.0040	–
	(0.000)	(0.000)	(0.006)	
Bulgaria	0.0705	0.5643	−0.0075	–
	(0.436)	(0.001)	(0.025)	
Croatia	−0.0624	−0.3240	0.0041	–
	(0.377)	(0.003)	(0.001)	
Ghana	0.4212	−0.5169	0.0008	–
	(0.000)	(0.000)	(0.518)	
Jamaica	0.3291	−0.4680	0.0013	–
	(0.000)	(0.001)	(0.401)	
Kenya	0.1677	0.3893	−0.0025	–
	(0.045)	(0.003)	(0.003)	
Pakistan	0.1042	−0.3821	0.0013	–
	(0.116)	(0.003)	(0.142)	
Romania	0.0849	0.4630	0.0000	–
	(0.224)	(0.001)	(0.992)	
Saudi Arabia	0.3420	−0.4584	0.0017	–
	(0.005)	(0.002)	(0.152)	
Slovenia	0.0025	−0.4879	0.0032	–
	(0.962)	(0.000)	(0.000)	
Trinidad and Tobago	0.2784	−0.4602	0.0017	–
	(0.000)	(0.001)	(0.269)	
Tunisia	0.3932	0.3630	−0.0052	–
	(0.000)	(0.002)	(0.002)	
Ukraine	0.3486	−0.4935	0.0023	–
	(0.000)	(0.001)	(0.231)	

are 0.0849, 0.4630, and 0.0000, respectively. These results indicate no trend in integration through time, but a large positive shift in integration following the breakpoint. The breakpoint for Romania corresponds to its entry in the EU. The remaining estimates in Panel C indicate decreases in integration for the respective countries subsequent to the breakpoint. Overall, the results in Table 6 show that interesting dynamics relating to world market integration can be captured with the structural break approach.

To further analyze integration dynamics, we present fitted values from the dummy-variable regressions. Specifically, for each country with an identified significant breakpoint, we report fitted values of the regression 12 and 6 months prior to the breakpoint, and 6 and 12 months after the break point. The fitted values indicate the overall level of integration for the country, as well as dynamics surrounding the breakpoint. Panels A–C of Table 7 present fitted values for countries with an identified breakpoint in the constant and time-trend, the time-trend only, and the constant only, respectively.

The results in Table 7 indicate increasing and decreasing levels of integration surrounding breakpoints for different countries. The results also indicate consistency across countries for which multiple breakpoint tests identify the same calendar month. For example, prior to the breakpoint and based on the model with a change in the trend term reported in Panel B, the overall level of integration for Argentina was low, and slightly decreasing from 0.115, 12 months prior to the break, to 0.110, 6 months prior to the break. Following the identified breakpoint, Argentina's overall level of integration increases rapidly to 0.452 at 6 months post-breakpoint, and then continues to increase to 0.461 at 12 months post-breakpoint. Results from Panel C, which reports models that allow a breakpoint in the constant term, indicate fitted values of 0.127 and 0.123, 12 and 6 months prior to the breakpoint, respectively, while the corresponding values after the breakpoint are 0.484 and 0.480. Therefore, results based on both a changing constant, and a changing trend term, indicate low levels of integration before a breakpoint for Argentina that are approximately equal to 0.1. Following the identified breakpoint of October 2005, the measure of integration remains relatively stable around 0.5. Results in both Panels B and C indicate that Kenya, Romania, and Tunisia all experience rapid increases in their level of integration following the identified breakpoints. However, the Ukraine and other countries experience decreasing levels of integration following the breakpoints.

Table 7
Structural break model fitted values.

This table reports fitted values from structural break regression models. We estimate

$$adjR_t^2 = \alpha_0 + \alpha_1 * break_t + \beta_0 t + \beta_1 t * break_t + e_t,$$

in which $adjR_t^2$ represents the adjusted R-square from the Pukthuanthong and Roll (2009) principal component approach during monthly sample t, t is an ordinal time-trend variable, and $break_t$ is a dummy variable taking the value of zero for all observations prior to the identified breakpoint, and taking the value of one otherwise. Entries under column headings, BP_{-12}, BP_{-6}, BP_{+6}, and BP_{+12} represent fitted values of $adjR_t^2$ 6 and 12 months prior to, and six and 12 months after the identified breakpoint, respectively. Quandt-Andrews Breakpoint test identify significant breakpoints for each country. Panels A–C present fitted values for countries with an identified breakpoint in the constant and time-trend, the time-trend only, and the constant only, respectively.

