Available online at www.sciencedirect.com

Borsa İstanbul Review

Borsa İstanbul Review 19-2 (2019) 149–157

http://www.elsevier.com/journals/borsa-istanbul-review/2214-8450

Full Length Article

Are ETFs good vehicles for diversification? New evidence for critical investment periods

Maria Elisabete Duarte Neves [a,d,*,1], Carla Manuela Fernandes [b], Pedro Coimbra Martins [c,2]

[a] *Polytechnic Institute of Coimbra, Coimbra Business School|Iscac, Quinta Agrícola - Bencanta, 3040-316, Coimbra, Portugal*

[b] *Professor at Aveiro University-ISCAA, R. Associação Humanitária dos Bombeiros Voluntários de Aveiro, 3810-500, Portugal*

[c] *Polytechnic Institute of Coimbra, Professor at Coimbra Business School|Iscac, Quinta Agrícola - Bencanta, 3040-316, Coimbra, Portugal*

[d] *University of Trás-os-Montes and Alto Douro, Quinta dos Prados, 5001- 801 Vila Real, Portugal*

Received 2 November 2018; revised 30 December 2018; accepted 9 January 2019

Available online 19 January 2019

Abstract

This paper discusses the real effects of diversification, risk, and performance for country-specific exchange-traded funds (ETF) investment vehicles, using a sample of twenty-two iShares for the period 2004–2015, which covers the global financial crisis. Typically, the delimitation of the periods of crises is based on noteworthy events, such as the collapse of Lehman Brothers. In this context, we consider an alternative approach to define the time frames to obtain a more detailed characterization of crisis periods, using a nonhierarchical clustering technique. This method comprises the clustering of the dates with similar ETF prices across countries, which allows the formation of relatively sequential time frames as a function of price volatility. We conclude that the benefits of diversification through this investment vehicle are limited, particularly in times of crisis, indicating the existence of contagion between funds that are indexes.

JEL classification: G11; C44; C61

Keywords: Clustering; Diversification; ETFs; Financial crisis; Principal component analysis

1. Introduction

One of the simplest investment methods is indirect international funds, because direct investment requires full knowledge of how the markets operate as well as interpretation of information that is somewhat complex. Moreover, these alternative investments are diverse, based on whether there is a bull or bear market. Identification of these periods is key for investor decision making.

We therefore use a new way of separating periods over the entire time frame in our study, which allows us to analyze the performance and the diversification of investment in exchange-traded funds (ETFs) before, during, and after the global financial crisis (GFC). We identify these time frames, which depend not on noteworthy events but on stock returns and thus differ from those usually reported in academic literature, using a nonhierarchical clustering technique to gain new insights on iShares.

ETFs can be defined as open-ended investment funds, traded on a stock market, which aim to attain a certain level of performance compared with a benchmark. ETFs are passive investment vehicles, which have become increasingly popular over a short period (Blitz and Huij, 2012). Like individual stocks, ETFs are traded in real time at a price determined by

* Corresponding author.

E-mail addresses: mneves@iscac.pt (M.E. Duarte Neves), carla.fernandes@ua.pt (C.M. Fernandes), pmartins@iscac.pt (P.C. Martins).

Peer review under responsibility of Borsa İstanbul Anonim Şirketi.

[1] Professor at the Polytechnic Institute of Coimbra-Coimbra Business School|ISCAC. Professor at University of Trás-os Montes and alto Douro-UTAD/CETRAD- FCT – Portuguese Foundation for Science and Technology under the project UID/SOC/04011/2013.

[2] CMAF-CIO – Faculty of Science of the University of Lisbon - Supported by Fundação para a Ciência e a Tecnologia (FCT), UID/MAT/04561/2013.

https://doi.org/10.1016/j.bir.2019.01.002

supply and demand (Madhavan, 2012). The first ETFs appeared in Canada in 1990, in the Toronto 35 Index Participation Fund (TIP), and since then the demand for ETFs has grown considerably, becoming an issue of interest to researchers (for an extended review, see Deville, 2008).

After Grubel's (1968) seminal work on the extension of portfolio analysis to international markets, a large number of empirical studies have also addressed the advantages of international diversification, because the correlation between domestic markets make them less effective for diversification.

In this regard, Coeurdacier and Guibaud (2011) report that investors actively rebalance their portfolio in favor of countries that offers superior diversification potential. Moreover, some authors argue that the co-movements between markets may change over time and vary in frequency (see, e.g., Ang & Chen, 2002; Rua & Nunes, 2009). If these correlations vary over time, they can also change significantly in times of financial crisis, affecting investment decisions in particular. For example, Forbes and Rigobon (1999), Ratanapakorn and Sharma (2002), Leong and Felmingham (2003), and Dalkir (2009) show that correlations between markets increase during volatile business cycles. Furthermore, Ahmed (2017) suggests that during financial crises herding behavior is present in almost every sector of the US stock market, because investors wish to copy presumably well-informed traders. Beine, Cosma, and Vermeulen (2010) also reveals that trade and financial integration have increased the probability that international equity markets will crash jointly, thus justifying the challenge of diversification during a market crash.

Finally, some authors have concluded that the benefits of international diversification have declined over time, because correlations among them have increased markedly in both developed markets (DMs) and emerging markets (EMs) (e.g., Bekaert, Hodrick, & Zhang, 2009; Chiou, 2008; Christoffersen, Errunza, Jacobs, & Langlois, 2012).

In this framework, although iShares have been marketed as a vehicle for international diversification, there is much debate as to whether securities listed on US exchanges really provide an effective method of diversification (Shin & Soydemir, 2010). Despite the advantages of using iShares over national stock market indexes, only a few studies have used iShares as proxies for foreign equity markets, and the results obtained to date are somewhat mixed or inconsistent.

