A three-tiered nested analytical approach to financial integration: the case of emerging and frontier equity markets

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This study investigates the patterns of integration of emerging and frontier equity markets with the US stock market during the period 2002-2014 characterised by financial turmoil and instability. To add rigour to the study, to overcome the limitations of simple correlation analysis of integration, and to produce more robust results, we propose a nested analytical approach based on a three-tiered research design. The first level uses the smooth transition conditional correlations among the US, emerging, and frontier markets. The second tier uses the results of the smooth transition approach to creating different international portfolios, which, based on alternative investment strategies, account for the time-varying correlations amongst markets and exploit the scope of international diversification with less integrated markets. Finally, the last tier of analysis uses returns and risks of these different international portfolios and applies structural models to explore characteristics and integration patterns in turbulent times. The three nested approaches indicate that the global financial crisis has produced a permanent increase in the degree of integration among the US and frontier markets. Conversely, the crisis's effect seems to have been only temporary in the case of integration among the US and emerging equity markets. Despite the changes brought by the crisis, the degree of integration among emerging markets and the US market is considerably more significant than the degree of integration among frontier and US markets. The novelty of this methodological approach enables us to provide some original contributions and empirical results that are robust and relevant to investors in international markets.

Key words: Markov Switching Regimes ARCH models, Smooth transition conditional correlation, optimal portfolio, diversification benefits, news approach.

JEL classifications: C1, G1.

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1. Introduction

This study aims to investigate to what extent the global financial crisis may have changed the interrelations and linkages between the US equity market with either emerging or frontier stock markets. It is widely recognized that the development of technologies, the removal of cross border barriers, and the prolonged low level of interest rates of major developed economies have given a substantial impetus to the worldwide trend in international financial markets integration. Emerging and frontier stock markets have become important destinations for foreign investors attempting to seek profitable diversification benefits.

Many empirical studies have analysed return spill-overs and volatility transmission among international stock markets to gain a clearer understanding of integration and predict portfolio opportunities and risk-sharing benefits. To ascertain whether equity markets are integrated or segmented is valuable information for both policymakers and investors. The formers are concerned about developments occurring in foreign equity markets as these might affect their own country's equity market. On the other hand, investors are interested in the degree of integration among domestic and foreign equity markets to evaluate potential gains from holding stocks traded domestically and abroad.

In the current literature, one of the indicators to proxy for international financial integration is represented by correlations and linkages among global stock indices (Vo, 2009). However, when multiple macro global factors drive returns, a simple correlation between the two stock markets may be a poor integration indicator. It is possible that two markets can be perfectly integrated and yet show a low degree of correlation if their country's stock market returns exhibit different sensitivities to these global macro factors. Moreover, correlation is only a pairwise measure of a linear association, and often it is desirable to move beyond pairwise connections and to accommodate nonlinearities.[3]

Other approaches that improve upon the use of correlation coefficients as a measure of integration have been developed. Among these are news-based measures that exploit the informative effect that global news has on price and yields of assets of those markets and countries which are globally integrated, while news of regional or local character is expected to exert an insignificant impact on prices or returns (Pukthuanthong and Roll, 2009). It is also widely recognized that stock market correlations increase during financial turmoil (see, for instance, Karanasos et al., 2016). Therefore, one can expect that the 2007-2008 global financial crisis, which had negatively affected developed economies' equity markets, might have affected the interrelations and the level of integration of these markets and the emerging and frontier equity markets (Pätäri et al., 2019).

To overcome the limitations of the simple correlation analysis, we investigate the changes in the degree of integration by proposing a new approach that addresses the following three empirical research questions: to what extent could periods of financial turbulence affect financial integration patterns? If changes in financial integration occurred, how could these changes affect different investors' portfolio decisions? If portfolio

[3] Alternative methodologies have been proposed to investigate the existence of non-linear relations between variables. Non-parametric measures such as Spearman's rank correlation coefficient, Kendall's rank correlation coefficient, and the Canova Method (Wang et al., 2015) are prevalent in measuring the association between variables. More recently, Ranjan and Najari (2019) proposed a new non-linear estimator useful for non-linear predictive models such as the support-vector-machine (SVM) model. Furthermore, Generalised-Additive-Models developed by Hastie and Tibshirani (1986) have been used to investigate the existence of non-linear relationships.

decisions were affected, what factors would influence different portfolios' performance in periods of unusual uncertainty and changes in the degree of financial integration? Given the three questions' sequential order, our approach uses a three-tiered nested research design to test hypotheses and investigate possible answers. In the first level, we address the first research question. We consider the financial interrelations between the emerging and US stock markets, taken as a proxy of developed equity markets, and between the frontier and US equity markets, and, following Aslanidis and Savva (2011) as well as Wang and Moore (2008), we measure these interrelations by applying a smooth transition analytical approach.[4] In doing so, we take the view that although higher correlation is not per se a necessary or a sufficient condition for integration, its presence could be a strong indication of it [5], and we accommodate nonlinearities by using a conditional perspective with time-varying correlations.

We exploit the smooth transition correlation analysis information to address the second research question and apply, in a second step, a portfolio diversification analysis through which we derive several hypothetical portfolios that reveal the outcomes of distinct diversification strategies in emerging and frontier markets. The main idea behind this approach is that the degree of integration with the US equity market affects diversification gains, both in terms of portfolio returns and risks.

Finally, we use a news-based approach to confirm the presence of interrelations and integrations among equity markets. To do so, we use the portfolio analysis results to address the third research question and investigate to what extent the returns and volatility of several hypothetical portfolios are affected by US economic and financial conditions and other global events in periods of prolonged and severe financial turmoil. Stronger reactions to US economic conditions and news reveal stronger integration with the US equity market. Therefore, this last structural type of analysis completes our three-tiered approach. It draws upon correlation and portfolio diversification analyses. It combines them with the news approach to provide a more robust answer to the original empirical question of how integrated the emerging and the frontier stock markets are with the US economy and how the crisis has affected these relations. Moreover, we believe that by identifying the main factors that have been relevant for international portfolio investors during the period 2002-2014, there are lessons to be learned when the management of portfolios is challenged by episodes of crisis and turbulence in the financial markets.

This sequential nested approach enables us to contribute to the current literature in the following three ways: firstly, by using market data at an aggregate level instead of regional or national data, we test and identify shifts in the integration among three equity markets at different stages of development throughout a period, which includes financial turmoil, low-interest rates, and use of unconventional monetary policies tools. Secondly, by extending our analysis to portfolio strategies, we can quantify the extent of diversification benefits for US-based

[4] We did not investigate the relationship between emerging and frontier markets, as these were analysed in Gupta (2014). In that study, an asymmetric dynamic conditional correlation model was used to investigate the relationship between several frontier market country-indices on the one hand and emerging and developed market country-indices on the other hand. Gupta (2014) found that frontier markets were less correlated with either emerging or developed markets than developed and emerging were among themselves. Furthermore, by performing an asset allocation analysis, Gupta (2014) found that global investors can improve their portfolio's performance by including stocks of companies listed on the frontier markets.

[5] Aslanidis and Savva (2011) recognize this limitation of the time-varying correlation, justify its use because the more integrated the markets are, the higher the co-movements between their prices become.

investors through a range of alternative portfolio strategies in markets more or less integrated with the US economy. Thirdly, by applying a third layer of structural analysis, we reveal and quantify the extent to which the returns and risks of international portfolios have been exposed to and affected by US economic factors, events, and unexpected economic surprises before and after the 2007 2008 financial crisis. The third set of results confirms the outcomes of previous layers of analysis on the degree of integration of emerging and frontier markets with the US equity markets and adds robustness to our findings.

The remainder of the paper is organised as follows. Section 2 discusses the relevant literature related to our approach based on three different layers of analysis. Section 3 describes the methodologies of each of these layers of analysis, while Section 4 presents the data. In Section 5, we report and discuss the smooth transition conditional correlation's empirical results and the portfolio diversification analysis. In the same section, we present the results of the structural approach that builds upon the results of the previous two tiers of analysis and combines them with the news approach to offer a more fruitful approach to the investigation of the integration of financial markets before and after the events of the 2007-2008 financial crisis. Section 6 concludes the paper.

2. Literature review

The literature review is organized as follows: firstly, we briefly review that part of the literature that focuses on correlation and contagion effects as an indirect measure of integration amongst markets; secondly, we review another part of the literature that focuses on time-varying volatility and degree of exposure to global events and news.

2.1 Correlation and contagion

A growing body of empirical literature investigates the financial integration of either emerging or frontier markets with their developed counterparts by looking at either stock market prices or correlation values as indicators of integration.[6] This developing area of research can be differentiated into four main strands following different methodologies used to detect the degree of integration among markets under study.

A first strand investigates equity market integration via the principal component analysis approach. For instance, Berger et al. (2011) find that frontier markets are still far from being integrated with the world market, although there is evidence that intermittent integration periods characterise the relationship between the frontier and world markets.

A second strand of the literature uses a smooth transition analysis approach. The main motivation in using this approach is to look at the speed at which markets become integrated. For instance, Savva and Aslanidis (2010) have used this approach to show that emerging stock markets in Eastern Europe have become more integrated with developed stock markets in the Euro area. Their findings show that integration among emerging and developed markets has increased over time.

A third strand of the literature uses various versions of multivariate GARCH models. For instance, Chiang et al. (2007) used a dynamic multivariate GARCH model to investigate pairwise correlations among eight Asian

[6] An alternative definition of stock market integration assumes that markets are integrated when the expected return of assets with identical risk is the same (Schotman and Zalewska, 2006).

stock markets during the 1997-1998 Asian financial crisis. They found a significant rise of correlation over the crisis period while a decline was observed in the post-crisis period. Baumöhl and Lyócsa (2014) investigated the correlation level among either emerging or frontier markets with a world market index by using a dynamic conditional correlation GARCH model (GARCH DCC). Their results show a low correlation between emerging and frontier markets with developed markets during normal times, while correlations tend to increase during periods of financial turmoil.

Sukumaran et al. (2015) investigated the degree of correlation and international portfolio diversification benefits by considering Australian, US, and frontier equity markets. Using a GARCH asymmetric dynamic conditional correlation (GARCH-ADCC) model, they found a lower correlation between the US and frontier markets than Australian and frontier markets. Secondly, via a portfolio analysis, they also showed that portfolio diversification benefits from an Australian investor's perspective are significantly lower than from a US investor's perspective.

More recently, Daugherty and Jithendranathan (2015) investigated the integration of twenty frontier equity markets with the US equity market. Using a bivariate GARCH DCC model, the authors found a significant regional variation in the level of integration among these markets. Alotaibi and Mishra (2017) also use GARCH DCC models to investigate the level of integration among the Gulf Cooperation Council (GCC) equity markets over the period 2002-2013. Their findings show that some markets are more integrated, although none of the GCC stock markets are entirely segmented to the others. Finally, Dutta (2018), using a bivariate VAR GARCH model, found evidence of a high correlation between the US, Brazilian and Chinese stock markets, highlighting a reduction in portfolio diversification benefits for international investors interested in diversifying their portfolios across the markets under study.

A fourth strand of the literature is based mainly on cointegration methodologies. For example, Égert and Kočenda (2007) use a battery of cointegration tests to investigate the degree of integration among Eastern European stock markets with selected major markets in the European Union (EU). Guidi and Ugur (2014) investigate the extent to which South-Eastern European equity markets are integrated with two leading markets, such as the UK and US equity markets. Their findings show evidence of intermittent time-varying integration. In a more recent study, Guidi et al. (2016) investigated the extent to which the Greater China stock markets are integrated with either the US or the UK stock markets. Their findings clearly show that the mainland China stock market is still far from fully integrated with either the US or UK equity markets.

Except for Guidi and Ugur (2014), Sukumaran et al. (2015), and Guidi et al. (2016), analysis of the degree of integration (or segmentation) does not extend to quantify the scope and benefits of international portfolio diversification. Our paper, in tier two, enables us to push the analysis further and highlight the implications that time-varying integration could have for international investors.

2.2 Spillovers: time-varying volatility and the news approach

The strands of literature we have reviewed so far have focused on returns correlations and contagion effects as a direct or indirect measure of integration. However, international integration entails more than correlation.

Integration usually is the result of major reforms in the financial and real sectors of the economy, often prompted by political and policy decisions, and as such, it is a slow-moving time-varying process. While cross-correlations can show temporary changes, integration is more likely to trend or move slowly than to revert quickly.

In normal times, when countries become more financially and economically integrated, the cross-market correlations of their equity markets increase, the risk of contagion increases, and countries are less protected from the risk of common global shocks. However, during a period of turbulence, the rising of cross-country correlations may result from increasing volatility due to common shocks rather than the result of increasing integration.

In this spirit, another strand of literature has focused on time-varying volatility spillover effects amongst integrated markets (see, for instance, Baele, 2005; Asgharian and Nossman, 2011). In a recent study, Karanasos et al. (2016) combined the two approaches and showed the existence of time-varying correlations and shock and volatility spillovers amongst European and Asian stock markets during 1988-2010.

An alternative approach to integration makes use of structural models to assess if the performance of assets is more dependent on global and foreign than on local and regional factors, by linking the presence of spillover effects not just to financial contagion, but also to monetary policies, global sentiments, and other economic variables (see, for instance, Belke et al., 2011). In this view, when markets become more integrated, equity returns are more exposed and react more strongly to global and US-wide market risk and less to local risk. Baele and Inghelbrecht (2009) add structural economic variables to the traditional Asymmetric GARCH specification and argue that stocks increased reactions to cash flow news (generally associated with economic integration) and/or to discount rate news (associated with financial integration) are a good indication of an increased convergence of equity markets.

The effects of unexpected macroeconomic surprises on stock markets have been widely investigated in the empirical literature. Several studies (see, for instance, Fair, 2003; Birz and Lott, 2011) found that, due to the leading role of the US in the world economy, the release of US macroeconomic announcements attract the interest of stock markets worldwide and produce significant effects on those financial markets more integrated with the US economy. Among all variables, the *Fed* rate is one of the most closely watched by equity market participants (Bernanke and Kuttner, 2005; Chan et al. 2008), together with the rate of US inflation (Moerman and Van Dijk, 2010), US labour market dynamics, GDP, unemployment, retail sales and durable goods (Birz and Lott, 2011), and finally the US nonfarm payroll, which is indicated to be the 'king of all news' (Andersen and Bollerslev, 1998; Wongswan, 2006). Finally, the forward-looking Institute for Supply Management (ISM) index is important because, by monitoring employment, production, new orders, and inventories, it describes the US economy's perceived state.

It is recognised that the impact of macroeconomic news on stock returns depends on the content of the news (good news versus bad news), on the phase of the cycle, and the characteristics of firms such as market capitalisation and book to market ratios (Cenesizoglu, 2011). More recently, Caporale et al. (2016) considered the effect of news on the stock returns and their volatility. Using a VAR-GARCH in mean approach, Caporale et al.

(2016) found that stock returns tend to respond more to negative rather than positive news, particularly during periods of financial turmoil.

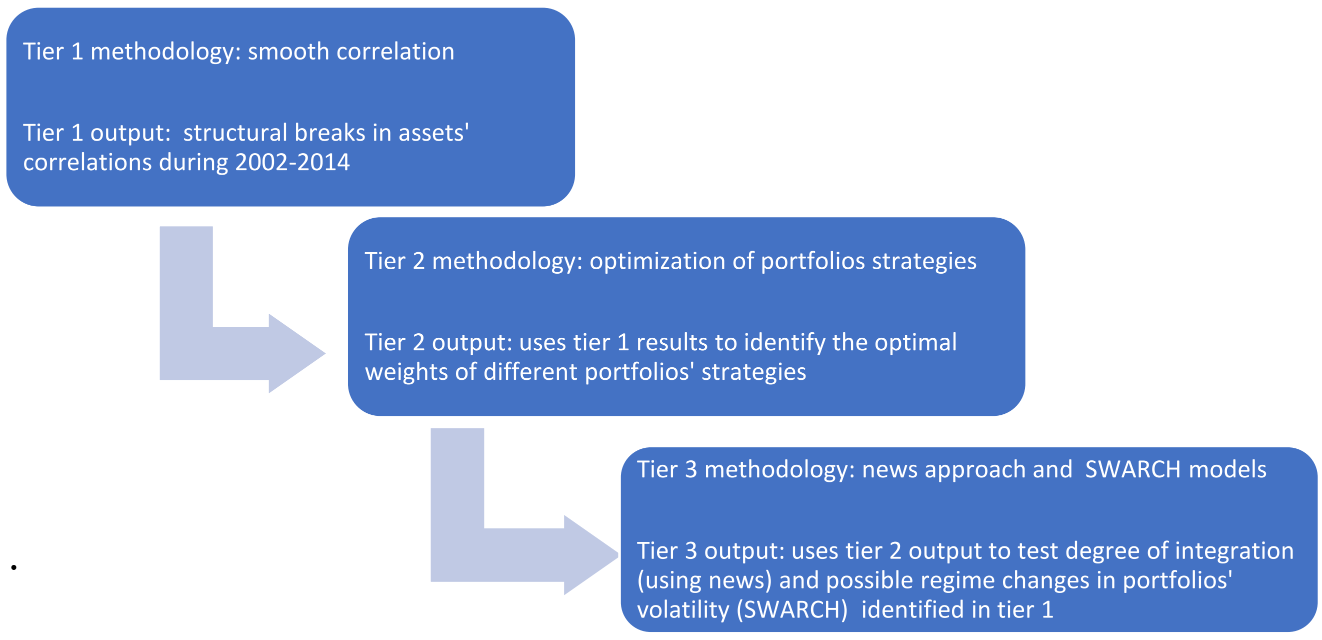
Our study positions itself between these two strands of literature. Following the spirit of Karanaos et al. (2016), we differentiate between time-varying conditional correlation and time-varying volatility breaks. In the spirit of Belke et al. (2011), we assess if and when international portfolios become more responsive to global events and US news. Our approach is nevertheless a novelty in using a three-step approach that enables us to consider the intertwined relations of time-varying contagion, international diversification, and time-varying integration of markets in a period of high uncertainty.