	BP_{-12}	BP_{-6}	BP_{+6}	BP_{+12}
Panel A: Breakpoint in constant and time-trend				
Slovenia	0.4590	0.4788	0.1344	−0.0624
Panel B: Breakpoint in time-trend				
Argentina	0.1146	0.1098	0.4521	0.4611
Botswana	0.5445	0.5859	0.2265	0.2283
Bulgaria	0.2844	0.3234	−0.0946	−0.0928
Croatia	0.3213	0.3459	0.0927	0.1011
Ghana	0.5132	0.6206	0.0313	0.0265
Jamaica	0.3783	0.3927	0.1066	0.0928
Kenya	−0.2416	−0.2572	0.0636	0.0600
Romania	0.0852	0.0852	0.5493	0.5727
Saudi Arabia	−0.0734	0.2752	−0.0518	−0.0446
Slovenia	0.4559	0.4751	0.0175	0.0181
Sri Lanka	−0.0330	−0.0726	0.1767	0.1641
Trinidad and Tobago	0.4283	0.4661	0.0467	0.0395
Tunisia	0.1036	0.0460	0.3700	0.3556
Ukraine	0.3982	0.4648	0.0940	0.0886
Panel C: Breakpoint in constant				
Argentina	0.1271	0.1229	0.4837	0.4795
Botswana	0.5207	0.5447	0.0814	0.1054
Bulgaria	−0.1095	−0.1545	0.3198	0.2748
Croatia	0.3230	0.3476	0.0728	0.0974
Ghana	0.4412	0.4460	−0.0613	−0.0565
Jamaica	0.3928	0.4006	−0.0518	−0.0440
Kenya	−0.2273	−0.2423	0.1170	0.1020
Pakistan	0.1913	0.1991	−0.1674	−0.1596
Romania	0.0849	0.0849	0.5479	0.5479
Saudi Arabia	0.3420	0.3522	−0.0858	−0.0756
Slovenia	0.4569	0.4761	0.0266	0.0458
Trinidad and Tobago	0.3600	0.3702	−0.0696	−0.0594
Tunisia	0.1696	0.1384	0.4390	0.4078
Ukraine	0.4038	0.4176	−0.0483	−0.0345

4. Diversification benefits of frontier market equities

The results presented within Section 3 indicate that broad frontier market indexes exhibit a low level of world market integration. Considering event-specific risk, Speidell and Krohne (2007) argue that frontier market volatility is not driven by the same factors that influence volatility within developed markets. In the context of Solnik (1974), if frontier market volatility is largely attributable to country-specific risk, and not driven by global factors, then frontier market diversification will reduce portfolio risk. In our study, we analyze the diversification benefits of broad frontier indexes relative to a broad diversified portfolio across market classifications. Since we observe low levels of integration within frontier markets, we show the diversification benefits across frontier indexes using an efficient frontier. The low R-squares imply that the frontier market indexes cannot be replicated by weighting stocks in another country.

4.1. Mean-variance frontier

We graphically document the potential performance gains from frontier market diversification by plotting the mean-variance frontier formed from three benchmark asset portfolios, namely, the US market, the MSCI Developed Markets Index, and the MSCI Emerging Markets Index, as well as the potential mean-variance frontiers formed by augmenting the three benchmark asset portfolios with either the value-weighted or equal-weighted frontier index. Results allowing short sales and results with short-sale restrictions are presented in Figs. 2 and 3, respectively.

Large portfolio improvements accrue through the inclusion of frontier indexes. The graphs suggest a 2% reduction in risk, while maintaining a given level of expected return when the equal-weighted frontier index is included, as well as a 1% reduction based on the value-weighted index. Interestingly, it seems that the equal-weighted index offers incremental portfolio improvement beyond the value-weighted index. This indicates that smaller markets may have offered superior performance during the sample, or may exhibit a lower relation with global factors.