For example, Phengpis and Swanson (2004) and Miffre (2007) studied the construction of optimal portfolios and concluded that iShares contain long-term information as an additional input to portfolio construction and hence enhance the benefits of diversification.

In general, studies on iShares focus on the international benefits of holding this type of ETFs and compare their performance to that of closed-end country funds (CCFs). In fact, the published academic literature has highlighted some of the benefits of the international diversification of portfolios through indirect investment (e.g., Rowland & Tesar, 2004). In the same way, it has been suggested that investors gain advantages from using indirect methods to build up internationally diversified portfolios and that the benefits of diversification were the same before and after the subprime crisis (Huang & Lin, 2011). In this context, Pennathur, Delcoure, and Anderson (2002) studied the diversification benefits of iShares through the application of single- and two-factor asset-pricing models to the prices of iShares for the period 1996−1999. They claim that the weak diversification potential of iShares might be related to the fact that their behavior is similar to that of the US market. Furthermore, they show that the return on iShares in the sample period considered is higher than that of the corresponding CCFs.

Many researchers have studied the performance of actively managed equity mutual funds, but the majority of them conclude that a relatively small number of active funds show persistent outperformance (see, e.g., Hendricks, Patel, & Zeckhauser, 1993; Elton, Gruber, & Blake, 1996; Carhart, 1997; Bollen & Busse, 2005). This is probably the main driver of passive investment vehicles such as ETFs.

Additionally, Rompotis (2011) reveals that the majority of the 50 iShares for the period 2002−7 outperform the market, using the S&P 500 Index as a proxy for benchmark returns. He also shows that the selected ETFs outperform the market, considering either the raw return or the risk-adjusted performance expressed by the Sharpe ratio and the Sortino ratio.

Harper, Madura, and Schnusenberg (2006) evaluate the performance of risk-adjusted prices of products and iShares and empirically show that passive investment strategies using iShares have a higher risk-adjusted performance than CCFs.

Phengpis and Swanson (2009) confirm that countries' ETFs are exposed to the movements of their underlying country indexes more than is the case in the US market, and for this reason they provide international diversification opportunities for US investors.

Tsai and Swanson (2009) show that the risk-adjusted returns on iShares are higher than those on CCFs, and with bigger diversification benefits.

However, although the latest empirical results seem promising for investors, some recent studies argue that even if indirect international diversification brings benefits, investors prefer to invest in their country of origin, rather than take advantage of foreign investment opportunities. Explanations for this home-bias phenomenon are in Berril and Kearney (2010) and Philips, Kinniry, and Donaldson (2012). As we can see, the benefits of international diversification have been widely discussed, and no consensus has been reached on its effective benefits. Tse and Martinez (2007) analyze the price discovery process and information transmission of twenty-four international iShares funds, concluding that these new financial products have limited diversification benefits. Their findings show that the prices of iShares are highly correlated with those of US iShares.

Analogously, Zhong and Yang (2005) suggest that iShares may not provide significant diversification gains because their movements are more closely related to the US market than foreign markets. Along the same lines, Barari, Lucey, and Voronkova (2008) also show that iShares are not perfect diversification products.

Regarding the profitability of iShares, Blitz, Huij, and Swinkels (2012) empirically show that the European index

funds and ETFs maintain performance clearly below their benchmark, suggesting that these results might be influenced not only by the cost of funds but also by taxes on dividends. Hence, this study allows us to assess, from the perspective of an international investor, the diversification benefits and performance for twenty-two funds of iShares in the period January 2, 2004, to December 31, 2015—before, during, and after the GFC. The funds studied here are mainly made up of assets in the Morgan Stanley Capital International (MSCI) index of each country.

Our results show that iShares underperform during the period of severe deterioration in financial markets. Furthermore, the sensitivity of these investment vehicles to these tremors provided fewer benefits from international diversification. Our results strongly suggest that both developed and emerging markets display similar sensitivity in iShares to systemic shocks, strengthened by principal component analysis (PCA).

This paper is organized as follows. Section 2 describes our data collection and methodology. Section 3 discusses the results. The final section presents our conclusions and suggestions for future research, based on the limitations in this study.

2. Data and methods

The data on daily prices of the twenty-two ETFs in iShares were gathered from Thompson Financial Datastream. Because we take the perspective of an international investor, all data were considered in US dollars.[3]

We used the interest rate on three-month Treasury bills as a proxy for risk-free interest rates, obtained from the database of the Federal Reserve Bank of St. Louis, where they are available on a daily basis, which is suitable for this purpose.[4]

We analyze the performance and diversification of investments in the twenty-two ETFs,[5] before, during, and after the GFC. Several authors have used this kind of approach to study the investment performance (as well as other aspects) at different moments, in particular, in times of crisis (see, e.g., Petajisto, 2013; Lean & Nguyen, 2014; Litimi, 2017; Mobarek, Mollah, & Keasey, 2014).

The usual delimitation of periods of crises is based on noteworthy events, such as the collapse of Lehman Brothers. This leads to different time frames for the beginning and the end of the GFC. For example, Meric, Lentz, Smeltz, and Meric (2010, 2012) take the period from October 9, 2007, to March 9, 2009, as the crisis period in the US as well as the other countries analyzed. Petajisto (2013) considers the period from January 2008 to December 2009 the financial crisis. Lean and Nguyen (2014) call the period from September 15, 2008,[6] to May 30, 2009, the crisis period. Mobarek et al. (2014) recognizes the crisis period as beginning August 9, 2007,[7] and ending December 31, 2009, arguing that the market turmoil begun in 2007, midyear, with the uncertainty surrounding the instability of the bank system.

Table 1
Mean and standard deviation of ETF prices in the twenty-two sample countries.