3. Methodological framework: three-tiered analytical design of the nested approach

As explained in the introduction section, the methodology we propose to study the issue of integration is based on a nested approach (see Diagram 1) which is based on three tiers, each building on the results of the previous step, to investigate portfolio diversification benefits and market linkages across the US, emerging and frontiers equity markets during the turbulent time of the 2007-2009 global financial crisis.

We need to clarify that the term nested is referred to the research design and not to an econometric model setting and testing. We do not compare models of different tiers with likelihood ratio tests, as would be done in an econometric analysis where the nested model is a subset of an original model and hence directly comparable with it. In this study the term nested refers to the structure of the research strategy, designed in a sequence of three tiers, and each subsequent tier embeds elements obtained from the previous step. This nested structure is explained in Diagram 1.

Diagram 1 – The three-tiered nested analytical approach and results.



The tier-one we focus on the first research question and investigate patterns of correlation of pairs of assets (US/EM and US/FM) without combining them in any specific way. We explore the extent to which the conditional variances and correlation among these assets' returns can vary over time, particularly during periods of financial turbulence. Tier-one uses a smooth transition methodology to test for changes in patterns of integration, and the dates and speed at which these changes occur. The information obtained in tier-one is then used in tier-two in the following way. A change in the conditional correlations among assets would affect portfolio diversification benefits and prompt investors to rebalance their portfolios. In tier-two, we combine assets into portfolios and exploit the changes in correlation regimes to answer our second research question. We assume different types of investors and three investment strategies: the equally weighted portfolio (EQWP) strategy, the minimum variance portfolio (MVP) strategy, and the certainty equivalency tangency portfolio (CET) strategy.

We then study how these portfolios' performances could be influenced by events, factors, and macroeconomic surprises that have occurred prior, during, and after the turbulent years of the 2007-2009 crisis. This third tier focuses on the last research question, and it deals with portfolios created in tier-two, which in turn, were based on information obtained from tier-one. The methodology followed in this part of the empirical analysis is based on the SWARCH analysis to allow these portfolios' conditional volatility to change across possible regimes, estimated together with the expected conditional returns.

The equation of the conditional mean of the SWARCH model has, in addition to the usual 'fundamentals', news variables, expressed as dummies that captured the effects of surprises (unexpected values) of selected macro variables on the week these were released. Among all news, the ones that undoubtedly attract investors' interest in both the US and non-US stock markets are the macroeconomic announcements about the US economy. Thus, by assessing the impact of this news on various portfolios, we can gain more valuable insights into the degree of integration between stock markets. To simplify our methodological framework's exposition and explanation, we organise the discussion in the following three sub-sections.

3. 1 The methodology of tier one: the smoothing transition conditional correlation analysis

Empirical studies of equity markets integration have employed a variety of methodologies to identify and test patterns of correlations. Popular among these methodologies is the dynamic conditional correlation (DCC), which aims to detect the presence of time-varying integration by applying multivariate GARCH (MGARCH hereafter) models (Engle, 2002). MGARCH models allow the conditional correlations to vary but cannot detect possible structural changes in correlations. In other words, MGARCH models do not allow for different correlation regimes and the possibility to change over time from one regime to another.

Two approaches can be used to test and allow structural changes in correlation. The first is by arbitrarily splitting the data into subsamples, imposing the dates for structural changes exogenously, and allowing correlations to switch abruptly from one regime to another at those dates. This method has the statistical flaws of imposing arbitrary dates and relying on a weak test, producing possible biased results.

The second approach, the smooth transition analysis, is based on Berben and Jansen (2005) and it overcomes these deficiencies. This approach uses a GARCH model, and the entire sample enables us to endogenously detect and test the occurrence of two or more correlation regimes and the possibility to change from one regime to another over time in a smooth way. By using the entire sample of observation and the class of GJR-GARCH (i,j) model, with smoothly time-varying correlations modelled as first order logistic transition function, it is possible to estimate simultaneously, and test three sets of parameters: the state constant correlation coefficients of each regime across which the smooth transition occurs; the date at which the transition from one correlation regime to another is half way through; the smoothness and speed at which the monotonic transition from one regime to another has occurred.

In this study, we use this smooth transition analysis approach and investigate the speed at which the integration level[7] among US markets and the emerging and frontier markets might have changed over time. We take this information as a first indication of market integration. We base the choice of such an approach on considering that the integration among the markets under study might change as a gradual process. As pointed out in several studies (see, for instance, Chelley-Stelley 2005; Savva and Aslanidis, 2010; Aslanidis and Savva, 2011), the smooth transition analysis is an approach used to detect structural breaks denoted as smoothed transitions between regimes over time. Therefore, these models are suitable to measure structural changes in the level of integration among markets.

Our starting point is to assume that the mean equation for the two-dimensional stock returns vector is modelled as a VAR model. Then, each conditional variance is assumed to follow a univariate GJR-GARCH(1,1) process.[8] The conditional correlations between the standardized errors are modelled by using the smooth transition conditional correlation (STCC) and double smooth transition conditional correlation (DSTCC) models (Berben and Jansen, 2005; Silvennoinen and Teräsvirta, 2005; Silvennoinen and Teräsvirta; 2009), which allow correlations to be time-varying. The STCC model assumes the presence of two regimes with state specific constant correlations. However, these correlations are allowed to change smoothly between the two regimes as a function of observable transition variables. More specifically, the conditional correlation is calculated as follows:

$$\rho_t = \rho_1\big(1 - G_t(s_t;\gamma,c)\big) + \rho_2 G_t(s_t;\gamma,c) \qquad (1)$$

in which the transition function $0 \leq G_t(s_t;\gamma,c) \leq 1$ is a continuous function of s_t, while γ and c are parameters. A widely used specification for the transition function is the logistic function:

$$\mathrm{G_t(s_t;\gamma,c)} = \frac{1}{1+\exp\left(-\gamma(\mathrm{s_t}-\mathrm{c})\right)} \qquad \gamma > 0 \qquad (2)$$

where the threshold parameter c locates the midpoint between the two regimes. The parameter γ determines the smoothness of the change in G_t as a function of s_t. As $\gamma \to \infty$, G_t becomes a step function ($G_t = 0$ if $s_t < c$ and $G_t = 1$ if $s_t > c$) and $G_t = 1$ so that the transition between the two extreme correlation states becomes

[7] As Aslanidis and Savva (2011) pointed out, the rationale of using correlation coefficients as a measure of market integration is based on the consideration that higher integration among markets results in higher co-movements between their returns. It must be pointed out that a higher correlation among markets is a necessary but not a sufficient condition for greater market integration.

[8] The GJR-GARCH model was proposed by Glosten et al. (1993) to overcome GARCH weaknesses in capturing the asymmetric effects of news.

abrupt (Savva and Aslanidis, 2010). In that case, the model approaches a threshold model in correlations. Since we are interested in modelling temporal change, the transitional variable is a time trend ($s_t = t/T$). Thus, we can identify the exact point of change for the correlations of the markets. The STCC model allows only for a single change in correlation between the markets. However, this may not be a sufficient description of the data. The DSTCC is a generalization of the single STCC and can be implemented by using the following equation:

$$\rho_t = \rho_1\big(1 - G_{1t}(s_t;\gamma_1, c_1)\big) + \rho_2 G_{1t}(s_t;\gamma_1, c_1)\big(1 - G_{2t}(s_t;\gamma_2, c_2)\big) + \rho_3 G_{1t}(s_t;\gamma_3, c_3)(G_{2t}(s_t;\gamma_3, c_3) \qquad (3)$$

The second transition variable in equation (3) is also a function of time; hence equation (3) allows the possibility of a non-monotonic change in correlation over the sample.

3.2 The methodology of tier two: the diversification portfolio analysis

The degree of financial integration is crucial in determining whether international investors benefit from diversifying their portfolio across international stock markets. Portfolio theory suggests that diversifying across less integrated markets will reduce the risk associated with portfolio holdings. Therefore, by considering US-based investors' point of view, we investigate to what extent there might be benefits for US investors in diversifying their portfolio holdings among either emerging and frontier markets in alternative to a US-only portfolio. We assume that investors are 'retail' type, unsophisticated and with a preferred habitat[9]: some of them will only invest domestically, some others will consider international portfolios. Among the latter, some will have more knowledge and feel more comfortable investing only in the pair of domestic and emerging market assets (US/EM). These investors could be concerned about the risks often associated with frontier markets such as political instability, poor liquidity, inadequate regulation, and large currency fluctuations. However, other US-based investors will prefer the pair of domestic and frontier market assets (US/FM). These investors could be deterred by the high correlation between US and emerging assets and attracted by the opportunities created by the low correlation between the US and the frontier stock markets.

We assume that those who invest in international assets can be of one of the following three types: a risk-averse type of investor, a maximizing returns seeker type of investor, both following optimization strategies, and a naive or inactive investor, who never re-adjusts the composition of the portfolio. This last type of investor and the US-market only investor, have been included for the comparative purpose of understanding the patterns of portfolio performances not linked to portfolio rebalances. Given the preferred 'habitat' assumption, the inactive investor will follow a simple strategy called *Equal Weighted Portfolio* (EQWP) and invest half of their portfolios in US stocks and the other half either in emerging equity markets or in frontier equity markets.

The expected return, $E(r_p)$, of the EQWP is given by the sum of expected returns, $E(r_i)$, in each equity market *i* included in the portfolio, that is:

$$E(r_p) = \sum_{i=1}^{2} w\, E(r_i) \quad with \quad w = 1/2 \qquad (4)$$

[9] The preferred habitat theory is a term structure theory of the interest rate that suggests that different bond investors prefer one maturity length over another and are only willing to buy bonds outside of their maturity preference if a risk premium for the maturity range is available. In our study, the US-based investors who are willing to invest internationally, prefer one international market (either emerging or frontier) over the other and are not inclined to buy outside their market preferences.

Analogously, the portfolio variance is given by:

$$V(r_p) = w^2\sigma_i^2 + w^2\sigma_j^2 + 2\ w^2\sigma_{ij} \qquad w = 1/2 \qquad (5)$$

where σ_{ij} is the covariance between US-emerging or US-frontier markets. As shown in equation 4, the composition of the domestic and international assets of the EQWP portfolio is constant over time. Thus, this portfolio serves as a reference point against which to measure the advantages of changing the assets' quotas in front of systematic market risks.

The second type of investor, the risk-averse type, will choose a *Minimum Variance Portfolio* (MVP) strategy to create a portfolio with the lowest possible variance. Conservative investors usually prefer this strategy. The MVP approach is solely based on the second moment of the assets in the portfolio. The following minimization problem implements the MVP strategy:

$$\text{Min} \quad \sigma_p^2 = w_i^2\sigma_i^2 + (1-w_i)^2\,\sigma_j^2 + 2w_i\,(1-w_i)\sigma_{ij} \qquad 0 \le w_i \le 1 \qquad (6)$$

The third portfolio strategy we consider is the *Certainty Equivalency Tangency* (CET), which is closer to the MVP since a rational, risk-averse investor will always choose a portfolio that has a moderate slope of the efficient frontier and, in the case of the MVP, not extreme values which are close to zero to infinity. The CET is referred to as the portfolio with the highest Sharpe ratio, and the CET portfolio strategy is implemented through the following maximization problem:

$$\text{Max} \quad CET = \frac{w_i[E(r_i)-r_f] + (1-w_i)[E(r_j)-r_f]}{\sqrt{w_i^2\sigma_i^2 + (1-w_i)^2\,\sigma_j^2 + 2w_i\,(1-w_i)\sigma_{ij}}} \qquad (7)$$

where r_f is the risk-free rate. Equation (7) indicates that the optimal portfolio composition depends on the expected risk premium of each component on its expected excess return over the risk-free rate and on the covariance matrix (Braga, 2016). Given our preferred habitat assumptions, the quotas of the MVP and CET portfolios refer only to the choice between two pairs: the US and emerging (USEM) or US and frontier markets (USFM). These quotas will change over time when investors rebalance their portfolios.

We implemented the EQWP, MVP, and CET strategies by excluding short selling, which implies that weights should not be negative, that is $w_i \ge 0$, for $i = 1,2$. By combining market preferences and the portfolio strategies, we end up with seven different portfolios: four optimal portfolios for USEM (USEM_MPV; USEM_CET) and USFM (USFM_MVP and USFM_CET) and three constant quota portfolios (US; USEM_EQWP; USFM_EQWP).

3.3 The methodology of tier three: volatility and returns of portfolios: the structural model

Our analysis has considered the point of view of US-based investors and their preferences regarding holding portfolios. Based on these preferences, we identified three types of investors following the three types of strategies described in the above section. A step forward in our analysis is to investigate how and to what extent external economic factors, fundamentals, and other US economic surprises (news) could affect these different portfolios' performances.

As pointed out earlier, we use a set of US macroeconomic announcements made by US government agencies and provided by *Econoday* and *DataStream*. A relevant question is whether and to what extent macroeconomic announcements affect portfolio decisions. Moreover, during the period under consideration, financial markets experienced large volatility because of the 2007-2009 financial crisis, unconventional measures of monetary policies, and uncertainty about expected policy changes in quantitative easing. These events may have caused structural changes in the volatility of the stock market returns. We use a regime-switching ARCH (SWARCH) model to investigate possible shifts of volatility, which allows the conditional volatility to be both time and state-dependent. In this way, the ARCH model's parameters can change between regimes with a switch governed by a discrete-time Markov process. Hamilton and Susmel (1994) and Canarella and Pollard (2007) argue that when a SWARCH is applied, the model has a better fit, and the volatility persistence is reduced. Moreover, failing to account for volatility breaks may lead to an overestimation of the true variance of the process and, in a conventional ARCH model, and a high degree of persistence of the conditional variance. A detailed discussion of Markov switching models can be found in Hamilton (1989), Hamilton and Susmel (1994), and Kim and Nelson (1999).

A SWARCH model enables us to account for these possible structural, endogenous switches, and it allows the parameters of the conditional variance to change in the presence of structural breaks. Its implementation requires a decision about the number of these regimes. In the spirit of the Hamilton and Susmel (1994) and Canarella and Pollard (2007) studies, we assume the conditional mean is not state-dependent, and that portfolio returns follow an autoregressive structure of some order. However, in contrast to those studies, we enrich the SWARCH model by also including other explanatory variables such as the ‘surprise’ news of some critical US economic indicators, some relevant fundamentals (interest rates and exchange rates), a dummy to account for the presence of the financial crisis and three dummies to account for the three waves of quantitative easing in the US. Interaction terms of the financial crisis dummy with news and fundamentals are also considered.

We estimate the ARCH-*t* distribution specifications of the $AR(i) - SWARCH(j,q)$ model with $i = 1,2; j = 1,2,3$ and $q = 1,2$. The observed equation of the SWARCH model tests the effects of news, fundamentals, past events, and past returns on current returns of portfolios of different types of investors within each preferred habitat. The generic SWARCH model of a portfolio can be represented as follows:

$$r_{m,t} = \alpha + \sum_i \beta_i \, r_{m,t-1} + \widetilde{\gamma}' \widetilde{X_t} + v_{m,t} \quad i = 1..n; \;\; m = portfolio\ type \tag{8}$$

$$v_{m,t} = \varepsilon_{m,t}\sqrt{g_m(s_t)} \tag{9}$$

$\widetilde{X_t} = matrix\ of\ fundamental, news\ and\ dummy\ variables;$

$s_t = j\ \ state\ variable; \quad j = 1, 2, 3;$

$j = 1\ low\ volatility\ state;$

$j = 2\ medium\ volatility\ state;$

$j = 3\ high\ volatility\ state;$

$$\varepsilon_{m,t} = \sqrt{h_{m,t}}\ u_{m,t} \qquad\qquad u_{m,t} \sim t_k(0,1) \tag{10}$$

$$h_{m,t} = \pi_{m,0} + \lambda\ \varepsilon_{m,t-1}^{2}\ I_{\varepsilon<0}(\varepsilon_{m,t-1}) + \sum_{q} \pi_{m,q}\, \varepsilon_{m,t-q}^{2} \quad q = 1,2 \qquad (11)$$

$I = indicator\ function\ for\ \varepsilon < 0;$

$if\ \lambda > 0\ \ negative\ residuals\ tend\ to\ increase\ the\ variance;$

The conditional volatility h_t (Equation 11) obeys an ARCH(q) *t* model, with *k* being the degrees of freedom of the Student's *t* distribution (Equation 10). However, the ARCH model parameters are not constant and can change depending on the state *j*, so the volatility is a state variable that follows a first order: *j-state* Markov process $(j = 3)$. Equation (9) indicates that the ARCH process is scaled by a factor $g(s_t)$, which is also state-dependent. In this way, the volatility process changes in scale when the system moves from one regime to another, and it is possible to compare relative sizes of variances. The transition probabilities p_{nj} to be in a state *n* and to move into state *j* are indicated as:

$P(s_t = j|s_{t-1} = n) = p_{nj}$ with $n = 1,2,3$ and $j = 1,2,3$.

with $0 \leq p_{nj} \leq 1$:

$$\sum_{j=1}^{3}(p_{nj}) = 1 \text{ for } n = 1,2,3; j = 1,2,3 \qquad (12)$$

The estimates also provide filtered probabilities and smoothed probabilities. One of these models' appealing features is that, given the observations of the time series, they enable us to draw a probabilistic inference about the hidden Markov chain to separate the unobserved regimes. The inference is expressed by computing, for each period *t*, the filtered state probability (FSP) of a regime. The FSP is the probability that in period *t*, the unobserved Markov chain for the Markov switching model is in a regime conditional on observing sample information up to period *t*. On the other hand, the smoothed full sample probability (SFP) of a regime is the probability that the unobserved Markov chain for the Markov switching model is in a specific regime in period *t*, conditional on observing all sample information.

The historical dates of the turning points are typically picked when the probability of a distinct regime crosses some pre-specified thresholds (Chauvet and Hamilton, 2006) so that the regimes can provide useful information about the occurrence of economic events.