The mean-variance frontiers form optimal portfolios based on ex-post information. An analysis of out-of-sample performance can determine if diversification benefits exist with ex-ante information. We maintain the portfolio grouping designations from Figs. 2 and 3, in which Portfolio 1 includes the benchmark market classification portfolios, and Portfolios 2 and 3 augment Portfolio 1 with the value-weighted frontier index and equal-weighted frontier index, respectively. Optimal portfolio weights are calculated with a 5-year estimation period, and then carried forward for the following calendar year. Given each portfolio grouping and ex-ante portfolio allocation, a time-series of monthly Sharpe ratios is calculated. The 3-month T-bill rate proxies for the risk-free rate. Summary statistics of the Sharpe ratios for each portfolio are reported in Table 8.

Out-of-sample performance tests confirm the diversification benefit of frontier markets. Results with and without short sales indicate substantial portfolio improvement from including frontier indexes. The mean and median Sharpe ratios for both Portfolios 2 and 3 are significantly greater, when compared to Portfolio 1, in all cases considered. For example, the mean monthly Sharpe ratio for Portfolio 3 is equal to 0.36 when short sales are prohibited, while the comparable estimate for Portfolio 1 is only equal to 0.20.[6]

[6] We perform the same analysis during the period before 2008 and find that Sharpe ratios are higher. This implies that the diversification benefit has decreased since 2008 but it still exists. Overall, the result in this section is consistent with our correlation analysis where we find correlation has increased since 2008.

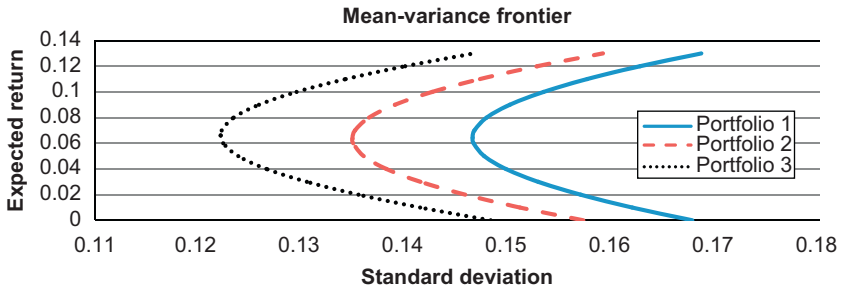

Fig. 2. Mean-variance frontiers allowing short sales. This figure depicts mean-variance frontiers for portfolios formed from market classification indexes. Portfolio 1 includes the US market, the MSCI World Index representing developed markets, and the MSCI Emerging Markets Index. Portfolios 2 and 3 augment Portfolio 1 with the value-weighted and equal-weighted frontier indexes, respectively. The sample period is from 1989 to 2009.

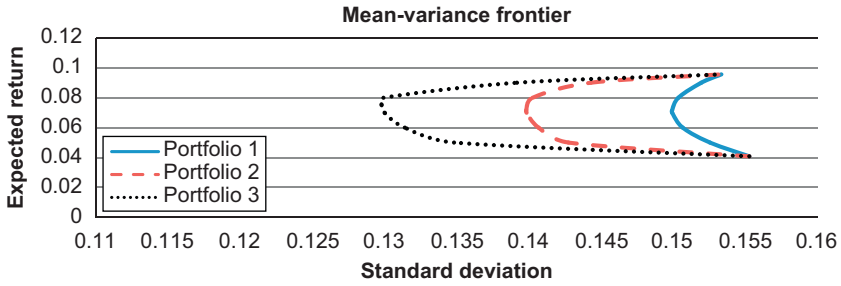

Fig. 3. Mean-variance frontiers restricting short sales. This figure depicts mean-variance frontiers for portfolios formed from market classification indexes. Portfolio 1 includes the US market, the MSCI World Index representing developed markets, and the MSCI Emerging Markets Index. Portfolios 2 and 3 augment Portfolio 1 with the value-weighted and equal-weighted frontier indexes, respectively. The sample period is from 1989 to 2009.

Table 8
Sharpe ratios based on out-of-sample weighting.

This table presents summary statistics of Sharpe ratios across portfolios based on out-of-sample portfolio weights. Portfolio 1 includes the US market, the MSCI World Index representing developed markets, and the MSCI Emerging Markets Index. Portfolios 2 and 3 augment Portfolio 1 with the value-weighted and equal-weighted frontier indexes, respectively. Optimal portfolio weights are calculated at the start of each calendar year, based on the previous 5 years of monthly data. Weights are maintained for the following 12 months. Sharpe ratio summary statistics are calculated based on the monthly time-series for each portfolio. The risk-free rate is the 3-month T-Bill rate. The symbol *** indicates that the mean or median statistic for Portfolio 2 or for Portfolio 3 is significantly larger than the comparable statistic for Portfolio 1 at the 1% level.