Country	Mean	St. Dev.	Country	Mean	St. Dev.
Australia	22.025	4.537	South Korea	49.385	12.498
France	26.014	5.180	Mexico	49.764	15.340
Germany	23.942	5.319	Italy	20.156	7.115
Sweden	27.140	6.250	Austria	21.966	7.659
UK	18.388	3.190	Brazil	49.210	19.609
Canada	25.516	5.347	Singapore	11.123	2.616
Hong Kong	16.573	3.684	Netherlands	21.596	4.433
Taiwan	13.174	2.028	Japan	11.215	1.729
Spain	39.213	10.043	Malaysia	11.320	3.218
Switzerland	24.146	5.781	South Africa	55.832	12.737
Belgium	16.475	4.843	US	139.952	33.337

Based on the criteria described above, we propose an alternative approach to defining time frames for a more detailed characterization of crisis periods, using a nonhierarchical clustering technique. In this way, using these periods, we examine diversification benefits and risk-adjusted performance using PCA.

2.1. Establishing time frames

Our data comprises the daily prices on twenty-two ETFs from iShares, from January 2, 2004, to December 31, 2015, a total of 3028 days. Table 1 presents the mean and standard deviation for each country's data. As mentioned above, their main investment component of these funds is assets underlying the MSCI index of each country.

$Price_{i,t}$ is the ETF price of country i on day t, for $i = 1, \ldots,22$ and $t = 1, \ldots,3{,}028$. We start by standardizing the data, defining the new standardized variable

$$SPrice_{i,t} = \frac{Price_{i,t} - \mu_i}{\sigma_i}$$

with μ_i and σ_i the mean and the standard deviation, respectively, of a country's ETFi prices.

Considering each daily vector of standardized prices across the countries: $SPrice_{\bullet,t}$ (representing the vector $SPrice_{i,t}$ for all $i = 1, \ldots,22$), for each day $t = 1, \ldots,3{,}028$, we use a clustering technique, k-means, to determine a partition of the days' vectors $SPrice_{\bullet,t}$ into clusters. k-means is a nonhierarchical clustering methodology that groups the elements (daily vector $SPrice_{\bullet,t}$) into independent clusters, such that the Euclidean distance (L2 norm) of the elements to their clusters' centroids is at the minimum. The k-means is described in MacQueen

[3] We assumed that international investors invest in US dollars, so we do not consider the variations in the exchange rates in the case of conversion of the investment returns into other currencies.

[4] We also use Kenneth French's database (http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html) for several countries.

[5] We do not include China's iShares in our database because the available information is not complete and proved to be insufficient for analysis.

[6] The bankruptcy of Lehman Brothers was announced on September 15, 2008.

[7] BNP Paribas ceased all its banking operations on August 9, 2007.

(1967), and an extensive number of applications and studies are revised in Jain (2010). A closely related approach was recently proposed in Martins (2017). In our case, we are not interested in observing the entire grouping framework, as in a hierarchical process, but in finding an adequate partition into a given number of clusters, so we optimize the clustering solution on a given number of clusters (k). To determine the appropriate number of clusters (parameter k value), we applied the k-means algorithm to some possible values of k, ranging between 2 and 6, for a putative number of clusters close to the number of groups related to the crisis in the entire range from January 2, 2004, to December 31, 2015. We used the R^2 ratio to assess the quality of the clustering solutions. Table 2 summarizes the k-means solution results for the k value range proposed. This also indicates the R^2 ratios and the best solution of the Euclidean distances to the solutions' centroids (column "best solution").

R^2 is the proportion of the variation explained by a particular clustering of the elements. It is defined by

$$R^2 = 1 - \frac{\sum_{i=1}^{22} SSW_i}{\sum_{i=1}^{22} SST_i}$$

with SSW_i the within-clusters variability (error sum of squares) and SST_i the total variability (total sum of squares), for each variable (country) i, for $i = 1, \ldots,22$, that is,

$$SSW_i = \sum_{j=1}^{k} \sum_{t \in Q^j} \left(SPrice_{i,t} - \overline{SPrice}^{j}_{i,\bullet} \right)^2 \text{ and } SST_i = \sum_{t=1}^{3028} \left(SPrice_{i,t} - \overline{SPrice}_{i,\bullet} \right)^2$$

Q_j represents the jth cluster (for $j = 1, \ldots,k$). $\overline{SPrice}^{j}_{i,\bullet}$ is the mean of variable (country) i*SPrices* for the days in cluster j, for $j = 1, \ldots,k$; and $\overline{SPrice}_{i,\bullet}$ is the overall mean of the *SPrices* for variable (country) i.

Considering the solutions in Table 2, we chose the partition involving five clusters ($k = 5$) for our study on the performance and diversification on the twenty-two ETFs, conducted in the next section. This is the solution with the smallest number of clusters with an R^2 of almost 0.8. This partition is shown in Fig. 1.

In Fig. 1, each point (in gray) represents a daily vector in its own cluster. The x-axis is the 3028 days (t) and y-axis measures the k clusters.

The clustering solution groups the day's sequentially, putting days with similar standardized prices in the same cluster. This way, we can clearly identify the periods in which prices have changed markedly, producing an automatic way to identify the periods with the most difference, based on their prices. This is an interesting methodology for determining the pre-crisis, crisis, and post-crisis periods. Thus, based on the division, we propose the following four periods for the forthcoming discussion, in which the third period is divided into two phases (see Fig. 2):

1. Stable period: from August 2, 2005, to November 21, 2006
2. Speculative period: from November 22, 2006, to August 6, 2008
3. Crisis period:
   a Severe phase: from October 2, 2008, to July 17, 2009
   b Post-severe phase: from July 20, 2009, to January 9, 2013
4. Recovery period: from January 10, 2013, to the end of the period (December 31, 2015)

We have not introduced any additional constraints to force the days to come up as the observed long sequential streams. In fact, this was an outcome of the clustering process over this data.