The matrix of regressors in the mean equation of the returns (equation 8) includes macroeconomic news, defined as the difference between the realized and the expected value of a 'scheduled' macroeconomic indicator. So, the news by definition is a surprise, and, in statistical terms, is the innovation that cannot be predicted (i.e., the expected value of the surprise is zero) but whose timing is known by the investors who know the calendar of the release of each macroeconomic announcement. The inclusion of the news in equation (8) is an approach widely used in the finance literature of GARCH and ARCH models and is grounded on the assumption of the semi-strong form of the efficient market hypothesis (EMH) that the current stock prices adjust rapidly to the release of all new public information. The news role is to separate its effects from the stochastic error term, which includes all other unaccounted surprises and stochastic shocks.

The SWARCH model represented by equations 8-11 allows us to investigate several issues. Firstly, in the equation of the conditional mean, we can assess the degree of integration of US, emerging and frontier markets in relation to economic conditions in the US. Secondly, we can assess if the degree of integration has been affected by the financial crisis. Thirdly, we can investigate the behaviour of volatility by allowing it to shift across different regimes. In section 5.3, we will explain in more detail the application of the SWARCH, the process of selection of the model, and the results.

4. Data

We used stock market price indices of US (MSCI_US),[10] emerging (MSCI_EM),[11] and frontier (MSCI_FM)[12] stock markets. Stock market prices were taken with weekly frequency[13] from *Thomson Reuters DataStream* and are in US dollars; this enables us to conduct our analysis from US investors' point of view. The period of analysis is from the 31st of May 2002 to the 26th of December 2014.[14] While previous studies have been conducted mainly at a national or regional level, we consider both emerging and frontier stock markets at an aggregate level. The rationale for this choice is that aggregate markets might reveal a clearer path regarding the progressive financial integration of equity markets.

Table 1 presents descriptive statistics. Returns in the emerging markets (MSCI_EM) have the largest standard deviation (3.222%), while returns in the frontier markets (MSCI_FM) have the smallest standard deviation (2.127%). Table 1 also shows that skewness is negative for all the stock market returns, indicating that large negative stock returns are more common than large positive stock returns. In all cases, kurtosis is greater than 3, indicating that all returns are leptokurtic, having significantly fatter tails and higher peaks than normal distribution. The Jarque-Bera statistic rejects the null hypothesis that returns are normally distributed for all stock markets under analysis.

Table 1 – Summary statistics of stock returns, 2002-2014

	MSCI US	MSCI EM	MSCI FM
Mean (%)	0.104	0.154	0.128
Standard deviation	2.488	3.222	2.127
Maximum (%)	11.526	18.662	6.999
Minimum (%)	-20.116	-22.564	-15.250
Skewness	-0.903	-0.971	-1.659
Kurtosis	11.491	10.695	13.140
Jarque-Bera	2059.954	1701.762	3111.706
P-value	0.00	0.00	0.00

Notes: This table presents summary statistics for the weekly returns of the US (i.e. MSCI-US), emerging (MSCI-EM) and frontier (MSCI-FM) stock markets. Returns were calculated as and are in US dollars. The Jarque-Bera statistic tests the null hypothesis of a normal distribution of stock market returns.

[10] The MSCI US Equity Index represents approximately 95% of the US equity market capitalisation. The *DataStream* code for the MSCI US index is MSUSAML(PI).

[11] The MSCI Emerging Markets Index captures large and mid-cap representation across 23 emerging stock markets located in the Americas (Brazil, Chile, Colombia, Mexico, Peru), Europe (Czech Republic, Greece, Hungary, Poland, Russia), the Middle East (Qatar, Turkey, United Arab Emirates) Africa (Egypt, South Africa) and Asia (China, India, Indonesia, Korea, Malaysia, Philippines, Taiwan, and Thailand). The *DataStream* code for the MSCI Emerging Markets Index is MSEMKF$(PI).

[12] The MSCI Frontier Markets Index captures large and mid-cap representation across 23 frontier markets (FM) countries located in the Americas (Argentina), Europe (Bulgaria, Croatia, Estonia, Lithuania, Kazakhstan, Romania, Serbia, and Slovenia), Africa (Kenya, Mauritius, Morocco, Nigeria, and Tunisia), Middle East (Bahrain, Jordan, Kuwait, Lebanon, and Oman) and Asia (Bangladesh, Pakistan, Sri Lanka, and Vietnam). The *DataStream* code for the MSCI Frontier Markets Index is MSFMKT$(PI).

[13] We used weekly data to overcome the time difference problem encountered when analysing international stock markets (Lo and MacKinlay, 1990; Burns et al., 1998; Sheng and Tu, 2000).

[14] We used data from the year 2002 because the time series data for frontier markets index is from May 2002; therefore, we started our empirical analysis from that time.

Table 2 presents the means of unconditional correlations among the equity markets for the period 2002-2014. The correlation coefficients have been calculated using weekly returns in US dollars. Thus Table 2 presents correlations from the viewpoint of US investors. As expected, the US market demonstrates a higher correlation with the emerging markets with an average value of 0.719. On the other hand, the US and frontier markets have relatively lower average correlations. The lower correlation coefficients between the US and frontier markets suggest larger potential international diversification benefits for US investors.

Table 2 – Weekly correlations for the period 2002-2014

	MSCI US	MSCI EM	MSCI FM
MSCI US	1		
MSCI EM	0.719	1	
MSCI FM	0.317	0.377	1

Notes: This table shows correlations among the US, emerging and frontier equity markets returns in the off-diagonal cells. The correlations were calculated using weekly returns in US dollars.

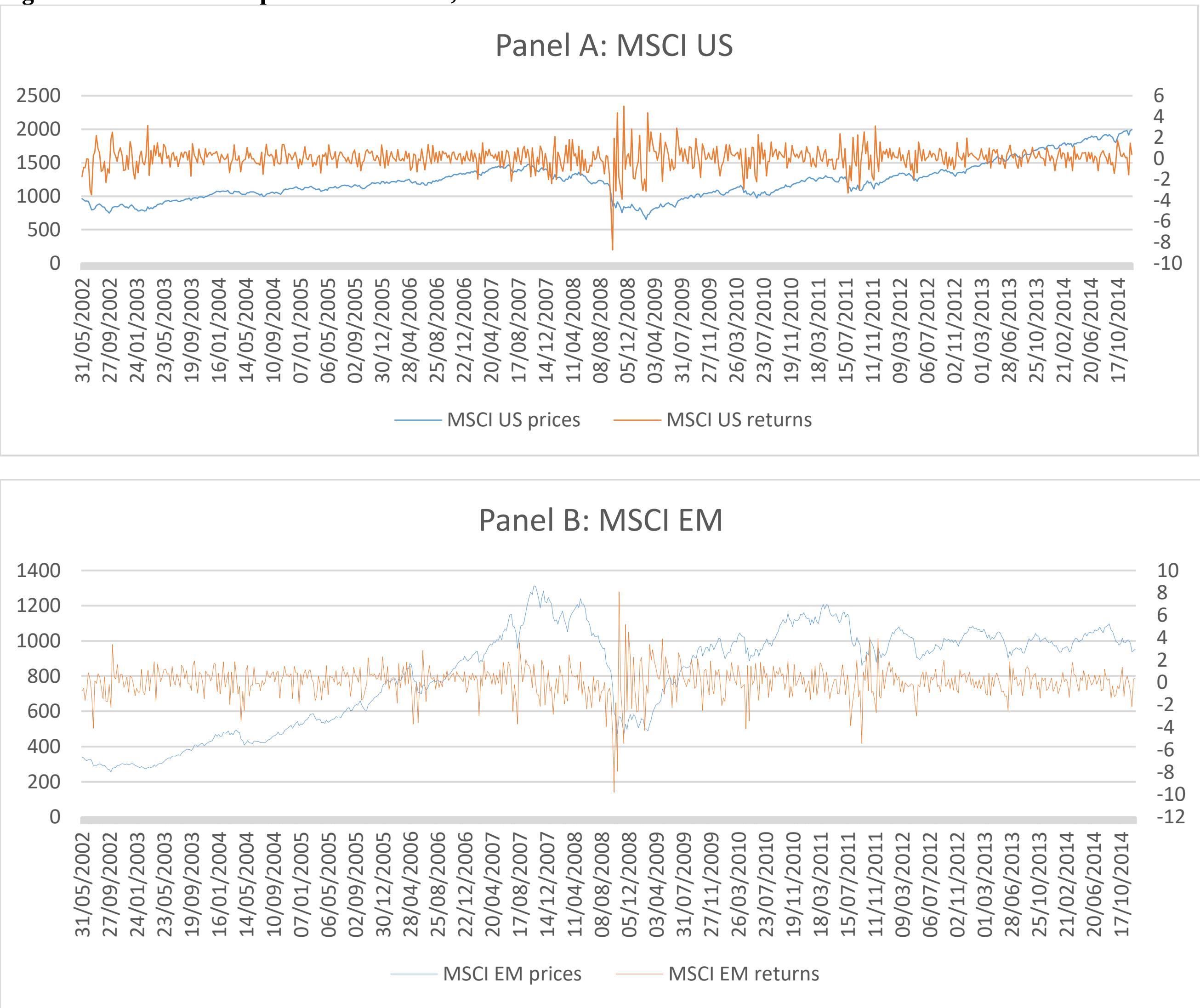
Figure 1 plots the weekly returns for each stock market indices over the period 2002-2014. Results show a strong tendency for the volatility of the stock index returns to a cluster. Large (small) returns tend to be followed by large (small) returns, suggesting that volatility changes over time. It is worth noticing that the higher volatility of returns during the 2007-2009 US financial crisis is not merely a phenomenon local to the US, but it appears to be common to both the emerging and frontier stock markets.

In addition to the data on stock prices, we also use data on various exchange rate series, interest rate series from *Thomson Reuters DataStream*, and data on major US macroeconomic indicators, as reported in Table 3. The expected values of US macroeconomic indicators were provided by *Econoday*, using market surveys completed by experts. Following a standard procedure, we calculate the surprise (news) by taking the difference between the actual released values and the expected values (as per the experts' consensus collected by *Econoday*) before the actual releases of the specific US macroeconomic indicator. We selected those macroeconomic indicators that several empirical studies of the news approach identified as more relevant (see, for instance, Fair, 2003; Ehrmann and Fratzscher, 2005; Cagliesi et al., 2016; Caporale et al., 2016). We focused only on US surprises and did not include surprises of emerging and frontier markets' macroeconomic variables. This choice is in line with the other well-known empirical result that US investors are much more sensitive to their domestic macroeconomic news than foreign news (Ehrmann and Fratzscher, 2002).

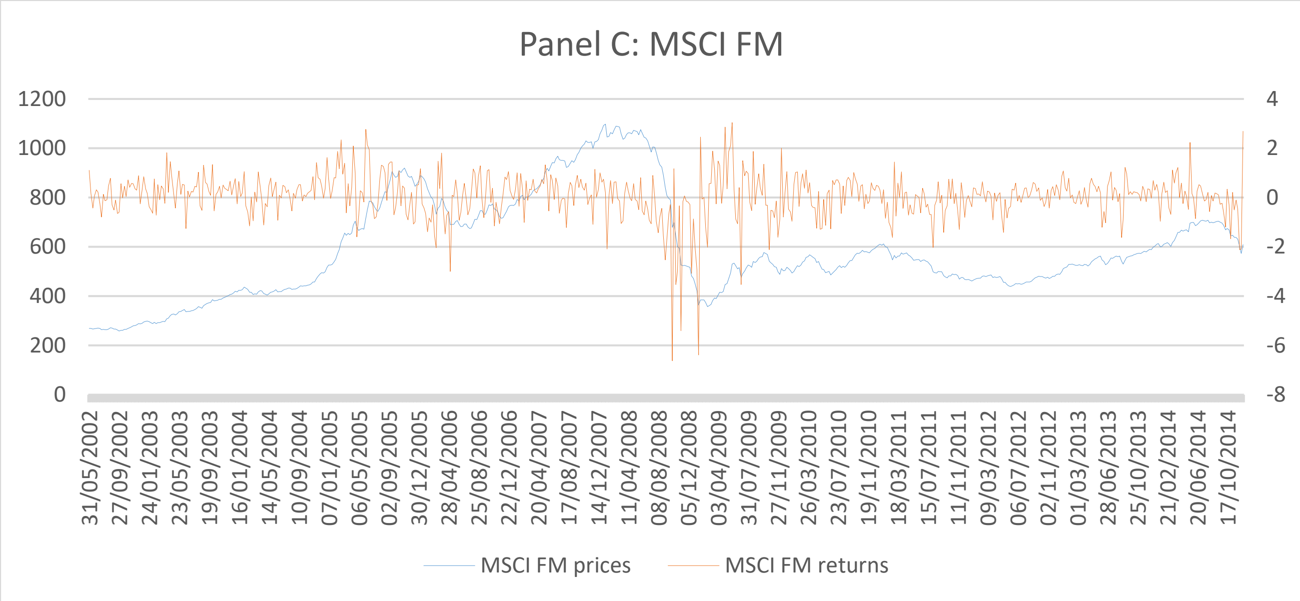
The news is a 'scheduled' event because the market is aware of when the news is released. The empirical literature of the news approach matches frequencies of the news with frequency of returns according to this criterion: the news is zero at any time that the macroeconomic indicator is not due to be announced, and different or equal to zero at the scheduled time of announcement (it is zero if the predicted and the actual values are the same when the announcement is made). The expected value of future news is zero.[15]

The news on macroeconomic indicators has been tested for cross-correlation, so to avoid issues of collinearity. The results show no evidence of collinearity. Lastly, we created a series of dummies for the period 2002-2014 that account for the three waves of US unconventional monetary interventions known as quantitative easing, and a financial crisis dummy variable to consider the financial crisis of 2007-2009. We used this latter dummy on its own or as an interaction term with other factors to test if the crisis had affected the responsiveness of returns to macroeconomic and financial variables.

Figure 1 – Stock market prices and returns, 2002-2014



[15] While the fundamental variables in the mean equation have the same weekly frequency as the stock returns, macroeconomic indicators are, in general, released at lower frequencies. An issue of a mismatch of frequencies would have arisen if, instead of using the innovation (news) of these indicators, we had used their announced and realised values. In these cases, the generalized autoregressive conditional heteroskedasticity–mixed-data sampling (GARCH-MIDAS) models suggested in Engle et al. (2013), Fang et al. (2020), and Conrad and Kleen (2020) would have been the appropriate models to use to account for short-term and long-term volatility components, when the long-term volatility component depends on many macroeconomic and financial variables. However, the variable of interest is not the value of the macroeconomic indicator but its innovation, removing the mixed data sampling issues and having to nowcast the future values of economic indicators.



Notes: This Figure shows prices and returns for MSCI US (Panel A), MSCI EM (Panel B), and MSCI FM (Panel C) indices respectively.

Table 3 - Variables used in the ARCH and SWARCH models

Name of announcement	Unit of announcement	Coverage release	Start date	Final date	Source	Number of observation
Consumer Price Index	Index M-M% change	Data is for the previous month	6 Jan 2003	30 Sept 2014	Econoday	141
Unemployment rate	% of labour force	Data is for the previous month	6 Jan 2003	30 Sept 2014	Econoday	141
Nonfarm payroll	Thousands	Data is for the previous month	6 Jan 2003	30 Sept 2014	Econoday	141
ISM index	Index M-M% change,	Data is for the previous month	6 Jan 2003	30 Sept 2014	Econoday	141
Producer Price Index (net of food and energy)	Index	Data is for the previous month	6 Jan 2003	30 Sept 2014	Econoday	141
Industrial production	Index, M-M% change	Data is for the previous month	6 Jan 2003	30 Sept 2014	Econoday	141
Average hourly earnings	USD per hour	Data is for the previous month	6 Jan 2003	30 Sept 2014	Econoday	141
Real GDP all (include Advance, Preliminary and Final)	Q/Q% change	Data is for the prior quarter	6 Jan 2003	30 Sept 2014	Econoday	141
Real GDP Advance	Q/Q% change	Data is for the prior quarter	6 Jan 2003	30 Sept 2014	Econoday	141
Real GDP preliminary	Q/Q% change	Data is for the prior quarter	6 Jan 2003	30 Sept 2014	Econoday	141
Leading indicators	M-M% change	Data is for the previous month	6 Jan 2003	30 Sept 2014	Econoday	141
Factory orders	M-M% change	Data is for 2 months prior to release month	6 Jan 2003	30 Sept 2014	Econoday	140
Euro to US dollar spot exchange rate (Price of one dollar in terms of euro)	W-W% change	Spot data	6 Jan 2003	30 Sept 2014	DataStream	141
UK to US dollar spot exchange rate (price of one dollar in terms of UK pounds)	W-W% change	Spot data	6 Jan 2003	30 Sept 2014	DataStream	141
Yen to US dollar spot exchange rate (price of one dollar in terms of Japanese yens)	W-W% change	Spot data	6 Jan 2003	30 Sept 2014	DataStream	141
US Treasury Bill	W-W% change	Spot data	6 Jan 2003	30 Sept 2014	DataStream	141
German short-term bond	W-W% change	Spot data	6 Jan 2003	30 Sept 2014	DataStream	141

Japanese short-term bond	W-W% change	Spot data	6 Jan 2003	30 Sept 2014	DataStream	141
Oil prices	W-W% change	Spot data	6 Jan 2003	30 Sept 2014	DataStream	141
Dummy Financial Crisis	Binary	Weekly	28 Sept 2007	26 Sept 2014	Authors' creation	141
Dummy Financial Crisis_08	Binary	Weekly	21 Mar 2008	26 Sept 2014	Authors' creation	141
Dummy QE_Wave 1	Binary	Weekly	25 Nov 2008	30 Mar 2010	Authors' creation	141
Dummy QE_Wave 2	Binary	Weekly	3 Nov 2010	30 June 2011	Authors' creation	141
Dummy QE_Wave 3	Binary	Weekly	13 Sept 2012	30 Dec 2013	Authors' creation	141

Notes: This table contains the list of news collected from various sources between May 2003 and September 2014. The *Consumer Price Index* measures the change in the average price level of a fixed basket of goods and services purchased by consumers. The *Unemployment rate* is calculated as the number of unemployed persons divided by the total number of persons in the labour force. The ISM index is a manufacturing composite index calculated through a survey of purchasing managers at roughly 300 US manufacturing firms nationwide. The PPI news is a family of indexes that measures the average change over time in the prices received by domestic producers of goods and services. The Industrial Production measures real output in industries such as manufacturing, mining and utilities. *Real GDP all* is the all-inclusive measure of economic activity. *Leading indicators* is a composite index of 10 forward-looking components including building permits, new factory orders, and unemployment claims.