	Short sales allowed			*Short sales prohibited*		
	Portfolio 1	*Portfolio 2*	*Portfolio 3*	*Portfolio 1*	*Portfolio 2*	*Portfolio 3*
Mean	0.3048	***0.3913	***0.4926	0.2022	***0.2630	***0.3566
Median	0.3232	***0.3861	***0.4178	0.2104	***0.2868	***0.3193
Max	0.6992	0.7265	1.1151	0.4916	0.5657	1.0323
Min	−0.1567	0.0237	0.0619	−0.0883	−0.0681	−0.0883
Std	0.1750	0.1336	0.2980	0.1489	0.1370	0.2992

4.2. Exchange-traded funds

Bekaert and Urias (1996) argue that analyses based on non-investable indexes may overstate diversification benefits. Given the nature of frontier markets, it is likely that barriers to investment exist. The recent advent of frontier market ETFs allows an analysis of diversification benefits based on investable indexes. The ETF analysis measures potential investment benefits from a naïve diversification strategy, or to investors who do not have access to individual stocks, and does not properly measure diversification potential for better-equipped and more sophisticated investors. However, the ETF analysis represents a conservative hurdle by which to measure diversification benefits. That is, if we show benefits from a naïve ETF investment, it is likely that significant diversification benefits exist to more sophisticated investors.[7]

[7] We thank the referee for making this point.

Table 9
Portfolio risk and return across ETFs.

This table presents summary statistics for international portfolios. Portfolios are formed with exchange-traded funds in which *EEM* represents the MSCI Emerging Markets Index ETF, *FRN* represents the frontier market ETF, *SPY* represents the S&P 500 ETF, and *VEU* represents the FTSE All-World excluding US ETF. ETF characteristics are reported in Panel A for the given samples. In Panel B, portfolio characteristics are reported for various weighting schemes. The portfolio weighting schemes are defined as the portfolio weights to the EEM, FRN, SPY, and VEU funds, respectively. Returns are in percentage form.

	July 1, 2008 to February 26, 2010		*July 1, 2008 to March 9, 2009*		*March 10, 2009 to February 26, 2010*	
	Holding period return	*Annualized standard deviation*	*Holding period return*	*Annualized standard deviation*	*Holding period return*	*Annualized standard deviation*
Panel A: ETF risk-return statistics						
EEM	−11.21	60.66	−53.62	85.29	91.45	33.53
FRN	−22.00	41.32	−60.24	50.08	96.19	32.96
SPY	−10.23	36.82	−46.04	50.35	66.35	22.38
VEU	−17.89	43.92	−54.35	58.61	79.81	28.84
Panel B: Risk-return statistics across portfolio weights						
Portfolio weights (*EEM,FRN,SPY,VEU*)						
0.30,0.00,0.40,0.30	−11.46	44.99	−50.30	61.85	78.14	26.98
0.20,0.10,0.40,0.30	−12.03	41.80	−50.84	56.72	78.94	26.11
0.25,0.10,0.40,0.25	−11.54	42.60	−50.72	58.00	79.52	26.34

Due to the limited available history, we focus on presenting measures of portfolio risk and return across varying levels of international diversification. We focus on exchange-traded funds representing the ex-USA Developed Markets, the S&P 500, the MSCI Emerging Markets Index, and frontier markets, and denote these ETFs based on their ticker symbols as *VEU*, *SPY*, *EEM*, and *FRN*, respectively. Summary statistics are presented for each ETF across the entire sample for which the frontier market ETF is available, July 2008 through February 2010, as well as across the sample from July 1, 2008 through March 9, 2009 which represents a period of extreme market decline in which the S&P 500 fell approximately 25%, and the sample from March 10, 2009 through February 26, 2010 in which the S&P 500 gained approximately 65%. We also construct portfolios across the developed and emerging market ETFs and then analyze the diversification benefits of frontier markets by shifting portfolio weights towards the frontier market indexes. We conduct comparisons across a variety of portfolio weighting schemes. The portfolio weights reported are arbitrarily selected for a typical international investor, but the results and conclusions do not change with different combinations of portfolio weights. We present results in Table 9.