Fig. 2 distinguishes these periods, putting them in line with standardized prices along the entire period.

Between the periods and in the boundaries between clusters are days that involving two boundary clusters, in most cases, which are very short. In this case, to set fixed days for the boundaries, each mixed shorter period is added to the neighboring cluster most represented in the shorter period, that is, the majority of the elements (days) are in the shorter period. For instance, a few days are in cluster 1 in the shorter period from August 2, 2005, to August 30, 2005. However, the majority are in cluster 2. So, we made the boundary August 2, 2005, because most of the days in the shorter period are in cluster 2.

In addition, we ignored a few days between the speculative period and the severe phase, from August 7, 2008, to October 1, 2008, because those days' standardized prices are more similar to those in cluster 2 than to the clusters in the periods mentioned.

Another observation involving the clustering solution under discussion is that the severe phase standardized prices are in the same cluster as those before the pre-crisis period. In effect, the prices in the severe phase of crisis fall before mid-2005.

Also, there is a shorter period in the post-severe phase for which the standardized prices resemble to those in the recovery period. This shorter period is in the first semester of 2011, from January 27, 2011, to July 27, 2011. A reason for this is the sovereign debt in some European countries, with a slight rebound in the credibility of the institutions. Several audits were conducted, and recommendations were made for financial improvement, including recapitalization, which lead to a substantial improvement in the regulation.

One last observation involves the extension of the larger time interval up to the end of 2015. In fact, one pertinent question arises: when did recovery actually start? The extended interval can actually detach a long period in which recovery was probably attempted, here as the post-severe phase, but real recovery is observed only beginning in early

Table 2
k-means best solutions, their sum of the Euclidean distances, and R^2.

k	Best solution	R^2
2	9999.122	0.4214
3	8137.053	0.6321
4	6845.054	0.7268
5	6028.145	0.7929
6	5545.472	0.8225

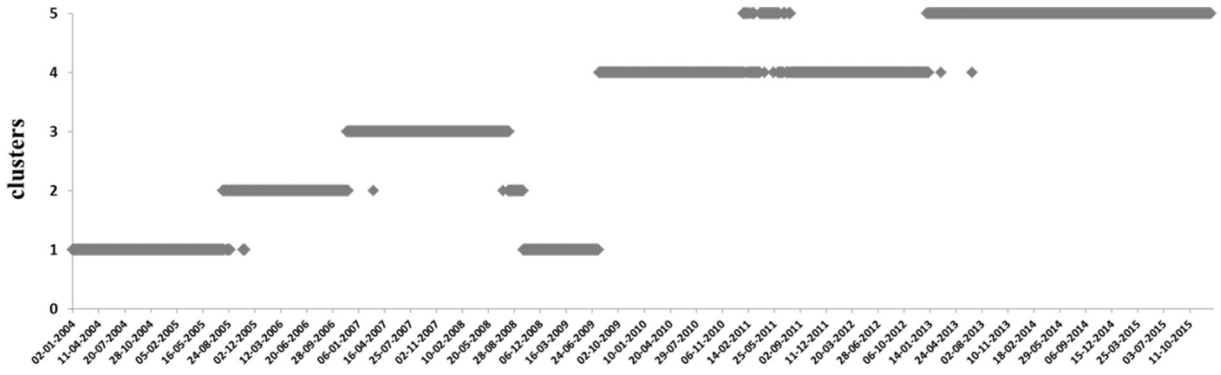

Fig. 1. k-means' clustering solution for $k = 5$.