5. Empirical results and discussion

This section illustrates the results of the smooth transition analysis, the potential (if any) portfolio diversification benefits, and the effect of US macroeconomic announcements on international portfolios. To simplify the exposition, we organise the discussion of the results into the following three sub-sections.

5.1 Tier-one: smooth transition correlation analysis and discussion of financial integration

Equations 1-3 show the set-up of the smooth transition time-varying correlations model. In that model, the state correlations are the correlations across which the process moves; the parameter c locates the midpoint between two state regimes and hence the inflection point of the logistic curve; the parameter γ represents the smoothness of the transition. Table 4 reports the estimated values of these parameters. Panel A of Table 4 refers to the DSTCC-GARCH applied to the pair of US/EM markets. The table shows the following three sets of estimated parameters: the state correlations (ρ_1, ρ_2, and ρ_3); the parameters of dates of transition (c_1 and c_2); and the speed of transition (γ_1 and γ_2).

The estimated values of state correlation coefficients indicate that the correlation coefficient between US and EM markets changed during the period of the study. It transited smoothly in a logistic fashion, from 0.642 to 0.831, and then again from 0.831 back to 0.647. The dates of these transitions can be identified by using the estimated parameters, c_1 and c_2. Each of these parameters is the inflection point of the logistic curve of the model and indicates the mid-point of the transition. It is expressed as a fraction of the sample size, so, from its value, it is possible to identify a calendar week. Thus, for instance the date parameter $c_1 = 0.52$, represents the 52% of the number of weeks in our sample and identifies in our sample calendar the week of the 23rd of January 2009. At that date, the transition from the 0.642 correlation to the 0.831 correlation was half-way through. Similarly, the second date parameter $c_2 = 0.67$, identifies the week in our sample calendar (24th of December 2010) at which the transition was at its midpoint.

The third types of speed parameters γ_1 and γ_2, are estimated simultaneously with the inflection and state correlation parameters. Each speed parameter relates to the logistic transition function; it affects its curvature, and hence the speed and smoothness of the transition from one state of correlation to another. In other words, the parameters γ_1 and γ_2, help locate the beginning and end of each transition. A higher value of γ means a speedier, quicker, shorter, and less smooth period of transition. This parameter cannot be negative and is unbounded above, meaning that the logistic transition function becomes a straight vertical line (a step) as γ tends to infinity. For instance, as shown in Table 4 - Panel A, the parameter γ_1 associated with the midpoint 23rd of January 2009 is 60.23 and the transition is much slower than the one for which the estimated γ_2 is equal to 500, associated with the midpoint 24th of December 2010. In this latter case the value of 500 indicates almost a jump from one regime to another. Our figures show in fact that the transition associated with 500 occurred in just a few weeks.

Panel B of Table 4 indicates that the STCC-GARCH model fits the changes in the correlation regime between the US and frontier equity markets. The interpretation of the date parameter c_1, the speed parameter γ_1, and the state correlation coefficients ρ_1 and ρ_2, is the same as before. In this case, the parameter of γ_1 is equal to 26.82, smaller than the value of γ_1 in the USEM model, which was 60.23. This fact means that the USFM logistic function is less steep, the transition is smoother and the length of the transition from low regime correlation to a higher regime correlation is longer than in the USEM case. The midpoint of the transition, c_1 , is equal to 0.506 corresponding to the week of the 19th of September 2008, the week of the Lehman Brothers collapse. For the US and FM pair of returns only two state correlation coefficients were statistically significant, meaning that there was only one change of regime from low to high. Therefore, while the transition to a higher regime was a temporary phenomenon for the pair US/EM, the change in the correlation between US and FM markets was a lasting structural break.

Table 4 – Smooth transition analysis results

	ρ_1	ρ_2	ρ_3	γ_1	γ_2	c_1	c_2	Date 1	Date 2
Panel A:									
US-EM	**0.642***** **(0.03)**	**0.831***** **(0.027)**	**0.647***** **(0.038)**	60.23 (.)	500 (.)	**0.52***** **(0.020)**	**0.67**** **(0.007)**	23 Jan 2009	24 Dec 2010
Panel B:									
US-FM	**0.099**** **(0.06)**	**0.438***** **(0.046)**	-	26.82 (.)	-	**0.506***** **(0.019)**	-	19 Sept 2008	-

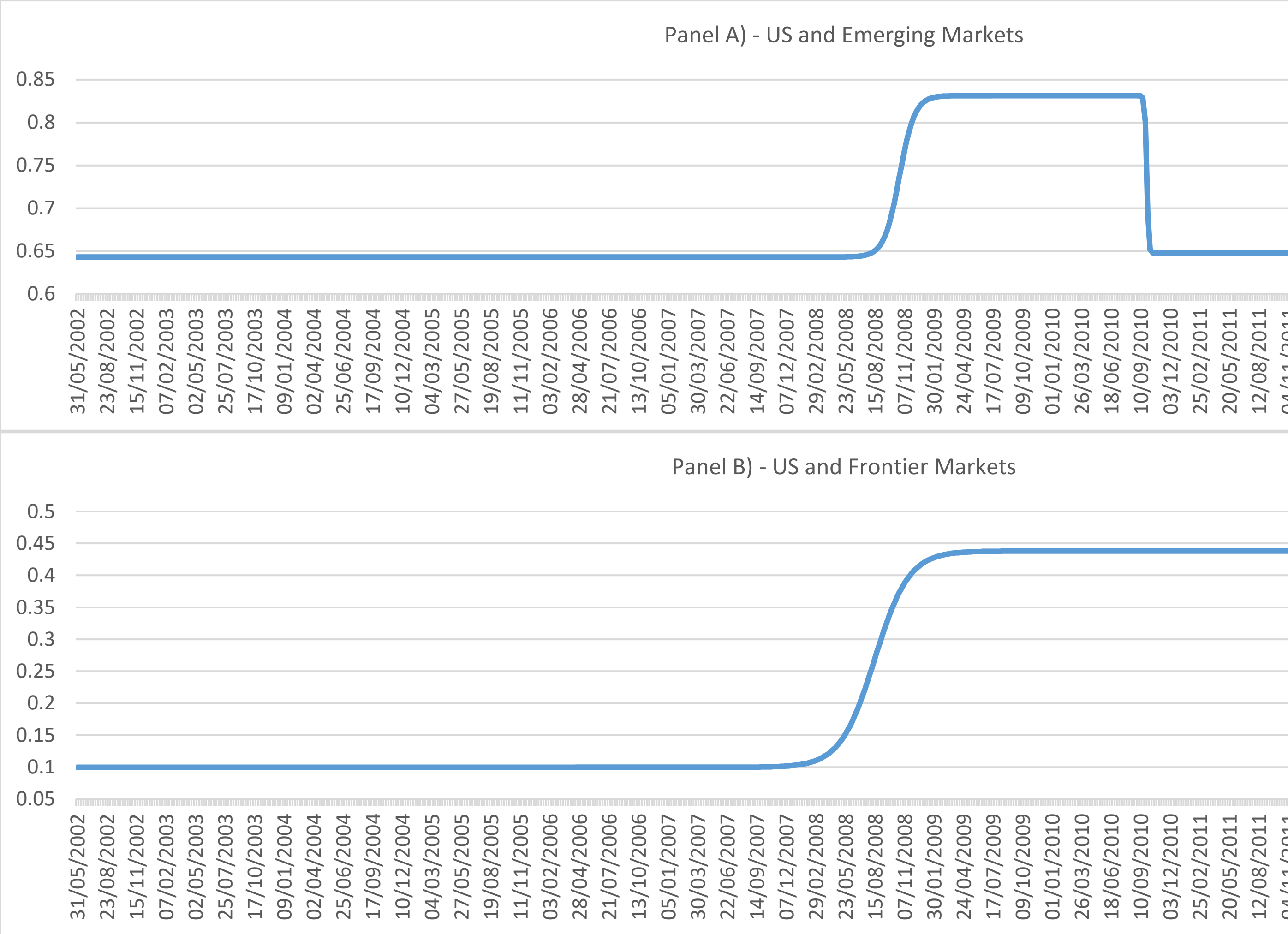
Notes: This table presents quasi maximum likelihood estimated of part of the parameters of DSTCC-GARCH model in the case of the US and emerging equity markets (Panel A), as well as the parameters of the STCC-GARCH model in the case of the US and frontier equity markets (Panel B). The parameters of the GARCH models are available upon request. 'Date 1' is the week that corresponds to c_1, and 'Date 2' is the week that corresponds to c_2 . Standard errors are in parentheses. ***/**/* denote statistical significance at the 1%, 5%, and 10% levels, respectively.

In Figure 2, Panels A and B illustrate these patterns of the time-varying correlations obtained by the DSTCC GARCH and the STCC GARCH models. From Panel A, it is evident that the 2007-2009 financial crisis was the driving force behind the correlation change between the US and the emerging markets from 2008 onwards. Dimitriou et al. (2013) found a similar result for the US and BRICS stock markets. However, as depicted in Panel A of Figure 2, the high correlation regime was not long lasting. In fact, by that end of the year 2010, the correlation coefficient returned abruptly to a pre-crisis value. Our results are consistent with Gao and Mei (2018), who found that the linear correlation coefficients between the US and major emerging Asian stock markets over 2007-2009 were higher than the before-crisis period and that they decreased in the post-crisis period.

Panel B of Figure 2 illustrates the correlation between the US and frontier markets. It shows that, despite the sizable increase since the end of 2008, the correlation between US and frontier is, at any time, much lower than the correlation between the US and emerging markets.[16] Further to this, the increase in the degree of correlation among the US and frontier markets did not revert to pre-crisis period levels, as was the case with the US and emerging markets. The permanent increase in the degree of correlation between the US and frontier markets from 2008 onward indicates a sharp reduction in terms of market segmentation between the US and frontier equity markets. Also, Samarakoon (2011) found that the correlation between US and frontier stock markets is much lower than the correlation between the US and emerging markets. Therefore, portfolio diversification opportunities between the US and frontier markets are more evident when compared to the US and emerging markets. In their study, Marshall et al. (2015) argued that lower correlations among frontier and developed markets led to higher portfolio diversification gains than the returns of portfolios of emerging and developed markets. The issue of incurring in frequent-transaction costs does not apply to our study because portfolio rebalances are carried out only on a few occasions associated with the correlations' structural changes.

[16] This finding is consistent with Zaremba and Maydybura (2019), who show that correlation between developed and frontier market equities is usually lower than between developed and emerging markets equities.

Figure 2 - Time-varying DSTCC for US with emerging and STCC for US with frontier markets



Notes: This figure illustrates the time-varying correlations between US and Emerging Markets (Panel A) and the US and Frontier Markets.

To summarise, the results of tier-one confirm some historical facts: the correlations between equity markets are not constant over time; at any point in time, the correlation between the pair US and EM financial markets has always been higher than the correlation between US and FM markets. Periods of high stock market volatility and, particularly, during bearish markets have been associated with instability in international equity correlations, and as expected, during the financial crisis, the correlations of both pairs US/EM and US/FM increased.[17] The tier-one analysis also suggests that, after a while, the correlation between the pair US/EM

[17] The increased correlation during the 2007-2009 global financial crisis could be explained as a flight-to-quality hypothesis (or herd behaviour) which is particularly relevant over periods of financial turmoil when investors in aggregate shift the portfolio allocation away from riskier assets (equities) into safer assets such as bonds. For instance, Bekiros et al. (2017), found that herding behaviour was the main reason behind the increase of the US stock market volatility over the 2007-2009 financial crisis, and the following changes in portfolio compositions. A recent study, Soylu and Güloğlu (2019) investigated the flight to quality between emerging equity markets and US bond markets. In our study, the focus is on equity markets alone, therefore the flight-to-quality can only happen across different classes of risky assets.

resumed its pre-crisis value, while the correlation of the pair US/FM did not revert. This longer-lasting effect of the crisis may indicate that, since the financial crisis, the US and FM markets might have become more integrated. The results of tier-one imply that, because of the correlation shifts, the benefits of diversification have also changed, prompting investors to re-adjust their portfolio strategies. An additional question is how US international investors had been holding alternative portfolios and would have reacted to these changes in correlation among the markets under study. The next section is devoted to answering that question.

5.2 Tier-two: portfolio analysis' results and discussion on performances and risks

In tier-two, we use tier-one findings on the time-varying correlations and their dates to rebalance the composition of the optimal strategy portfolios (MVP and CET), described in equations (6) and (7). Specifically, we start with the investors in the US and emerging markets, and we assume that these investors would have re-optimized their portfolio holding three times, as follows: between May 2002 and January 2009 (which we define as Period 1), between February 2009 and December 2010 (Period 2) and then between January 2011 and December 2014 (Period 3). These were the periods as identified in Figure 2 – Panel A. The results are reported in Table 5, where we indicate the changes in each portfolio's composition and performance of each portfolio.[18]

We conducted a historical inspection of the dates of the changes of correlations estimated in tier-one, to understand their economic justification. For the US and frontier markets, the estimated date of the re-optimization fell on the week of 19 September 2008, the week of Lehman Brother's collapse. This date did not surprise us. For the US and emerging markets, the estimated date for re-optimization fell on the week of 23 January 2009, the week when the newly elected US President Barack Obama took office.[19] The same USEM portfolios were re-optimized again, following tier-one results, during the week of 23rd December 2009. However, due to the Christmas break and extensive holiday periods, we decided to rebalance the portfolio in the first week of January. By the end of 2010, the US economy had bounced back, and was growing again. The emerging economies had shown a much faster recovery than the advanced economies, which created opportunities for portfolio re-adjustments.[20]

Using the dates obtained from tier-one, we can calculate the performances of all portfolios. Table 5 shows each portfolio's simple average return in each period, its standard deviation, and Sharpe ratios (where relevant). The USEM_EQWP portfolio's performances reflect the pure effect of trends in returns and volatility because its asset composition never changes. Within each period, it is possible to compare performances of different strategies and the benefit of diversification. For instance, over the period May 2002 – January 2009, US

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[18] Portfolio strategies were executed using the Excel solver. Table 5 reports the simple weekly average return, standard deviation, and Sharpe ratios. The Sharpe Ratio measure calculates the average return over and above the risk-free rate of return per unit of portfolio risk, that is $SR_i = (\bar{R}_i - R_f)/\sigma_i$ where R_i is the average return for portfolio *i* during a specified time period, $R_i$is the average risk-free rate of return, and σ_i is the risk of portfolio *i*. The Sharpe ratio measure indicates on average how much an excess return (above risk-free rate) an investor is rewarded per unit of portfolio risk the investor bears.

[19] Barack Obama took the oath of office as the 44th President of the United States, and then delivered the State of the Union speech in February. Therefore, given the importance of these two events, we assumed that international investors might have rebalanced their portfolio in between these two critical events. Therefore, we postponed the re-optimization to the week of 6 February 2009.

[20] An historical inspection of these dates reveals that January 2009 is also linked to some important macro-financial news and events that could reinforce the decision to change their portfolio holdings. Firstly, the Obama administration announced a stimulus package (the 'American Recovery and Reinvestment Act of 2009'), to inject $800 billion in the US economy to help stabilise financial markets. Moreover, at the beginning of 2009, emerging markets showed a better prospect of growth than developed markets, which may have prompted a renovated interest in investing more in those markets.

investors would have ended up with negative weekly returns on average if they had kept their holdings in the domestic market only (Table 5 – Column 1 of Panel A). Alternatively, if they had diversified their portfolio between domestic and emerging markets, the average weekly returns would have been positive under the EQWP strategy (Table 5 – Column 2 of Panel A), and CET (Table 5 – Column 4 of panel A) strategies with values of 0.026%, and 0.002%, respectively. On the other hand, if we consider Period 2 (i.e., February 2009 – December 2010), Panel B – column 4 shows that the CET strategy would have been the one ensuring the highest returns in comparison to the EQWP and MVP strategies, even though this would have come at the price of the highest risks. If we look at the results related to Period 3 (January 2011 – December 2014), we find that both MVP (Table 5 - Column 3 of panel C) and CET (Table 5 – Column 4 of panel C) strategies were the ones ensuring the highest returns and lowest risk to US investors.[21]

However, in the case of the CET strategy, investors would have considered only the US market. Over time, across periods, it is possible to compare the performance of constant quotas portfolio (EQWP strategy) and the domestic portfolio only, so as not to be confounded by the effect of a change in portfolio composition, which occurs in the optimal portfolio (CET, MVP).

Table 5 – US and emerging stock markets: portfolio performances

	(1) US Domestic market	(2) EQWP	(3) MVP	(4) CET
Panel A: Period 1 from May 2002 – Jan 2009				
Average weekly returns	-0.071%	0.026%	-0.063	0.002%
Standard deviation	2.597%	2.846%	2.592%	2.729%
Sharpe ratio	0.229	0.243	0.232	0.244
Weight MSCI_US	100%	50%	95.95%	62.13%
Weight MSCI_EM	-	50%	4.05%	37.87%
Panel B: Period 2 from Feb 2009 – Dec 2010				
Average weekly returns	0.38%	0.556%	0.425%	0.665%
Standard deviation	2.925%	2.99%	2.910%	3.171%
Sharpe ratio	0.422	0.472	0.44	0.48
Weight MSCI_US	100%	50%	87.1%	19.08%
Weight MSCI_EM	-	50%	12.9%	80.92%
Panel C: Period 3 from Jan 2011 – Dec 2014				
Average weekly returns	0.24%	0.075%	0.178%	0.24%
Standard deviation	2.013%	2.066%	1.981%	2.013%
Sharpe ratio	0.33	0.241	0.303	0.33
Weight MSCI_US	100%	50%	81.17%	100%
Weight MSCI_EM	-	50%	18.83%	0%

Notes: This table presents the results for portfolios optimised on US and emerging equity market returns. Column 1 reports the results in the case a US investor had invested in the US market only (i.e. domestic market). Columns 2, 3, and 4 report the results in the case a US investor would have adopted alternative portfolio strategies (i.e., EQWP, MVP, and CET) by diversifying between the US and the emerging stock markets. MSCI_US weight and MSCI_EM weight indicate the % allocation in each of the markets in accordance with the strategy chosen.