Results in Table 9 indicate that the inclusion of the frontier market ETF reduces the annualized standard deviation of a diversified portfolio. Results hold for the bear and the bull markets. During the bull market, the inclusion of FRN not only reduces risk but also increases return.[8] It should be noted that the FRN fund inception date was June 12, 2008, but the analysis starts on July 1, 2008 to avoid the influence of any abnormal trading that might occur when the fund was first introduced to the market.

5. Conclusions

This study considers returns from frontier market countries, as well as broad frontier market indexes. The results relate to significant prior literature that investigates levels of world market integration, as well as the diversification benefits of international investing. These two broad topics are related as finance theory implies an inverse relationship between international diversification benefits and levels of world market integration. However, we uniquely focus on frontier markets, which previously have received relatively little attention. We find little evidence of frontier market integration within the world market and a lack of consistent integration dynamics. However, our structural break models indicate periods of increasing and decreasing integration for specific frontier market countries.

The results we obtain from this study are robust. The subperiod analysis, out-of-sample performance test, and use of ETFs confirm our overall results that frontier markets are not integrated and thus, provide international diversification benefits when they appear in a diversified portfolio that includes developed and emerging equities. Although we feel confident that frontier markets provide diversification benefits to international investors, further studies are needed to address remaining issues related to asset pricing in frontier markets.

Appendix A. Frontier market macro-economic variables

See Table A1.

[8] In unreported analyses, mean-variance spanning tests indicate significant diversification benefits of both broad frontier market indexes, as well as country-specific indexes. These results are available from the authors upon request.

Table A1
The table presents the economic variables of the frontier markets within our sample. All variables are presented in US$. With the exception of GDP per capita, all GDP and market capitalization represent billions of dollars. Average GDP growth is in percentage form. Average GDP and average GDP growth are based on data covering 1993 through 2008 (or 2007 for Oman and UAE), while average market capitalization is from 1993 (or the year when data became available) to 2009. Data are from the World Development Indicator of the World Bank.

Country	*2008 GDP per capita*	*2008 GDP*	*Average GDP*	*Average GDP growth*	*2009 Market capitalization*	*Average market capitalization*
Argentina	8236.00	328.46	239.10	3.69	48.03	72.20
Bahrain	28,240.00	21.90	9.81	5.63	16.93	13.50
Botswana	6982.00	13.41	7.35	5.38	4.28	1.91
Bulgaria	6546.00	49.90	19.64	2.81	7.33	4.10
Croatia	15,637.00	69.33	31.85	3.44	26.62	12.66
Estonia	17,454.00	23.40	9.36	5.19	1.70	2.83
Ghana	713.00	16.65	8.43	4.88	2.51	1.62
Jamaica	5438.00	14.61	9.07	1.44	6.13	5.97
Jordan	3596.00	21.24	10.20	5.50	31.89	15.28
Kenya	783.00	30.35	15.17	3.19	10.97	4.59
Kuwait	54,260.00	148.02	53.57	7.20	96.32	57.30
Lebanon	6978.00	29.26	17.97	4.06	12.89	4.45
Lithuania	14,098.00	47.34	17.72	3.56	4.62	3.73
Mauritius	7345.00	9.32	5.22	4.63	4.98	2.28
Nigeria	1370.00	207.12	72.02	4.25	33.37	16.46
Oman	~15,273.00	~41.64	21.04	4.27	17.30	7.73
Pakistan	991.00	164.54	84.97	4.19	32.21	20.70
Romania	9300.00	200.07	68.08	3.63	31.32	11.09
Saudi Arabia	19,022.00	468.80	224.28	2.75	318.74	180.74
Slovenia	27,019.00	54.61	27.21	4.31	12.14	6.91
Sri Lanka	2013.00	40.56	19.37	5.25	8.17	3.45
Trinidad and Tobago	18,108.00	24.15	10.55	5.81	11.15	7.65
Tunisia	3903.00	40.31	23.51	4.63	9.31	3.51
Ukraine	3899.00	180.35	67.39	−0.19	16.86	19.12
UAE	~45,531.00	~198.69	81.44	6.00	109.61	80.76

~ indicates that the figure is based on 2007 data as 2008 data are not available.

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