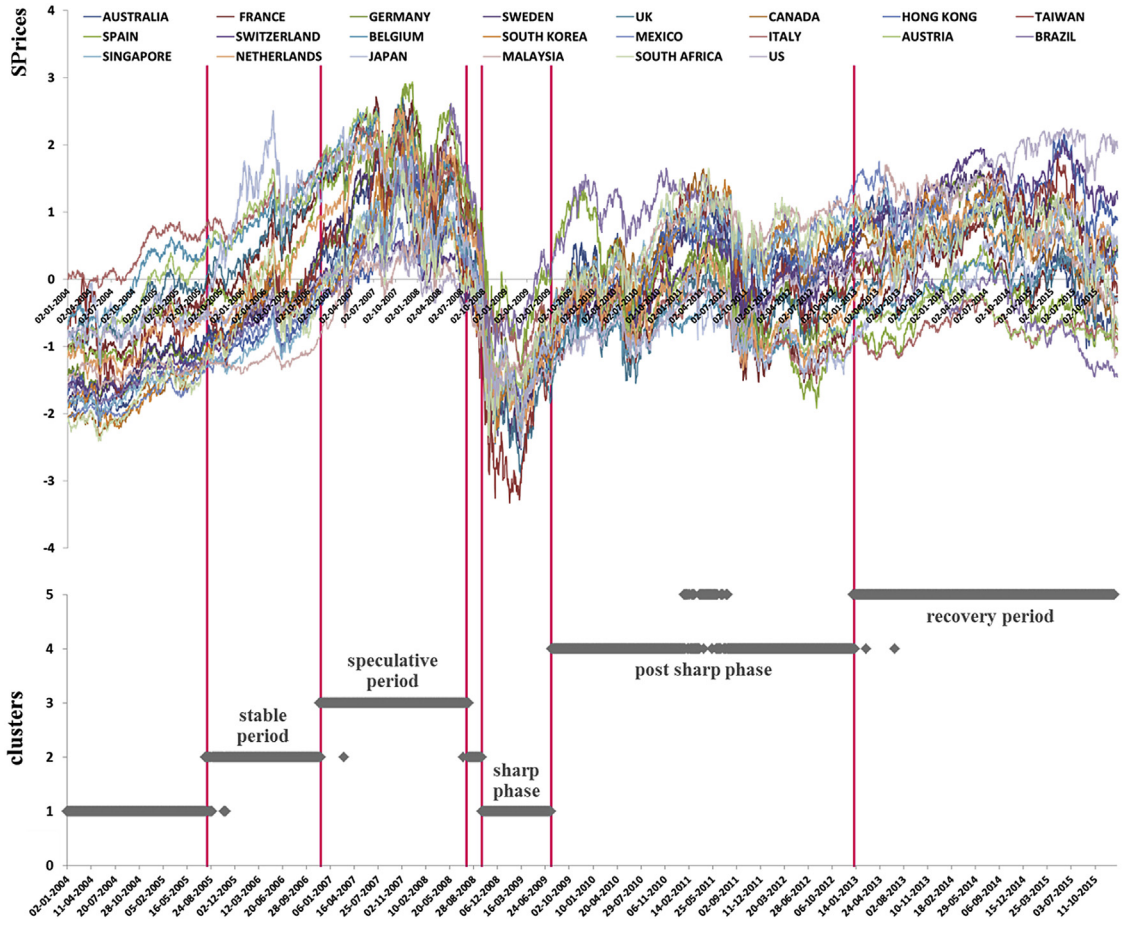

Fig. 2. The periods determined by the clustering solution projected over a graph of the standardized prices.

2013. In fact, this recovery actually occurred differently in each country, as mentioned in Didier, Hevia, and Schmukler (2012).

2.2. Discussing performance and diversification on the twenty-two ETFs

Given the proposed timeframes, we examine diversification benefits and risk-adjusted performance using PCA to capture the relationship between the twenty-two iShares, representing developed and emerging markets (following the classification used in Christoffersen, Errunza, Jacobs, & Jin, 2014).

To conduct our empirical study, we initially calculated the daily log returns of each fund:

$$R_{i,t} = log\left(\frac{Price_{i,t}}{Price_{i.t-1}}\right) \times 100$$

Then, to evaluate the performance of the funds, we calculated the Sharpe ratio (Reddy, 2016):

$$S_p = \frac{\overline{R}_p - \overline{R}_f}{\sigma_p}$$

where σ_p represents the standard deviation of the funds returns.

We conducted an analysis of the diversification benefits that an international investor may obtain by combining his investment in the twenty-two funds using the PCA technique, as in Meric, Welsh, Weidman, and Meric (2008b, 2010, 2011, 2012). This technique corresponds to a mathematical procedure that uses an orthogonal transformation to convert a set of observations of variables, possibly correlated, in a set of principal components. The application of the PCA results in the identification of groups, or clusters, such that intragroup correlation is greater than the correlation between groups. Each group contains funds that are more homogeneous, i.e., highly correlated. Thus, to obtain the principal components, we used the correlation matrix as input in the PCA technique, requiring, as a condition of extraction, that the eigenvalues are higher than one and varimax rotation. The objective is to obtain the loadings for funds with similar variability patterns in each of the principal components.

This procedure allows us to evaluate the diversification perspectives, since the funds grouped in the same principal component are strongly correlated, which means that investing in these funds will bring the investor weak diversification benefits. International investors should invest in funds with high loadings in different principal components, to obtain the maximum diversification benefits.

To evaluate the effects of the financial crisis on the performance of the funds and on the benefits of diversification, we applied the methods described above considering the previously identified time frames.

3. Results

As shown above, the results in prior literature are mixed as to whether diversification benefits exist when funds are allocated across international iShares.

In the first steps of our analysis, we calculate the measures for risk and performance (Table 3).

In the second period, the results show an increase in the levels of global risk in the majority of the funds, this means that volatility increases in this period. At the same time, the returns become negative, on average. Despite the price levels in this period (see Fig. 2), this is evidence of the turbulence that preceded the severe phase of the crisis. In this phase, the returns remain negative, in general, and the levels of risk continue high in the first period.

Therefore, no positive relationship is seen between risk and return, despite the most common theoretical assumptions in the literature. Anyway, this observation would gain additional inside if the time frame is longer, including many more bull and bear market events.

In the fourth period, despite the decline in the level of risk, the results show that investments in ETFs still had negative performance, on average, which indicates that the recovery in global markets is not yet been totally consolidated, although the patterns of prices seems to be reverting to the previous trend (see Fig. 2).

According to Meric, Ratner, and Meric (2008a), ETFs that replicate country indexes offer good opportunities to obtain high returns and diversification benefits during bull market periods; however, they are bad investments during bear market periods.

In the application of the PCA technique, one factor was extracted in the crisis period and two factors in the remaining periods (Table 4).

This result indicates a high correlation between markets during turbulent times, which led to a decrease in the benefits of diversification that ETFs can provide.

The results of this approach also show that European markets are significantly correlated, because they have high loadings in the first factor, regardless of the period analyzed. This result highlights that the benefits of diversification in Europe are very limited.

In non-crisis periods, European countries (developed markets) have high loadings on the first factor, while South Africa and countries in the Americas and Asia (most of which are emerging markets) have high loadings on the second factor. For example, this means that investors, whose portfolios include ETFs from countries in Europe, America, or Asia, achieve some degree of diversification in their investment. Conversely, during the crisis, the diversification possibilities are extremely limited, because all the funds are represented on the same factor.

Finally, the US ETF seems to have similar loadings in the two factors, that is, the fund was correlated with European, Asia, and Latin American countries.

Overall, the results are consistent with the findings of Meric et al. (2010, 2011).

Our results are in line with those of others, showing that market correlation increases during financial crises. Baig and Goldfajn (1999), for example, found that correlation between markets increased during the Asian financial crisis in 1997–98 and that the increase in market correlation is an indication of contagion. Dimitris and Dimitriou (2015) adopted a similarly strict definition of contagion as a significant increase in correlation between stock returns in different markets during a crisis.