[21] Jayasuriya and Shambota (2009) investigated the returns of a MVP strategy. They found that diversified portfolios that included emerging and frontier markets would offer US investors higher returns than US only portfolios.

Table 6, for the USFM portfolio, can be read as the same as Table 5. Within each period, it is possible to compare performances. For instance, between May 2002 and September 2008, our findings show that the CET strategy (Panel A – Column 4) had been the one that would have generated the highest level of weekly returns. Secondly, by adopting either the EQWP, MVP or CET strategy (Panel A, Columns 2, 3, and 4 respectively), US investors would have been better off than if they had adopted a domestic portfolio strategy only (Panel A, Column 1). Therefore, the benefits of international portfolio diversification would have been evident over the first sub-period. If we consider the Sharpe ratio values, over the same period, the CET strategy was to reward US investors with the highest Sharpe ratio measure (0.301). Therefore, for each unit of portfolio total risk an investor bore, the CET strategy would have rewarded the US investor with a weekly excess return of 0.301 in 2002-2008, which was the highest if compared to the Sharpe Ratio values of the other strategies (0.114 for the domestic only portfolio strategy, 0.26 for the MVP strategy, and 0.28 for the MVP strategy).

In the second period, from October 2008 to December 2014 (Table 6 - Panel B), the results of portfolio diversification would have been limited in terms of weekly returns. Neither the EQWP, MVP or the MVP strategy would have offered higher weekly returns than the domestic market portfolio strategy. In other words, the domestic market portfolio strategy would have generated higher weekly returns. In terms of Sharpe Ratios, the CET (Column 4) portfolio would have rewarded US investors with the highest Sharpe ratio measure (0.617), against 0.526, 0.603, and 0.616 for the domestic, EQWP, and MVP strategies respectively.

Table 6 – US and frontier stock markets: portfolio performances

	(1) US Domestic market	(2) EQWP	(3) MVP	(4) CET
Panel A: Period 1 from May 2002 - Sept 2008				
Average weekly returns	0.05%	0.198%	0.211	0.273%
Standard deviation	1.97%	1.376%	1.371%	1.477%
Sharpe ratio	0.114	0.26	0.28	0.301
MSCI_US weight	100%	50%	45.33%	24.18%
MSCI_FM weight	-	50%	54.67%	75.82%
Panel B: Period 2 from Oct 2008 - Dec 2014				
Average weekly returns	0.168%	0.043%	0.001%	0.002%
Standard deviation	2.915%	2.266%	2.216%	2.216%
Sharpe ratio	0.526	0.603	0.616	0.617
MSCI_US weight	100%	50%	33.27%	33.52%
MSCI_FM weight	-	50%	66.73	66.48%

Notes: This table presents the results for portfolios optimised on US and frontier equity market returns. Column 1 reports the results in the case a US investor had invested in the US market only (i.e. domestic market). Columns 2, 3, and 4 report the results in the case a US investor would have adopted one of those portfolio strategies (i.e., EQWP, MVP, and CET) by diversifying between the US and the emerging stock markets. MSCI_US weight and MSCI_EM weight indicate the % allocation in each of the markets in accordance with the strategy chosen.

The advantage of using the estimated dates from tier-one is that these dates are not arbitrary. The disadvantage is that investors may have adjusted their portfolios earlier or later during the transition period, or more often than we assumed. In particular, CET investors, being more willing to operate while markets are in a situation of high volatility, may have rebalanced their portfolios earlier than the estimated dates. On the other hand, MVP-type investors, being less inclined to take risks, may have waited longer to rebalance their portfolios. We carried out two sensitivity analysis exercises to check the robustness of the optimal strategy rebalancing.

In the first exercise, we assumed that the re-optimization of USME_CET and USFM_CET portfolios occurred not in the middle of each transition period, but at its beginning, when the correlation coefficient started to change. We assume the opposite for MVP investors: that the re-optimization occurred at the end of each transition period (see Table 7 below). Changing the re-optimization dates produces small effects for the USEM portfolio, mainly in the financial crisis period. As expected, by waiting till the end of the transition period, MVP investors would have ended up with a higher quota of US assets, which, by the end of the year 2010, had become less risky than EM assets. On the other hand, CET investors, by reacting immediately to the changing in correlation and waiting less, would have ended up with a higher quota of EM assets (which had better return than US assets right after Lehman Brother's collapse). For the pair of USFM assets (Table 8), the change in re-optimization dates would not have had much effect on the direction of MVP investors' decisions but would have affected the CET investors noticeably. By rebalancing their portfolios well in advance of the Lehman Brothers collapse[22], CET investors would have invested in US assets more than FM assets. This result is not surprising, given that in the months leading to the Lehman Brothers collapse, the frontier markets had faced a persistent decrease in returns (see Figure 1 – panel C).

Table 7 – Rebalancing portfolios for the sensitivity analysis US and Emerging markets

	(1)		(2)		(3)		(4)	
	USEM_MVP rebalanced at estimated dates as per tier-one (baseline scenario)		USEM_MVP Rebalanced at end of transition		USEM_CET rebalanced at estimated dates as per tier-one (baseline scenario)		USEM_CET Rebalanced beginning of transition	
	US	EM	US	EM	US	EM	US	EM
Period 1	96%	4%	94%	6%	62%	38%	81%	18%
Period 2	87%	13%	100%	0%	19%	81%	0	100%
Period 3	81%	19%	81%	19%	100%	0%	100%	0

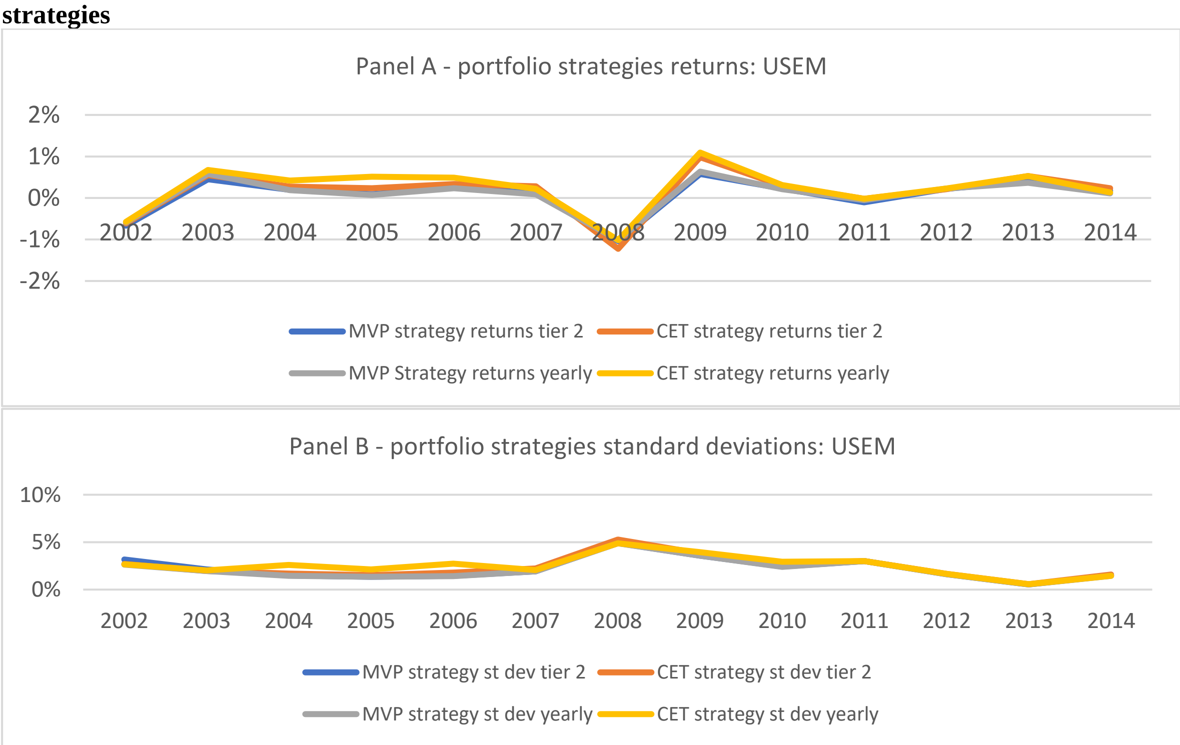
Table 8 – Rebalancing portfolios for the sensitivity analysis US and Frontier markets

	(1)		(2)		(3)		(4)	
	USFM_MVP rebalanced at estimated dates as per tier-one (baseline scenario)		USFM_MVP Rebalanced at end of transition		USFM_CET rebalanced at estimated dates as per tier-one (baseline scenario)		USFM_CET Rebalanced beginning of transition	
	US	FM	US	FM	US	FM	US	FM
Period 1	45%	55%	42%	58%	24%	76%	0	100%
Period 2	33%	67%	27%	73%	33%	67%	63%	37%

[22] Lehman Brothers Inc. filed for bankruptcy in September. 15, 2008.

Our results rely on the assumption that investors re-optimize their portfolios only when the correlation regimes change. To check the robustness of these results, we investigate the situation whereby investors re-optimize their portfolios more often than the periods indicated by the tier-one smooth correlation model. We assume that investors would rebalance their portfolio every year. For every year of the sample, we computed the weekly average returns of these more active investors and matched these portfolios' performance with the comparable weekly average returns of the optimal portfolios, CET MVP, whose re-optimization is linked to the changes in correlation regimes. Figure 3, for USEM portfolios, and Figure 4, for USFM portfolios, illustrate the results. In Figure 3, the closeness of the two MVP-strategy lines, one representing the yearly re-optimization and the other one representing the tier-one-based re-optimization, and the closeness of the two CET lines, indicate that the results of our more parsimonious approach are robust and that a more active reallocation would not have produced substantially different performances. The only exception for the CET strategy is the period 2004-2006. If, during that interval, CET investors had increased the quota of emerging market assets (and reduced the quota of US assets), they could have gained higher returns (Figure 3 - Panel A), together with higher risk (Figure 3 - Panel B), than they obtained under the baseline scenario of tier-one. For the USFM portfolios, in Figure 4, similar results: the two lines of the MVP returns are close to one another, and so are the two lines of the CET returns (Panel A), except for the period 2005-2006. If, during that period, CET investors had increased their frontier market holdings, they could have gained higher returns (Panel A), at the cost of much higher volatility (Panel B), than under the baseline scenario. Vice-versa, if MVP investors had reduced their FM holdings in 2005, they would have reduced the risk of their portfolio as well as the returns. Overall, our parsimonious approach to re-limiting MVP and CET portfolios' re-optimization to when there are shifts in correlation regimes, instead of arbitrarily assign dates for more frequent re-optimization, seems to be reasonable.

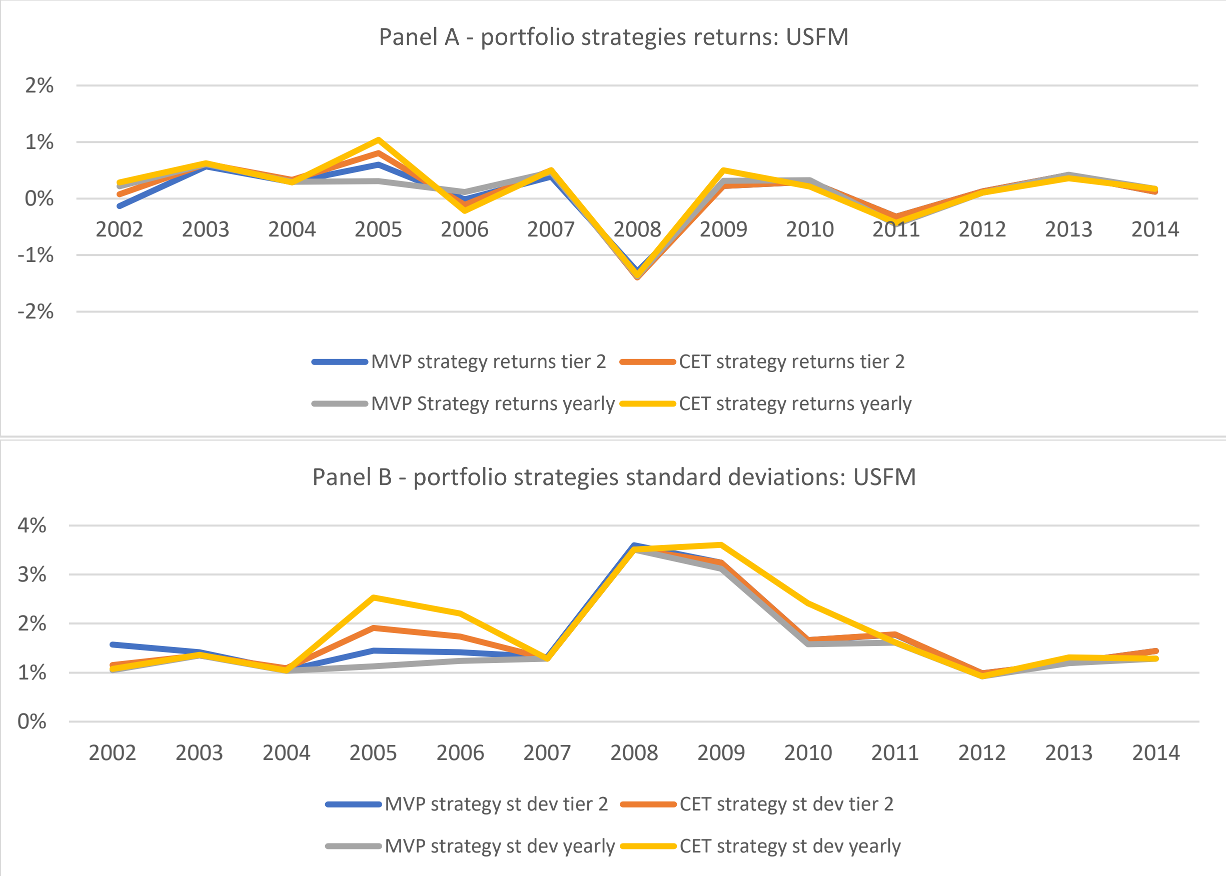
Figure 3 – Returns and standard deviations: the case of alternative US and emerging stock market portfolio strategies



Notes: This figure shows portfolio returns for the US and emerging equity markets associated with two different portfolio strategies (Panel A), as well as the standard deviations associated with each of the alternative portfolio strategies (Panel B) over the period 2002-2014. In particular Panel A illustrated the trend of portfolio returns for the case of portfolios rebalanced annually (MVP strategy returns yearly and

CET strategy returns yearly), vs portfolio returns strategy rebalanced annually but with quotas as identified in Tier 2 (MVP strategy returns tier 2 and CET strategy returns tier 2). Panel B illustrates the standard deviations of the mentioned portfolio strategies.

Figure 4 – Returns and standard deviations: the case of alternative US and frontier stock market portfolio strategies



Notes: This figure shows portfolio returns for the US and frontier equity markets associated with two different portfolio strategies (Panel A), as well as the standard deviations associated with each of the alternative portfolio strategies (Panel B) over the period 2002-2014. In particular Panel A illustrated the trend of portfolio returns for the case of portfolios rebalanced annually (MVP strategy returns yearly and CET strategy returns yearly), vs portfolio returns strategy rebalanced annually but with quotas as identified in Tier 2 (MVP strategy returns tier 2 and CET strategy returns tier 2). Panel B illustrates the standard deviations of the mentioned portfolio strategies.

After the sensitivity analysis exercise on the re-optimization frequency assumption, we are now in the position to make further inference about the gains from holding the USEM and USFM optimal portfolios over purely US-only portfolios. We measure the gains from holding international portfolios by looking at the Sharpe ratio measure increase as suggested in Eun and Resnick (2009). Table 9 is based on the results of tables 5 and 6. The Sharpe ratio measure change is obtained by taking the difference in the Sharpe ratio between the USEM (or the USFM) and the US portfolios. Panel A(B) of Table 9 summarises the benefit (or cost) of using a USEM(USFM) optimal portfolio (such as CET and MVP) over a domestic US-only portfolio from the perspective of US investors. Looking at Table 9, we observe that it is always possible to obtain Sharpe ratio gains over the US-only portfolio by diversifying in either EM or FM markets. Within each habitat, better results could be achieved by focusing on CET rather than MVP strategies. The only exception to this rule occurs in period 3 for the MVP strategy for the USEM portfolio. Column 1 - Panel A of Table 9 shows that over the period January 2011 - May 2014, the return per unit of risk of the US-only portfolio would have been better than the one of the MVP USEM portfolio. In that period the US assets offered a higher return and slightly higher risk than the USEM combination of assets.

Table 9 – Gains from international diversification

	(1) MVP	(2) CET
Panel A: US and EM	ΔSR	ΔSR
Period 1:May 2002 - Jan 2009	0.003	0.015
Period 2: Feb 2009 - Dec 2010	0.018	0.058
Period 3: Jan 2011 - Dec 2014	-0.026	0
Panel B: US and FM	ΔSR	ΔSR
Period 1: May 2002 - Sep 2008	0.166	0.187
Period 2: Oct 2008 - Dec 2014	0.088	0.091

Notes: This table presents potential gains from international investment from the perspective of US investors using two optimal portfolio strategies, that is the MVP and CET. Panel A) shows the potential gains achieved by US investors diversifying their portfolio between US and emerging markets considering three holding periods. Panel B) shows the potential gains for diversifying between the US and frontier markets by considering two holding periods. ΔSR is the difference in the Sharpe ratio between the optimal portfolio and the US-only domestic portfolio.

5.3 Tier-three: the structural analysis's results and discussion

The first two tiers of analysis led us to identify changes in the correlation regimes, build hypothetical international portfolios based on diversification strategies, and compare their performances. These different strategies, and their associated portfolios, can be related to three types of investors: the first type is an investor who prefers to maintain the status quo and, because of this preference, does not readjust the composition of their portfolio during the entire period. Through the lens of behavioural finance theory, this investor displays a high degree of loss aversion or 'a status quo bias.' The second type of investor is a risk-averse 'shareholder' who changes the composition of his portfolio two or three times during the 2002-2014 period to minimise the risk, while the third type of investor is also an active type who changes the composition of their portfolio two or three times, but whose objective is to maximise returns.

We remind the reader that changing the 'composition' of a portfolio is referred here to changing the weights, not the assets, of the same portfolio. Indeed, borrowing an expression from the term structure theory, we assume that equity market investors have their own 'preferred habitat', meaning those investors with knowledge of and preference for the US and frontier markets will choose portfolios in these markets. In contrast, investors with knowledge of and preference for the US and emerging markets will choose portfolios with combinations of those assets. Nobody would venture outside his preferred habitat, into a market of which he has little knowledge. Within each preferred habitat, there will be three types of investors for a total of six cases.

This section focuses on the third research question. It is based on the results of tier-two and it aims to investigate the factors that could affect the performance of the various tier-two portfolios during the 2002-2014 period. Our goal is to understand the extent to which portfolio returns and volatility have reacted to economic factors and events during the turbulent financial years of the period under investigation. We assume that each portfolio is affected by its specific factors and by commonly shared events, and we test for these hypotheses.

Tier-three estimation strategy and results

Before performing any estimates, we report some basic descriptive statistics of each of the seven portfolio strategies. Table 10 reports some descriptive statistics over the entire sample of US only assets portfolios and the 6 US mixed portfolios. As expected, the MVP one has a lower mean and lower risk within optimal portfolios, while the opposite is true for the CET portfolio. Besides, as shown in Table 10, the Jarque-Bera tests and the high kurtosis coefficients of all the series indicate non-normality, typical of financial and high-frequency series. Based on this finding, we estimate ARCH and SWARCH models using a conditional Student's t-distribution instead of a normal distribution. For all seven series, the Ljung Box tests reveal the autocorrelation of the returns and the squared returns. These findings justify our choice to introduce the lagged dependent variables among the regressors and to test for the presence of an ARCH type process for the conditional variance.

Table 10 – Summary Statistics

	US Only	US-Emerging			US-Frontier		
		EQWP	MVP	CET	EQWP	MVP	CET
Mean (%)	0.127	0.166	0.125	0.217	0.138	0.126	0.150
Standard deviation	2.450	2.666	2.446	2.609	1.879	1.845	1.903
Minimum (%)	-20.117	-21.340	-20.215	-21.043	-17.683	-16.869	-16.882
Maximum (%)	11.526	14.376	11.543	13.336	6.067	6.242	6.239
Skewness	-0.961	-1.081	-1.010	-1.090	-2.048	-2.199	-2.029
Kurtosis	9.749	10.25	10.103	10.067	15.32	15.559	13.797
Jarque-Bera	2513.82	2798.48	2706.73	2705.32	6412.41	6666.09	5274.42
LB(2)	5.25	8.48	5.42	9.12	23.21	37.95	48.28
$LB^2(2)$	77.93	85.85	74.41	77.97	39.66	29.74	29.20
LB(4)	10.08	12.00	10.85	11.47	29.83	54.25	66.37
$LB^2(4)$	128.28	209.04	128.02	181.56	46.32	37.31	39.47
Obs.	611	612	612	612	612	612	612

Notes: This table presents the main descriptive statistics of the hypothetical portfolios' strategies. The Jarque-Bera test has a Chi Squared distribution with 2 degrees of freedom. The Ljung-Box test for the squared returns has a Chi squared distribution with *n* degrees of freedom.

We used the following estimation strategy: we used the results of the Ljung-Box test to estimate alternative specifications of ARCH models using weekly observation for the period May 2002-December 2014. Tables A1-A2 in the Appendix A show the estimates of the selected final ARCH models. In Appendix A (Table A3-A10), we report the steps in selecting the final ARCH and SWARCH specifications. For each of the portfolios, the first step was to estimate a series of ARCH models and use AIC, Schwarz, and conventional statistical significance criteria to select the ARCH specification. We tested each model for the presence of autocorrelation and autoregressive conditional heteroskedasticity in the standardized errors (Ljung-Box, and McLeod-Li tests) and possible volatility breaks (Andrews-Ploberger break test with the Newey-West correction). Based on the volatility break test results, we moved into SWARCH model and using a parsimonious approach; we use a Likelihood Ratio (LR) test to SWARCH specifications of a two versus three regime switches. Tables A3-A10 in Appendix A report and explain the model selection process and the statistics.

In every specification of the ARCH and SWARCH models, we also looked at the possibility of leverage effects, present only for a few portfolios, and the possible lagged effects of the macroeconomic news included in the mean equation. None of the included macroeconomic news produced any statistically significant effect beyond the week of its announcement. After the ARCH estimates, we tested for model stability and possible regime switches using the CUSUM statistics.[23] The CUSUM tests and charts are reported in the Appendix B (Figures B1 and B2). The graphical inspection of the CUSUM charts led us to use SWARCH models to account for the instability and time changes in the coefficients' values.

Tier-three estimation results: expected returns and volatility of different portfolios

Tables 11 and 12 report the SWARCH estimates for the hypothetical portfolios' strategies and Tables A1 and A2 in the Appendix A report the ARCH-t estimates of the same portfolios. Several results can be observed from the tables. Firstly, when we move from ARCH-t into SWARCH-t models, we can notice that the conditional mean's coefficients are quite stable (in value and statistical significance), but that the ARCH components of the conditional variance change quite substantially. There is evidence for state varying volatility, and the presence of endogenous switching regimes makes those ARCH parameters that were statically significant in the ARCH models become statistically not significant in the SWARCH models. In other words, the ARCH components disappear when we allow the volatility to be state-dependent. This result is in line with Edwards and Susmel (2001) findings, who also made use of weekly stock market data for a group of Latin American countries to investigate their volatility throughout turbulent times. Moreover, for all models, the SWARCH specification leads to improvements of likelihood values.

We focus now on the SWARCH estimates presented in Tables 11 and 12 to discuss other noteworthy results. We start comparing the AR component first across 'preferred' markets, and then across investors within the same market. Finally, in a separate section, we compare the SWARCH components of all portfolios.

Table 11 – SWARCH model results: US and emerging markets

	EQWP US-Emerging SWARCH(3,2) Symmetric	MVP US-Emerging SWARCH(2,2) Asymmetric	CET US-Emerging SWARCH(3,1) Symmetric
Mean Equation			
Constant	**0.848****	**0,227****	**0.319*****
	(0.350)	**(0.091)**	**(0.098)**
Dependent variable (-1)	-0.045	**-0.091****	**-0.075****
	(0.039)	**(0.036)**	**(0.033)**
Dependent variable (-2)	-	-0.020	0.028
		(0.340)	(0.033)
News ISM	**-0.174***	-0.111	**-0.128 0.382*****
	(0.102)	(0.095)	**(0.126)0.091**
News ISM post crisis 2008	**0.558*****	**0.329****	0.382**
	(0.158)	**(0.136)**	(0.151)
% change Dollar_Euro	**-0.328*****	**-0.319*****	**-0.464*****
	(0.083)	**(0.05)**	**(0.052)**
% change Dollar_Euro post crisis 2008	**-0.278****	-	-
	(0.119)		
% change Dollar_Yen post crisis 2008	-	**0.390*****	0.428***
		(0.066)	(0.066)
% change Oil_price post crisis 2008	-	**0.193*****	**0.213*****
		(0.023)	**(0.030)**
Japan bond Y10_Rate	-0.287	-	-
	(0.243)		
Japan bond Y10_Rate post crisis 2008	**-0.419****	-	-
	(0.196)		
US_TB_Monthly_Rate	-	0.005	0.016

[23] Under the null hypothesis, the statistic is drawn from a CUSUM distribution. If the calculated CUSUM statistics appear to be too large to have been drawn from the CUSUM distribution, the null hypothesis of model stability is rejected. The CUSUM chart shows the cumulative sum of differences between the values and the average. If the values are all above average for some time, the cumulative sum will steadily increase. A segment of the CUSUM chart with an upward slope indicates a period where the values tend to be above average. Likewise, a segment with a downward slope indicates a period where the values tend to be below average. For a stable process, the cumulative sum will vary randomly and remain within a control band. However, if the mean shifts upwards to some value, an upward trend will quickly develop in the cumulative sum, which will exceed the control limit band; in this case, one can conclude that the process is unstable.

		(0.035)	(0.036)
US_TB_Monthly_Rate post crisis 2008	-	-0.429	**-0.602****
		(0.359)	**(0.278)**
Dummy_QE_wave 1	**0.83****	**0.381***	**0.480***
	(0.352)	**(0.215)**	**(0.255)**
Dummy_QE_wave 3	-0.251	-	-
	(0.226)		
Variance Equation			
ARCH(1)	-0.011	-0.048	0.041
	(0.119)	(0.037)	(0.058)
ARCH(2)	0.002	0.001	-
	(0.048)	(0.042)	
GV(1)	**2.066*****	**1.861*****	**1.964*****
	(0.29)	**(0.165)**	**(0.298)**
GV(2)	**7.561*****	-	**3.684*****
	(1.303)		**(0.617)**
GV(3)	**45.013*****	**10.299*****	**10.91*****
	(11.319)	**(1.934)**	**(2.016)**
Asymmetry	-	**0.278*****	-
		(0.099)	
NU	30.466	30.438	**9.456*****
	(57.148)	(31.214)	**(3.477)**
THETA (1,1)	**14.606*****	**5.042*****	**4.943*****
	(3.611)	**(0.660)**	**(0.734)**
THETA (2,1)	**10.906*****	-	-15.445
	(3.403)		(29.803)
THETA (1,2)	**2.040***	**-3.872*****	**11.13*****
	(1.259)	**(0.569)**	**(0.781)**
THETA (2,2)	**5.115*****	-	**15.416*****
	(1.023)		**(0.731)**
THETA (1,3)	**-16.295*****	-	-18.611
	(4.449)		(14.795)
THETA (2,3)	**-3.104*****	-	**-4.038*****
	(1.055)		**(0.782)**
Log likelihood	-1291.211	-1204.524	-1242.321

Notes: Standard errors are in parentheses. ***/**/* denote statistical significance at the 1%, 5%, and 10% levels, respectively. Non-entry means that the variable was not included in the estimated equation.

Table 12 – SWARCH model results: US and frontier markets

	ALL US SWARCH(3,2) Symmetric	EQWP US-Frontier SWARCH(3,1) Asymmetric	MVP US-Frontier SWARCH(3,1) Asymmetric	CET US-Frontier SWARCH(3,1) Asymmetric
Mean Equation				
Constant	**0.396*****	**0.338*****	**0.547*****	**0.541*****
	(0.085)	**(0.101)**	**(0.137)**	**(0.142)**
Dependent variable (-1)	**-0.117*****	**0.095****	**0.125*****	**0.202*****
	(0.039)	**(0.044)**	**(0.037)**	**(0.046)**
Dependent variable (-2)	-	**0.101*****	**0.062***	**0.069*****
		(0.038)	**0.033**	**(0.033)**
News ISM	**-0.183*****	**-0.135***	-0.109	-0.049
	(0.088)	**(0.084)**	(0.078)	(0.087)
News ISM post crisis 2008	**0.610*****	**0.325*****	**0.215****	0.126
	(0.132)	**(0.113)**	**(0.099)**	(0.126)
News PPI_Net	**-1.010****	-	-	-
	(0.502)			
News Nonfarm Payroll	**0.005*****	-	-	-
	(0.001)			
% change Dollar_Euro	**-0.162****	-0.041	-	-
	(0.066)	(0.084)		
% change Dollar_Euro post crisis 2008	**-0.276*****	**-0.240***	-	-
	(0.090)	**(0.136)**		
% Change Dollar_Yen	-	-	**0.120****	**0.139****
			(0.057)	**0.065)**
% Change Dollar_yen post crisis 2008	-	-	**0.149****	0.083
			(0.072)	(0.076)
% change Oil-price	-	-	**-0.029***	-0.015
			(0.016)	(0.016)
% change Oil-price post crisis 2008	-	-	**0.167*****	**0.152*****

			0.023	**(0.023)**
FED rate	-0.033	-	-	-
	(0.030)			
FED Rate_post crisis	**-0.254****	-	-	-
	(0.112)			
US_TB_Monthly_Rate	-	-	**-0.086*****	-0.068
			(0.043)	(0.046)
Dummy_QE_wave 1	-	0.302	-	-
		(0.224)		
Dummy_QE_wave 2	-	-0.053	-	-
		(0.218)		
Dummy_QE_wave 3	-	**0.259****	-	-
		(0.114)		
Dummy Financial crisis 2008	-	**-0.267****	-0.472***	**-0.454*****
		(0.125)	0.146	**(0.142)**
Variance Equation				
ARCH(1)	0.018	-0.006	0.002	-0.003
	(0.049)	(0.054)	(0.051)	(0.050)
ARCH(2)	0.03	-	-	-
	(0.044)			
GV(1)	**1.906*****	0.042	**0.147****	**0.484*****
	(0.163)	(0.068)	**(0.075)**	**(0.184)**
GV(2)	**6.611*****	**1.497*****	**1.494*****	**2.011*****
	(0.987)	**(0.134)**	**(0.135)**	**(0.283)**
GV(3)	**40.432*****	**13.994*****	**12.317*****	**12.380*****
	(10.932)	**(4.274)**	**(3.297)**	**(4.053)**
Asymmetry	-	**0.328*****	**0.221*****	**0.221****
		(0.114)	**(0.095)**	**(0.108)**
NU	49.592	**12.546****	23.301	15.545
	(83.649)	**(5.288)**	(17.606)	(10.083)
THETA (1,1)	**13.393*****	**10.19*****	**11.135*****	**12.347***
	(0.307)	**(0.482)**	**(0.345)**	**(6.903)**
THETA (2,1)	**8.630*****	**9.374*****	**9.240*****	9.824
	(0.255)	**(0.480)**	**(0.182)**	(6.915)
THETA (1,2)	0.947	1.448	1.577	**2.301****
	(0.958)	(1.281)	(1.158)	**(1.167)**
THETA (2,2)	**4.943*****	**6.131*****	**6.185*****	**5.803*****
	(0.816)	**(0.929)**	**(0.859)**	**(0.918)**
THETA (1,3)	**-14.824*****	**-16.312*****	-46.529	-14.669
	(3.325)	**(5.099)**	(29.607)	(27.589)
THETA (2,3)	**-3.055*****	**-3.569*****	**-3.546*****	**-3.432*****
	(0.913)	**(1.046)**	**(0.879)**	**(0.874)**
Log likelihood	-1243.190	-1077.533	-1045.233	-1063.211

Notes: Standard errors are in parentheses. ***/**/* and denote statistical significance at the 1%, 5%, and 10% levels, respectively. A non-entry means that the variable was not included in the estimated equation.

Tier-three estimation results: expected returns across markets

From Tables 11 and 12, we can notice that the conditional means' estimated coefficients show some similarities and some differences across US domestic only, US-Emerging and US-Frontier equity markets portfolio returns. We highlight four comparisons here. Firstly, as shown in Table 12, the returns of USFM portfolios are more affected by their history than US domestic only and USEM portfolios, both in terms of duration and in terms of magnitude (the autoregressive components of the frontier returns display longer and bigger delayed effects than the ones of the USEM).[24] This finding is not surprising given that frontier markets are often characterised by thin trading and illiquidity that make pricing and valuations in these markets quite predictable, leading to market inefficiencies. [25] Recent studies have investigated the existence of the illiquidity

[24] All AR processes are stationary, and frontier portfolios alternate positive and negative correlations (having one positive and one negative root). The roots of the AR(2) process were: -0.168; 0.370 for CET; -0.207, 0.333 for MVP; and -0.274, 0.333 for EQWP; the roots of the AR(1) were: -0.075 for CET, -0.091 for MVP, and -0.117 for the US portfolio.

[25] Frontier markets in comparison to emerging markets are typically smaller, less developed, less liquid, and more difficult to access than major emerging markets in Asia, Europe, the Middle East, Africa, and Latin America. They are less correlated to the major developed or emerging markets due to their limited economic exposure to the rest of the world. For this reason, frontier markets should be considered an alternative investment option for global investors seeking diversification. They offer higher investment returns because of their significant growth potential. However, their risks are generally higher than those of developed or emerging markets.

premium in the returns of frontier stock markets. For instance, Stereńczak et al. (2020) found no evidence of an illiquidity premium in 22 frontier markets, and their results support Batten and Vo (2014), who in their study claim that the lack of evidence about the presence of an illiquidity premium in the frontier markets is due to their low level of integration with the global economy. This factor may lead international investors with longer horizons to forgo a liquidity premium favouring diversification gains.[26]

Secondly, international portfolios seem to be affected by some common US and international factors such as the ISM surprises (ISM is the only macroeconomic news relevant to US investors holding mixed international portfolios), the dollar-euro exchange rate, the dollar-yen exchange rate, the price of oil and US and Japanese bond rates. On the other hand, as expected, the domestic US only portfolio is only responsive to US domestic news such as ISM, Nonfarm Payroll, PPI, *Fed* rates, and the dollar-yen exchange rate. With a few exceptions that will be explained later, all coefficients have the expected signs: economic events favourable to US business have a positive effect on returns.

Thirdly, all portfolios have been affected by the financial crisis in their changed reaction to macroeconomic news. The presence of the interaction terms captures this behaviour. These specific effects of the financial crisis could be of various natures: for instance, some factors become relevant or gain more strength after the crisis, while others even invert their signs. These post-crisis changes, common to all portfolios, vary across investors, and we devote more attention to these in the next section of the paper. The other way the financial crisis affected the expected returns is via the period dummy called *Financial crisis 2008*. However, this is true only for the frontier portfolios whose constant terms (and hence unconditional mean) decrease substantially after the crisis.