4. Conclusion

In this paper, we examined the benefits of diversification, performance and risk for twenty-two iShares funds, regarding the temporal boundaries of the GFC.

The empirical literature examining the benefits to diversification using indirect investment vehicles is mixed. To contribute to the debate, this paper examines the question of whether a selected group of iShares is linked, whether such links were influenced by the GFC, and what the implications of these findings mean for diversification and risk-adjusted returns in developed and emerging markets.

After dividing the overall sample into four periods, using a nonhierarchical clustering technique (*k*-means), our results

Table 3
Measures for risk and performance of the ETFs iShares (Annualized data).

ETF	Period 1		Period 2		Period 3a		Period 3b		Period 4	
	Risk St. Dev. (%)	Sharpe Ratio (%)	Risk St. Dev. (%)	Sharpe Ratio (%)	Risk St. Dev. (%)	Sharpe Ratio (%)	Risk St. Dev. (%)	Sharpe Ratio (%)	Risk St. Dev. (%)	Sharpe Ratio (%)
Australia	4546	0,229	11,846	−0,137	7450	−0,075	5473	0,039	4423	−0,140
France	3602	0,207	9717	−0,164	7041	−0,185	6262	0,057	3955	−0,102
Germany	3913	0,233	9988	−0,168	5916	−0,132	6145	0,099	4083	−0,118
Sweden	4754	0,195	12,543	−0,115	7837	−0,002	6711	0,073	4025	−0,127
UK	3415	0,170	9945	−0,172	5733	−0,108	4592	0,102	3631	−0,174
Canada	3746	0,263	9543	−0,104	5438	−0,022	4192	0,033	3541	−0,210
Hong Kong	4697	0,201	11,053	−0,102	4401	−0,054	4196	0,090	4057	−0,026
Taiwan	5408	0,071	11,022	−0,095	5160	−0,031	4627	0,048	3993	−0,077
Spain	3771	0,278	9875	−0,123	9015	−0,208	7236	0,001	4700	−0,162
Switzerland	3407	0,209	7791	−0,131	5429	−0,056	4245	0,138	3023	−0,057
Belgium	3569	0,216	9730	−0,253	6713	−0,099	5139	0,082	3270	0,064
South Korea	5832	0,204	13,862	−0,113	6455	−0,026	5744	0,071	3741	−0,168
Mexico	5517	0,263	10,782	−0,093	5995	0,108	5010	0,078	3863	−0,197
Italy	3475	0,185	9913	−0,201	8115	−0,207	7474	−0,003	5097	−0,063
Austria	4323	0,279	11,190	−0,198	8112	−0,200	6184	0,031	3961	−0,147
Brazil	7539	0,252	14,663	−0,075	7547	−0,006	5578	−0,105	7299	−0,253
Singapore	4794	0,209	10,645	−0,090	4970	0,098	4393	0,026	3171	−0,189
Netherlands	3572	0,213	9749	−0,184	6732	−0,076	5456	0,077	3662	−0,059
Japan	4107	0,095	8558	−0,118	3817	−0,094	4286	0,066	3658	−0,008
Malaysia	4404	0,184	7609	−0,104	3883	0,203	3728	0,095	6323	−0,272
South Africa	6288	0,179	13,682	−0,085	7254	−0,010	6138	0,024	5998	−0,131
US	2550	0,124	7867	−0,149	4181	−0,013	3559	0,200	2978	0,072

Table 4
PCA results.

ETF	Period 1		Period 2		Period 3a	Period 3b	Period 4	
	Principal Components - *Loadings*							
	1	2	1	2	1	1	1	2
Australia	0.559	0.482	0.530	0.665	0.934	0.922	0.390	0.704
France	0.846	0.402	0.849	0.463	0.973	0.958	0.897	0.364
Germany	0.818	0.405	0.806	0.454	0.955	0.949	0.861	0.350
Sweden	0.803	0.404	0.822	0.393	0.927	0.933	0.785	0.390
UK	0.825	0.406	0.739	0.513	0.953	0.945	0.708	0.543
Canada	0.571	0.409	0.565	0.535	0.894	0.903	0.482	0.630
Hong Kong	0.307	0.815	0.395	0.807	0.915	0.843	0.296	0.671
Taiwan	0.296	0.781	0.324	0.802	0.871	0.817	0.285	0.784
Spain	0.850	0.392	0.818	0.424	0.959	0.872	0.841	0.316
Switzerland	0.821	0.357	0.792	0.422	0.917	0.900	0.750	0.386
Belgium	0.835	0.356	0.812	0.394	0.899	0.937	0.860	0.333
South Korea	0.354	0.798	0.401	0.829	0.886	0.881	0.287	0.765
Mexico	0.497	0.658	0.523	0.701	0.900	0.894	0.373	0.706
Italy	0.818	0.389	0.835	0.416	0.948	0.920	0.849	0.299
Austria	0.702	0.374	0.743	0.437	0.880	0.922	0.818	0.296
Brazil	0.445	0.694	0.535	0.688	0.930	0.878	0.283	0.668
Singapore	0.405	0.707	0.433	0.803	0.891	0.897	0.337	0.759
Netherlands	0.818	0.419	0.832	0.446	0.953	0.952	0.873	0.354
Japan	0.462	0.681	0.440	0.599	0.917	0.791	0.457	0.511
Malaysia	0.274	0.641	0.330	0.727	0.837	0.856	0.146	0.653
South Africa	0.556	0.577	0.626	0.616	0.916	0.890	0.372	0.726
US	0.572	0.575	0.590	0.673	0.959	0.933	0.634	0.559
Explained variance (%)	41.423	30.865	42.284	36.160	84.544	81.116	38.926	31.609
Cumulative explained variance (%)	41.423	72.288	42.284	78.444	84.544	81.116	38.926	70.534

clearly indicate that the twenty-two ETFs considered are not a great vehicle for diversifying investment, despite representing a substantial portion of global indexes. Furthermore, in the two phases of the crisis period, this evidence is more pronounced.

In fact, when straight PCA procedures were applied to the individual periods, we show that the benefits of diversification are insubstantial. At the same time, as expected, during the financial crisis, the risk-adjusted performance indicators of

iShares are negative. Nevertheless, the outcome is not surprising in view of current trends in globalization and the extent to which most financial markets are now interrelated. This conclusion derives from an interpretation of the results of the PCA in which only one factor was extracted, which indicates a high correlation between the funds, presenting these high loadings in the first and unique principal component.

These findings cast doubt on the desirability of international portfolio diversification, particularly during a market downturn, as shown by Vermeulen (2013).

Our results show evidence of contagion in iShares returns worldwide during the GFC, assuming an increase in correlation during a crisis compared to a stable period as evidence of contagion, following, for example, King and Wadhwani (1990) and Lee and Kim (1987).

These observations have important implications for international investment decisions, because an agent who invests in European and American ETFs has limited opportunities for diversification.

Another aspect to stress is the division of the time period into four relevant time periods, separating the most relevant periods, namely, before, during, and after the GFC. We used an independent technique to cluster the entire period, which does not depend on any events involving the GFC. This technique can be used as a benchmark for similar approaches in the future.

To the best of our knowledge, this is a novel approach that reveals the boundary dates for a clearer separation of the stages of crisis, in addition to pre- and post-crisis time periods. Moreover, this casts doubt on the desirability of international portfolio diversification, particularly during a market downturn, offering investors valuable information.

Other alternative investment variables could usefully be considered in future research. In addition, cultural factors could be introduced, as well as other countries with different institutional environments.

Conflict of interest

There is no conflict of interest.

Acknowledgments

This work was supported by European Structural and Investment Funds in the FEDER component, through the Operational Competitiveness and Internationalization Program (COMPETE 2020) [Project No. 006971 (UID/SOC/04011)]; and national funds, through the FCT (Portuguese Foundation for Science and Technology) under the project UID/SOC/04011/2013. It was also partially supported by the FCT under the project UID/MAT/04561/2013.

References

Ahmed, B. (2017). Herding effect on idiosyncratic volatility in U.S. industries. *Finance Research Letters, 23*, 121−132.

Ang, A., & Chen, J. (2002). Asymmetric correlations of equity portfolios. *Journal of Financial Economics, 63*, 443−494.

Baig, T., & Goldfajn, I. (1999). Financial market contagion in the Asian crisis. *IMF Staff Papers, 46*(2), 167−195.

Barari, M., Lucey, B., & Voronkova, S. (2008). Reassessing co-movements among G7 equity markets: Evidence from iShares. *Applied Financial Economics, 18*(11), 863−877.

Beine, M., Cosma, A., & Vermeulen, R. (2010). The dark side of global integration: Increasing tail dependence. *Journal of Banking & Finance, 34*, 184−192.

Bekaert, G., Hodrick, R., & Zhang, X. (2009). International stock return comovements. *The Journal of Finance, 64*, 2591−2626.

Berril, J., & Kearney, C. (2010). International diversification and the home bias puzzle. *Journal of Economics and Business, 62*(4), 235−256.

Blitz, D., & Huij, J. (2012). Evaluating the performance of global emerging markets equity exchange-traded funds. *Emerging Markets Review, 13*(2), 149−158.

Blitz, D., Huij, J., & Swinkels, L. (2012). The performance of European index funds and exchange-traded funds. *European Financial Management, 18*(4), 649−662.

Bollen, N., & Busse, J. (2005). Short-term persistence in mutual fund performance. *Review of Financial Studies, 18*(2), 569−597.

Carhart, M. (1997). On persistence in mutual fund performance. *The Journal of Finance, 52*(1), 57−82.

Chiou, W. J. P. (2008). Who benefits more from international diversification? *Journal of International Financial Markets, Institutions and Money, 18*(5), 466−482.

Christoffersen, P., Errunza, V., Jacobs, K., & Jin, X. (2014). Correlation dynamics and international diversification benefits. *International Journal of Forecasting, 30*(3), 807−824.

Christoffersen, P., Errunza, V., Jacobs, K., & Langlois, H. (2012). Is the potential for international diversification disappearing? A dynamic copula approach. *Review of Financial Studies, 25*(12), 3711−3751.

Coeurdacier, N., & Guibaud, S. (2011). International portfolio diversification is better than you think. *Journal of International Money and Finance, 30*(2), 289−308.

Dalkir, M. (2009). Revisiting stock market index correlations. *Finance Research Letters, 6*, 23−33.

Deville, L. (2008). *Exchange traded funds: History, trading and research, handbook of financial engineering*. New York: Springer.

Didier, T., Hevia, C., & Schmukler, S. L. (2012). How resilient and countercyclical were emerging economies during the global financial crisis? *Journal of International Money and Finance, 31*(8), 2052−2077.

Dimitris, K., & Dimitriou, D. (2015). Contagion of the global financial crisis and the real economy: A regional analysis. *Economic Modelling, 44*, 283−293.

Elton, J., Gruber, M., & Blake, R. (1996). The persistence of risk-adjusted mutual fund performance. *Journal of Business, 69*(2), 133−157.

Forbes, K., & Rigobon, R. (1999). No contagion, only interdependence; measuring stock market co-movements. *The journal of Finance*, 7267. NBER Working Paper Series.