This finding is consistent with the results presented in the smooth transition analysis and the portfolio diversification analysis results, and it confirms the robustness of our results. From the diversification analysis, it is evident that, after the global financial crisis, the USFM portfolios have relatively larger quotas of non-US assets than the USEM portfolios (except for the EQWP). The combination of larger frontier quotas and the fact that frontier markets have experienced fast increasing returns before the crisis and heavy losses or small returns after the crisis can explain why the constant term (long term returns) of the frontier equations has decreased. However, this reduction also occurs for equal quota EQWP USFM portfolio, despite the increased correlation with the US market that was revealed by the smooth transition analysis. That analysis showed that frontier markets have become more integrated with the US market but that their integration degree is still much lower than the level of integration of the emerging market with the US market. As a result, in equal quota portfolios (EQWP), the US market's positive performance after the crisis has partially been able to counteract the negative performance of the frontier markets.

The fourth comparison across preferred markets concerns the magnitude of estimated coefficients. We can notice that the USEM markets portfolios show consistently stronger responses than the US-Frontier markets

[26] In occasions of portfolios' re-adjustments, failing to account for severe and systematic illiquidity episodes, such as no trade bands, could result in an overestimation of optimal frontier assets' quotas in the MVP and the CET portfolios and a better risk/returns profile of the EQWP portfolios. To study more in detail the presence and the possible effects of an illiquidity premium, we looked at zero returns observations as a proxy of no trade (and hence of severe illiquidity). The inspection of the MSCI frontier index daily data, over the period 31st of May 2002 to the 26th of December 2014, revealed only five episodes (out of 3281 daily observations) of zero returns, each coinciding with specific days of festivities. Despite that for some frontier markets and local and smaller companies, there may be zero trading days and zero returns, the use of an aggregated index and weekly data, makes our sample free from severe and systematic illiquidity episodes. Moreover, we assume investors with long term horizon preferences, driven by diversification gains and wishing to re-adjust their portfolios in times of structural correlations (and hence degrees of integration) changes.

portfolio to the same factors and events, although these responses vary across types of investors. This fact may depend on the composition of emerging markets, where the US quota is dominant, or it may indicate that emerging markets are more integrated with the US stock market.[27] To explore the latter point more fully, we would need to compare the equally weighted portfolio (EQWP) of the USEM markets to one of the USFM markets so that the composition of the two portfolios is the same before and after the financial crisis. The results confirm that US economic conditions and surprises exert a significantly smaller impact on the EQWP USFM than on the EQWP-USEM portfolio and that investors in this latter market have been more affected by the 2007-2009 financial crisis. Moreover, USEM portfolio returns have been responsive to the first round of quantitative easing. In contrast, the USFM portfolios have responded only to the last wave of the Fed's interventions, suggesting that investors have responded to early interventions by venturing into the more familiar and accessible emerging markets but have subsequently turned to frontier markets search of higher returns.

To summarise: our findings seem to confirm that frontier markets are less integrated with the US stock market because they show reduced reactions to US conditions and news than the emerging countries. As a result, investors in less integrated markets are offered diversification benefits. The financial crisis has affected the degree of integration of emerging markets much more than the integration of frontier markets.

Tier-three estimation results: expected returns across type of investors

Tables 11 and 12 can be interpreted within each preferred market to make some comparisons across investor types. We can highlight here some new, unusual results. First, the financial crisis has affected the portfolio returns of diverse types of investors in different ways. Consider, for instance, the case of the status quo type of investor: among all investors, they are those who are more dramatically affected by the financial crisis in their reaction to the ISM news. This result may suggest that, before the crisis, investors with all US holdings or with fixed and equal share holdings seemed to read ISM not as a leading indicator but as a lagging one: an ISM reading higher than expected did not generate optimism about the strength of the US economy but rather was interpreted as if ISM had peaked and would soon decrease. In these circumstances, investors would sell stocks to invest in something else, causing a reduction in returns. The price of oil offers another interesting story: before the crisis, this variable was relevant only to risk minimiser investors in frontier markets (MVP); these investors – at a time when the US oil output appeared to be in inexorable, long term decline – were negatively affected by increases in the price of oil, which would hit consumer demand and, ultimately, business profits. However, if we consider the period after the financial crisis – which coincides with a rapid increase in the US production of oil – we find a different result: under the new US oil supply conditions, an increase in the price of oil became beneficial to US business, with a positive effect on stocks prices and returns.

The second comparison across investors is the distinctive relation of the dollar and stock returns. The estimated coefficients show that the US emerging market investors were positively affected by the strengthening of the dollar-yen exchange rate before and after the 2007-2009 financial crisis, but that they were negatively affected by the strengthening of the dollar-euro rate. This result is in line with existing literature (see, for instance, Cagliesi et al., 2016), and it is a stylised fact that since 2003 (after the burst of the high-tech bubble)

[27] Pätäri et al. (2019) argue that integration, or co-movement. among developed and emerging market is usually stronger than developed and frontier markets.

the US dollar and the Standard and Poor index have shown a negative relation. This is because a stronger dollar would prompt investors to sell their shares of US firms because of the loss of competition, and also sell shares of international firms in mixed portfolios because of the risk associated with their indebtedness in the dollar. This negative reaction is even stronger after the crisis. In periods of global uncertainty, any positive sign about the US economy signalled via a stronger dollar euro would prompt the selling of international shares and the rise of US capital inflow from emerging and frontier markets.

The third comparison is about monetary variables and policies. The sign of the relationship between the yield of the 10-year US bonds (or Japanese bonds) and the stock returns are consistently negative across investors and time: higher (lower) yields move inversely with returns. During periods of economic expansion, bonds and the stock market trade inversely as they compete for capital. However, in periods of the early stages of economic recoveries when inflationary pressures are weak, bonds and stocks move together (and hence yields and returns move in opposite directions) in response to the combination of mild economic growth and the central banks' commitments to low-interest rates to stimulate the economy. The Fed rate's coefficient expresses the same negative relation: policies of low-interest rates (so low costs of borrowing) are good for business and hence for stock returns. The other policy variable of the model is represented by Quantitative Easing (QE), the Fed's unconventional monetary tool in three periods. The first wave was relevant only to investors in emerging markets, and it produced a substantial effect on their returns. The extra money was moved into the stock market in search of higher returns than the ones offered by competing assets. This fact is in line with Khatiwada's (2017) findings and Bhattarai et al. (2018).

Tier-three estimation results: volatility across all portfolios

In this section, we discuss the results of the SWARCH estimates of the volatility component. Firstly, all USFM portfolios exhibit a 'leverage effect', which is an asymmetric reaction to IID shocks' volatility. According to the leverage effect, losses (i.e., unexpected negative shocks), tend to produce a greater influence on future volatility than gains of equivalent magnitude (i.e., positive innovation or good news) and all USFM portfolios have three volatility regimes. By inspecting the volatility coefficients in Tables 11 and 12, together with Figure 5 (Panels A-G) one can see the only portfolio with only two regimes of volatility is one of the risk-averse type of investor holding US/EM assets. The graphs indicate some common patterns: all portfolios switched to a regime of high volatility during the financial crisis; for most weeks in the sample, however, the volatility of portfolios was in either low or medium regimes; as expected, for both USFM and USEM portfolios the volatility of CET strategies is, in each regime, always bigger than the volatility of MVP portfolios. Lastly, the fixed quota portfolio (EQWP), particularly the pair US/EM, shows in each regime much higher volatility than optimal strategies. If we compare the regimes of the fixed quotas portfolios of the pairs US/FM and US/EM with the all US assets portfolio regimes, the USEM is much closer to pure US portfolio and higher than the US volatility itself. This is explained by the high correlation between the EM markets and the US markets. An increase in US and EM volatility results in amplified volatility of the fixed quota USEM portfolio.

Table 13 compares the relative sizes of variances by calculating the ratios between the volatility's estimated coefficients across different regimes. When a ratio is missing, there has never been a switch in or out between the regimes. The Table shows that the jumps in volatility from one regime to another are more pronounced for

MVP portfolios than for CET. For instance, for the US/FM pair, an MVP portfolio's high-volatility regime is eight times bigger than its medium regime volatility. For a CET portfolio, that ratio drops to 4. The same is true for jumps from low to medium volatility regimes. Therefore, CET portfolios tend to have higher volatility but a narrower range of value than MVP strategies, displaying smaller jumps in switching from one regime volatility to another.

Table 14 reports the estimated transition probabilities at each point in time of staying in the same volatility regimes or moving into another regime. These estimated probabilities of remaining in each regime are all close to one, indicating that states are quite persistent, so, once in a regime, the system tends to remain in it. However, this persistence, or state duration, varies considerably across markets and types of investors. For instance, as is shown in Table 14 – Panel A, investors in USEM portfolios are expected to stay in the low volatility state for a duration which is the longest across all groups and among all states: 156 weeks for MVP, 143 weeks for CET and 41 weeks for EQWP. If we look across investors within the same market, the status quo type of investor is the one with the shortest expected duration in a low volatility state (three weeks if in a frontier market and 41 weeks if in emerging markets). This result does not surprise since this type of investor does not actively manage its portfolio in response to risk and returns.

Table 13 – Relative conditional variances

	Ratio of high regime variance to medium regime variance	Ratio of medium regime variance to low regime variance	Ratio of high regime variance to low regime variance
Panel A: US-Emerging			
EQWP_USEM portfolio	5.95	3.66	-
MVP_USEM portfolio	5.53	-	-
CET_USEM portfolio	2.96	1.88	5.56
Panel B: US-Frontier			
EQWP_USFM portfolio	9.35	35.79	-
MVP_USFM portfolio	8.24	10.13	-
CET_USFM portfolio	6.16	4.15	25.56
Panel C: US only			
US-ONLY portfolio	6.12	3.47	-

Notes: This table illustrates, for each portfolio, the relative variance calculated as the ratio between state dependent volatilities. When a ratio is missing, it means that there has never been a switch in or out between the regimes.

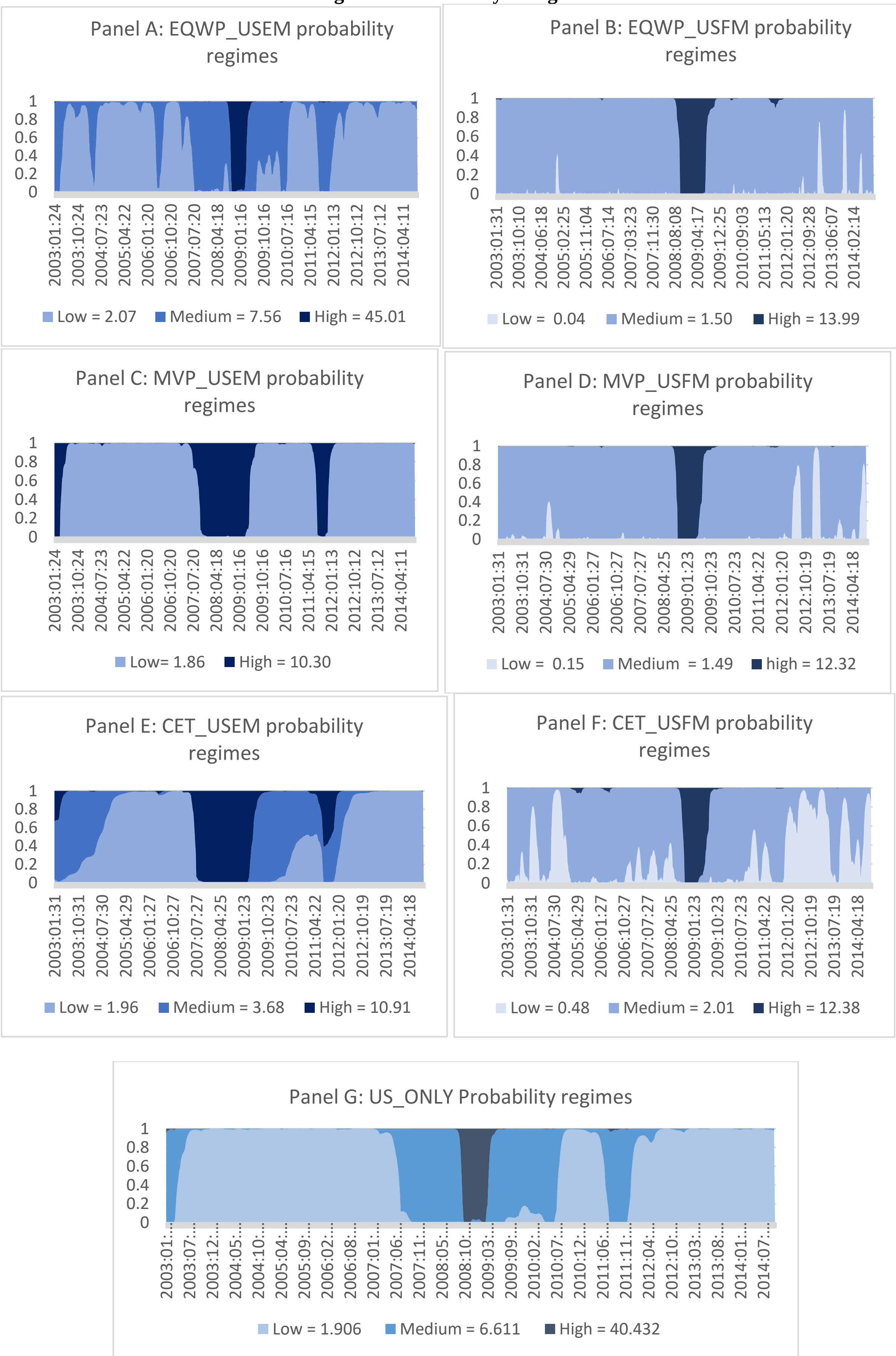
Table 14 – Transition probabilities and average duration in weeks

	From Low volatility regime		From Medium volatility regime		From High volatility regime	
	Transition probability	Average Duration week	Transition probability	Average Duration week	Transition probability	Average Duration week
Panel A: US-Emerging						
EQWP_USEM portfolio						
To Low volatility regime	0.976	41	0.050	1	0.000	0
To Medium volatility regime	0.024	1	0.950	20	0.043	1
To High volatility regime	0.000	0	0.000	0	0.957	23
MVP_USEM portfolio						
To Low/Medium volatility regime	-	-	0.994	156	0.020	1
To High volatility regime	-	-	0.006	1	0.980	49
CET_USEM						
To Low volatility regime	0.993	143	0.014	1	0.000	0

To Medium volatility regime	0.000	0	0.986	71	0.017	1
To High volatility regime	0.007	1	0.000	0	0.983	59
Panel B: US-Frontier						
EQWP_USFM portfolio						
To Low volatility regime	0.690	3	0.000	0	0.000	0
To Medium volatility regime	0.310	1	0.990	100	0.030	1
To High volatility regime	0.000	0	0.010	1	0.970	33
MVP_USFM portfolio						
To Low volatility regime	0.869	8	0.000	0	0.000	0
To Medium volatility regime	0.131	1	0.988	84	0.028	1
To High volatility regime	0.000	0	0.012	1	0.972	36
CET_USFM						
To Low volatility regime	0.926	14	0.029	1	0.000	0
To Medium volatility regime	0.000	0	0.968	31	0.031	1
To High volatility regime	0.074	1	0.003	1	0.969	32
Panel C: US only						
To Low volatility regime	0.991	111	0.000	0	0.000	0
To Medium volatility regime	0.009	1	0.975	40	0.045	1
To High volatility regime	0.000	0	0.025	1	0.954	22

Notes: This table illustrates, for each portfolio and related diversification strategy, the probability of being in a state of low, medium, or high volatility as well as the probability of moving across different states of volatility. The table illustrates, also for each portfolio and related diversification strategy, the average number of weeks of remaining in a state of low, medium, or high volatility and moving from each state.

Figure 5 - Probability of regimes



Notes: These figures illustrate smoother probabilities for low, medium, and high volatility regimes. In particular, Panel A shows regime changes in a portfolio constructed in accordance with the EQWP strategy and based on the US and emerging markets. Panel B shows regime changes in a portfolio constructed in accordance with the EQWP strategy and based on the US and frontier markets. Panel C shows regime changes in a portfolio constructed in accordance with the MVP strategy and based on the US and emerging markets. Panel D shows regime changes in a portfolio constructed in accordance with the MVP strategy and based on the US and emerging Markets. Panel E shows regime changes in a portfolio constructed in accordance with the CET strategy and based on the US and emerging Markets. Panel F shows regime changes in a portfolio constructed in accordance with the CET strategy and based on the US and frontier Markets. Panel G shows regime changes in a portfolio on the US market only.

6. Concluding remarks

In this study, we investigate financial integration by proposing an approach that combines three nested levels of analysis: the smooth transition conditional correlation, the portfolio diversification, and the news based structural analysis. This new methodological approach enables us to produce a series of original and robust empirical results.

These empirical findings offer three main original contributions to the current empirical literature. Firstly, our tier-one analysis suggests that the global financial crisis has produced a permanent effect on the level of integration among the US and the frontier markets. Conversely, the crisis's effect seems to have been only temporary in the case of integration among the US and emerging equity markets. The results also show that, despite the crisis's changes, the degree of integration among the US and emerging markets is considerably larger than the degree of integration among the US and frontier markets. Secondly, the results from tier-two analysis of portfolio diversification point out that US investors would have achieved a higher level of returns if they had diversified their portfolios by considering either emerging or frontier equity markets instead of keeping a US-only portfolio. This result is justified because the correlation across these markets is not perfect, so there are diversification benefits. However, investing in frontier markets rather than emerging or in US-only portfolios, could have reduced the risk before and after the financial crisis. This finding, thus, would corroborate that emerging and US stock markets are more integrated than frontier and US markets.