Grubel, H. G. (1968). Internationally diversified portfolios: Welfare gains and capital flows. *The American Economic Review, 58*(5), 1299−1314.

Harper, J., Madura, J., & Schnusenberg, O. (2006). Performance comparison between exchange-traded funds and closed-end country funds. *Journal of International Financial Markets, Institutions and Money, 16*(2), 104−122.

Hendricks, D., Patel, J., & Zeckhauser, R. (1993). Hot hands in mutual funds: Short-run persistence of relative performance. *The Journal of Finance, 48*(1), 93−130.

Huang, M., & Lin, J. B. (2011). Do ETFs provide effective international diversification? *Research in International Business and Finance, 25*(3), 335−344.

Jain, A. K. (2010). Data clustering: 50 years beyond K-means. *Pattern Recognition Letters, 31*(8), 651−666.

King, M., & Wadhwani, S. (1990). Transmission of volatility between stock markets. *Review of Financial Studies, 3*, 5−33.

Lean, H., & Nguyen, D. (2014). Policy uncertainty and performance characteristics of sustainable investments across regions around the global financial crisis. *Applied Financial Economics, 24*(21), 1367−1373.

Lee, S. B., & Kim, K. J. (1987). Does the October 1987 crash strengthen the co-movements among national stock markets? *Review of Financial Economics, 3*, 89−102.

Leong, S., & Felmingham, B. (2003). The interdependence of share markets in the developed economies of East Asia. *Pacific-Basin Finance Journal, 11*, 219−237.

Litimi, H. (2017). Herd behavior in the French stock market. *Review of Accounting and Finance, 16*(4), 497−515.

MacQueen, J. (1967). Some methods for classification and analysis of multivariate observations. *Proceedings of the Fifth Berkeley Symposium on Mathematical Statistics and Probability, 14*(1), 281−297.

Madhavan, A. (2012). Exchange-traded funds, market structure, and the flash crash. *Financial Analysts Journal, 68*(4), 20−35.

Martins, P. (2017). *Goal clustering: VNS based heuristics arXiv Preprint arXiv:1705.07666*. Cornell University Library.

Meric, I., Gishlickb, H., Taga, L., & Meric, G. (2011). Risks, returns, and portfolio diversification benefits of country index funds in bear and bull markets. *Business and Economics Research Journal, 2*(1), 1−14.

Meric, I., Lentz, C., Smeltz, W., & Meric, G. (2010). Evidence on the performance of country index funds in global financial crisis. *International Journal of Business and Finance Research, 4*(4), 89−101.

Meric, I., Lentz, C., Smeltz, W., & Meric, G. (2012). International evidence on market linkages after the 2008 stock market crash. *International Journal of Business and Finance Research, 6*(4), 45−57.

Meric, G., Ratner, M., & Meric, I. (2008a). Portfolio diversification with country index funds. *Global Business and Finance Review, 13*(2), 1−9.

Meric, G., Welsh, C., Weidman, S., & Meric, I. (2008b). Returns and co-movements of domestic and country index funds: Global portfolio diversification implications. *Journal of Global Business Issues, 2*(2), 115−124.

Miffre, J. (2007). Country-specific ETFs: An efficient approach to global asset allocation. *Journal of Asset Management, 8*(2), 112−122.

Mobarek, A., Mollah, S., & Keasey, K. (2014). A cross-country analysis of herd behavior in Europe. *Journal of International Financial Markets, Institutions and Money, 32*, 107−127.

Pennathur, A., Delcoure, N., & Anderson, D. (2002). Diversification benefits of iShares and closed-end country funds. *Journal of Financial Research, 25*(4), 541−557.

Petajisto, A. (2013). *Inefficiencies in the pricing of exchange-traded funds*. WP New York University.

Phengpis, C., & Swanson, P. (2004). Increasing input information and realistically measuring potential diversification gains from international portfolio investments. *Global Finance Journal, 15*(2), 197−217.

Phengpis, C., & Swanson, P. (2009). iShares and the US market risk exposure. *Journal of Business Finance & Accounting, 36*(7-8), 972−986.

Philips, C., Kinniry, F., Jr., & Donaldson, S. (2012). The role of home bias in global asset allocation decisions. *Vanguard Research*.

Ratanapakorn, O., & Sharma, S. C. (2002). Interrelationships among regional stock indices. *Review of Financial Economics, 11*(2), 91−108.

Reddy, W. (2016). Evaluation of Australian industry superannuation fund performance; asset allocation to property. *Journal of Property Investment & Finance, 34*(4), 301−320.

Rompotis, G. (2011). Predictable patterns in ETFs' return and tracking error. *Studies in Economics and Finance, 28*(1), 14−35.

Rowland, P., & Tesar, L. (2004). Multinationals and the gains from international diversification. *Review of Economic Dynamics, 7*(4), 789−826.

Rua, A., & Nunes, L. C. (2009). International co movement of stock market returns: A wavelet analysis. *Journal of Empirical Finance, 16*(4), 632−639.

Shin, S., & Soydemir, G. (2010). Exchange-traded funds, persistence in tracking errors and information dissemination. *Journal of Multinational Financial Management, 20*(4−5), 214−234.

Tsai, P., & Swanson, P. (2009). The comparative role of iShares and country funds in internationally diversified portfolios. *Journal of Economics and Business, 61*(6), 472−494.

Tse, Y., & Martinez, V. (2007). Price discovery and informational efficiency of international iShares funds. *Global Finance Journal, 18*(1), 1−15.

Vermeulen, R. (2013). International diversification during the financial crisis: A blessing for equity investors? *Journal of International Money and Finance, 35*, 104−123.

Zhong, M., & Yang, H. (2005). Risk exposures and international diversification: Evidence from iShares. *Journal of Business Finance & Accounting, 32*(3−4), 737−772.