Thirdly, the tier-three SWARCH model analysis seems to reaffirm the results of the previous two tiers of analysis. By looking at portfolios' reactions to US macroeconomic conditions and news and switches in volatility regimes, the SWARCH model provided another angle to answer the empirical question of how integrated the US, emerging, and frontier stock markets are. The SWARCH structural analysis of tier-three suggests that frontier markets are less integrated with the US economy and show a reduced or null reaction to US news than countries that are more dependent on the US's economic conditions. We also found that the financial crisis has affected both portfolio's volatility and portfolio's returns by changing the responsiveness of returns to economic variables and surprises. The risk of various portfolios strategies, as measured by volatility, has exhibited different phases or endogenous structural breaks. Moreover, our estimates indicate that some international portfolios are more influenced by positive than by adverse shocks, indicating a leverage effect. The financial crisis and the channelling of QE liquidity outside the US stock markets have contributed to increases in the degree of integration of emerging as well as frontier markets with the US market, offering investors in emerging and frontier stocks diversification benefits, which investors have exploited as more liquidity was poured into the US market with subsequent waves of QE.

Further research on the topics discussed in this paper may be pursued in several directions to overcome data and analysis's potential limitations. For instance, it could be valuable to comprehensively examine the relationship between the illiquidity premia in diversified portfolios and international financial market integration using higher frequency data and specific countries and assets. This extension would enable us to incorporate transaction costs and consider net returns in portfolio choices. Cross-section data showed that transaction costs vary consistently across either emerging or frontier equity markets, and measuring them is very challenging (Marshall et al., 2015). The inclusion of transaction costs and illiquidity measures may lead to different portfolio allocations. However, in our analysis, the use of aggregate data at a weekly frequency and the rare episodes of portfolio readjustments reduces the impact of transaction costs as a factor of risk. Secondly, we focused only on the reallocation within the risky part of international portfolios, leaving aside the reallocation between bond and equity. This focus is not a concerning limitation, provided that the quota on risky assets is never zero. However, a broader portfolio analysis that includes bonds and equities could reveal useful insights, particularly in periods of extensive quantitative easing use. Third, in our study, we considered US factors as the main ones affecting either USEM or USFM portfolio equity returns. However, it could be the case that emerging and frontier economic indicators might significantly impact equity portfolios. Further research might overcome all these limitations so that US investors who wish to diversify their investments in either the emerging or frontier equity markets might have additional insights about risks and rewards associated with international portfolio diversification.

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APPENDIX A

Table A1: ARCH estimates US and Emerging markets

	EQWP US-Emerging ARCH(2) Symmetric	MVP US-Emerging ARCH(2) Asymmetric	CET US-Emerging ARCH(1) Symmetric
Mean Equation			
Constant	**0.691*****	**0.248****	**0.350*****
	(0.245)	**(0.098)**	**(0.106)**
Dependent variable (-1)	-0.066	**-0.088****	**-0.080***
	(0.042)	**(0.041)**	**(0.043)**
Dependent variable (-2)		-0.036	0.008
		(0.041)	(0.035)
News ISM	-0.120	-0.104	-0.035
	(0.118)	(0.105)	(0.117)
News ISM post crisis 2008	**0.440*****	**0.335****	**0.293***
	(0.170)	**(0.145)**	**(0.164)**
% change Dollar_Euro	**-0.396*****	**-0.306*****	**-0.477*****
	(0.083)	**(0.058)**	**(0.058)**
% change Dollar_Euro post crisis 2008	**-0.233****		
	(0.119)		
USMONTHLY_Crisis post 2008		-0.204	-0.459
		(0.283)	(0.289)
% Change Dollar_Yen post crisis 2008		**0.388*****	**0.463*****
		(0.075)	**(0.081)**
% change Oil-price post crisis 2008		**0.162*****	**0.191*****
		(0.026)	**(0.027)**
JAPBOND_10Year	-0.148		
	(0.172)		
JAPBOND10_2008	-0.266		
	(0.178)		
US_TB_Monthly_Rate		-0.011	0.014
		(0.037)	(0.40)
Dummy_QE_wave 1	**0.635****	**0.424***	**0.690*****
	(0.330)	**(0.228)**	**(0.268)**
Dummy_QE_wave 3	-0.278		
	(0.223)		
Variance Equation			

Constant	**2.79*** (0.373)**	**2.029*** (0.244)**	**3.13*** (0.383)**
ARCH(1)	**0.325*** (0.068)**	**0.117* (0.067)**	**0.300*** (0.095)**
ARCH(2)	**0.202*** (0.067)**	**0.111* (0.063)**	
D(1)		**0.414*** (0.159)**	
D(2)		0.105 (0.102)	
Shape	**5.169*** (0.984)**	**7.688*** (2.330)**	**5.432*** (1.113)**
Log Likelihood	-1309.265	-1223.960	-1268.7887

Notes: Standard errors are in parentheses. ***/**/* denote statistical significance at the 1%, 5%, and 10% levels, respectively. A non-entry means that the variable was not included in the estimated equation.

Table A2: ARCH estimates US and Frontier markets

	ALL US Symmetric	EQWP US-Frontier ARCH(1) Asymmetric	MVP US-Frontier ARCH(1) Asymmetric	CET US-Frontier ARCH(1) Asymmetric
Mean Equation				
Constant	**0.507*** (0.05)**	**0.313** (0.084)**	**0.506*** (0.153)**	**0.556*** (0.155)**
Dependent variable (-1)	**-0.123*** (0.041)**	**0.094** (0.038)**	**0.172*** (0.041)**	**0.218*** (0.041)**
Dependent variable (-2)		**0.065* (0.036)**	0.054 (0.034)	0.053 (0.034)
News ISM	-0.135 (0.102)	-0.115 (0.087)	-0.110 (0.084)	-0.099 (0.089)
News ISM post crisis 2008	**0.511** (0.149)**	**0.331** (0.115)**	0.181 (0.115)	0.183 (0.127)
News PPI_Net	**-0.979** (0.469)**			
News Nonfarm Payroll	**0.005** (0.001)**			
% change Dollar_Euro	**-0.231** (0.112)**	-0.055 (0.055)		
% change Dollar_Euro post crisis 2008	**-0.190** (0.082)**	**-0.253*** (0.071)**		
% Change Dollar_Yen			**0.140** (0.061)**	**0.157*** (0.062)**
% Change Dollar_yen post crisis 2008			0.1120 (0.078)	0.072 (0.079)
% change Oil-price			-0.029 (0.017)	-0.014 (0.017)
% change Oil-price post crisis 2008			**0.117*** (0.027)**	**0.174*** (0.027)**
FED rate	-0.048 (0.035)			
FED Rate_post crisis	**-0.290*** (0.098)**			

US_TB_Monthly_Rate			-0.072	-0.076
			(0.044)	(0.049)
Dummy_QE_wave 1		0.401		
		(0.281)		
Dummy_QE_wave 2		- 0.071		
		(0.222)		
Dummy_QE_wave 3		0.147		
		(0.160)		
Dummy Financial crisis 2008		**-0.242****	**-0.404****	**-0.487****
		(0.115)	**(0.158)**	**(0.160)**
Variance Equation				
Constant	**2.252*****	**1.683*****	**1.636*****	**1.767*****
	(0.302)	**(0.192)**	**(0.195)**	**(0.206)**
ARCH(1)	**0.303*****	**0.129***	**0.140 ***	**0.134***
	(0.076)	**(0.075)**	**(0.079)**	**(0.078)**
ARCH(2)	**0.236****			
	(0.076)			
Asymmetry		**0.549*****	**0.338****	**0.372****
		(0.178)	**(0.155)**	**(0.165)**
Shape	**6.016*****	**5.334*****	**5.349*****	**4.883*****
	(1.384)	**(1.078)**	**(1.008)**	**(0.862)**
Log Likelihood	-1262.713	-1102.513	-1071.980	-1089.553

Notes: Standard errors are in parentheses. ***/**/* denote statistical significance at the 1%, 5%, and 10% levels, respectively. A non-entry means that the variable was not included in the estimated equation.

Table A3 – US only portfolio

	ARCH(1)	ARCH(2)	ARCH(3)
α_0	2.963***	2.257***	2.001***
	(0.356)	(0.250)	(0.271)
α_1	0.404***	0.302***	0.257***
	(0.084)	(0.072)	(0.066)
α_2	-	0.236***	0.218***
		(0.075)	(0.066)
α_3	-	-	0.108**
			(0.052)
Log Likelihood	-1274.7	-1262.9	-1259.40
Akaike Information Criterion (AIC)	2575.3	2553.7	2548.8
Schwarz Information Criterion (SIC)	2632.7	2615.5	2615.0
Ljung-Box (LB)	9.33	12.5	10.07
	[0.41]	[0.14]	[0.18]
McLeod-Li (ML)	-	-	0.207***
			(0.063)
Andrews Ploberger corrected (APNW)	29.4***	21.6***	17.4**
	[0.00]	[0.00]	[0.03]

Notes: based on AIC and SW tests we selected an ARCH(3) model; in all models, the LB and ML tests indicated presence of autocorrelation of the standardized squared residuals; for all models, the APNW test indicated the presence of a structural break in the conditional volatility. Standard Errors are reported in parentheses, while *p-values* are reported in brackets. ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively. Both the LB and ML for up to ten lags.

Table A4 – EQWP USEM

	ARCH(1)	ARCH(2)	ARCH(3)
α_0	3.693***	2.797***	2.188***
	(0.464)	(0.354)	(0.321)
α_1	0.391***	0.325***	0.240***
	(0.105)	(0.088)	(0.080)
α_2	-	0.202***	0.184***
		(0.069)	(0.070)
α_3			
Log Likelihood	-1320.58	-1309.4	-1299.6
Akaike Information Criterion (AIC)	2667.2	2646.8	2629.4
Schwarz Information Criterion (SIC)	2724.5	2708.6	2695.6
Ljung-Box (LB)	12.39	11.9	9.48

	[0.19]	[0.15]	[0.22]
McLeod-Li (ML)	120***	28.2***	15.6**
	[0.00]	[0.00]	[0.03]
Andrews Ploberger corrected (APNW)	14.71*	1.97*	1.97*
	[0.07]	[0.06]	[0.056]

Notes: based on AIC and SW tests we selected an ARCH(3) and an ARCH(2) model and used them both in the SWARCH model; however with the ARCH(3) model it was not possible to achieve convergence; the LB and ML tests indicated presence of autocorrelation of the standardized squared residuals; for all models, the APNW test indicated the presence of a structural break in the conditional volatility. Standard Errors are reported in parentheses, while *p-values* are reported in brackets. ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively. Both the LB and ML for up to ten lags.

Table A5 – EQWP USFM

EQWP_USFM	ARCH(1)	ARCH(2)	ARCH(3)
α_0	1.684***	1.334***	1.224***
	(0.178)	(0.169)	(0.159)
α_1	0.129**	0.067	0.024
	(0.070)	(0.058)	(0.056)
α_2	-	0.129**	0.043
		(0.064)	(0.059)
α_3	-	-	-0.015
			(0.075)
γ_1	0.549***	0.430***	0.424***
	(0.164)	(0.147)	(0.146)
γ_2	-	0.209	0.189*
		(0.147)	(0.112)
γ_3	-	-	0.309**
			(0.123)
Log Likelihood	-1102.5	-1093.1	-1086.10
Akaike Information Criterion (AIC)	2235.1	2220.3	2210.2
Schwarz Information Criterion (SIC)	2301.3	2295.3	2294.1
Ljung-Box (LB)	7.07	2.70	2.31
	[0.13]	[0.44]	[0.32]
McLeod-Li (ML)	59.02***	63.83***	12.44***
	[0.00]	[0.00]	[0.00]
Andrews Ploberger corrected (APNW)	23.95***	20.58**	16.71
	[0.001]	[0.013]	[0.185

Notes: based on AIC and SW tests, we selected an ARCH(1) model; for all models the LB and ML tests indicated presence of autocorrelation of the standardized squared residuals; the APNW test indicated the presence of a structural break in the conditional volatility. Standard Errors are reported in parentheses, while *p-values* are reported in brackets. ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively. Both the LB and ML for up to ten lags.

Table A6 – MVP USEM

	ARCH(1)	ARCH(2)	ARCH(3)
α_0	2.516***	2.039***	1.770***
	(0.239)	(0.254)	(0.226)
α_1	0.124*	0.117*	0.093
	(0.072)	(0.063)	(0.060)
α_2	-	0.111*	0.048
		(0.061)	(0.050)
α_3	-	-	0.032
			(0.058)
γ_1	0.518***	0.413***	0.345***

	(0.162)	(0.159)	(0.129)
γ_2	-	0.105	0.187*
		(0.102)	(0.100)
γ_3	-	-	0.208**
			(0.100)
Log Likelihood	-1231.8	-1224.3	-1214.9
Akaike Information Criterion (AIC)	2493.6	2482.6	2467.9
Schwarz Information Criterion (SIC)	2559.8	2557.6	2551.8
Ljung-Box (LB)	18.33**	18.24**	12.09*
	[0.03]	[0.02]	[0.10]
McLeod-Li (ML)	59.13***	30.36***	23.12* **
	[0.00]	[0.00]	[0.00]
Andrews Ploberger corrected (APNW)	20.51***	16.84*	14.13
	[0.006]	[0.097]	[0.460]

Notes: based on AIC and SW tests and on statistical significance of the ARCH coefficients, we selected an ARCH(2) model; for all models the LB and ML tests indicated presence of autocorrelation of the standardized squared residuals; the APNW test indicated the presence of a structural break in the conditional volatility. Standard Errors are reported in parentheses, while *p-values* are reported in brackets. ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively. Both the LB and ML for up to ten lags.

Table A7 – MVP USFM

	ARCH(1)	ARCH(2)	ARCH(3)
α_0	1.638***	1.226***	1.067***
	(0.163)	(0.147)	(0.151)
α_1	0.140**	0.115	0.042
	(0.072)	(0.070)	(0.063)
α_2		0.087	0.075
		(0.056)	(0.057)
α_3			0.107
			(0.081)
γ_1	0.338**	0.251**	0.274**
	(0.144)	(0.131)	(0.124)
γ_2		0.329**	0.306**
		(0.151)	(0.143)
γ_3			0.057
			(0.106)
Log Likelihood	-1072.06	-1060.7	-1056.1
Akaike Information Criterion (AIC)	2174.1	2155.4	2150.2
Schwarz Information Criterion (SIC)	2240.3	2230.4	2234.0
Ljung-Box (LB)	13.48	12.0	11.28
	[0.142]	[0.42]	[0.13]
McLeod-Li (ML)	109.6***	65.408***	25.23***
	[0.00]	[0.00]	[0.00]
Andrews Ploberger corrected (APNW)	30.09***	25.18***	24.81***
	[0.000]	[0.000]	[0.002]

Notes: based on AIC and SW tests and on statistical significance of the ARCH coefficients, we selected an ARCH(1) model; for all models the LB and ML tests indicated presence of auto correlation of the standardized squared residuals; tfor all models, the APNW test indicated the presence of a structural break in the conditional volatility. Standard Errors are reported in parentheses, while *p-values* are reported in brackets. ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively. Both the LB and ML for up to ten lags.

Table A8 – CET USEM

CET_USEM	ARCH(1)	ARCH(2)	ARCH(3)
α_0	3.147***	2.551***	2.160***
	(0.341)	(0.289)	(0.281)
α_1	0.296***	0.263***	0.182***
	(0.082)	(0.075)	(0.065)
α_2	-	0.173***	0.157**
		(0.065)	(0.063)
α_3	-	-	0.165***
			(0.058)
Log Likelihood	-1269.0	-1261.9	-1254.8
Akaike Information Criterion (AIC)	2566.0	2553.9	2541.6
Schwarz Information Criterion (SIC)	2627.8	2620.1	2612.2
Ljung-Box (LB)	17.6**	20.0**	15.29**
	[0.03	[0.02	[0.03
McLeod-Li (ML)	74.23***	35.54***	9.97
	[0.00]	[0.00]	[0.19]
Andrews Ploberger corrected (APNW)	27.67***	21.19***	18.48*
	[0.000]	[0.004]	[0.084]

Notes: based on AIC and SW tests we selected an ARCH(2) and an ARCH(1) model and used them both in the SWARCH model; however with the ARCH(2) model it was not possible to achieve convergence; the LB and ML tests indicated presence of autocorrelation of the standardized residuals and squared residuals; for all models, the APNW test indicated the presence of a structural break in the conditional volatility. Standard Errors are reported in parentheses, while *p-values* are reported in brackets. ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively. Both the LB and ML for up to ten lags.

Table A9 – CET USFM

CET_USFM	ARCH(1)	ARCH(2)	ARCH(3)
α_0	1.767***	1.331***	1.052*
	(0.182)	(0.169)	(0.169)
α_1	0.134*	0.121	0.062
	(0.077)	(0.077)	(0.062)
α_2	-	0.152**	0.155**
		(0.074)	(0.075)
α_3	-	-	0.137
			(0.090)
γ_1	0.372**	0.302**	0.333**
	(0.159)	(0.145)	(0.1360
γ_2	-	0.175	0.153
		(0.138)	(0.137)
γ_3	-	-	0.062
			(0.118)
Log Likelihood	-1089.50	-1079.90	-1074.6
Akaike Information Criterion (AIC)	2209.1	2193.8	2187.3
Schwarz Information Criterion (SIC)	2275.3	2268.8	2271.1
Ljung-Box (LB)	14.29	15.12**	15.34**
	[0.113	[0.06	[0.03
McLeod-Li (ML)	92.92***	79.93***	16.83**
	[0.000]	[0.00]	[0.02]
Andrews Ploberger corrected (APNW)	34.32***	29.44***	28.70***
	[0.000]	[0.000]	[0.000]

Notes: based on AIC and SW tests and on statistical significance of the ARCH coefficients, we selected an ARCH(1) model; for all models the LB and ML tests indicated presence of autocorrelation of the standardized squared residuals; for all models, the APNW test indicated the presence of a structural break in the conditional volatility. Standard Errors are reported in parentheses, while *p-values* are reported in brackets. ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively. Both the LB and ML for up to ten lags.

Table A10 – Testing SWARCH on selected ARCH

	US	USEM			USFM		
SWARCH		EQWP	MVP	CET	EQWP	MVP	CET
Log Likelihood two regimes	-1251.5	-1298.2	**-1204.5**	-1245.1	-1078.4	-1050.0	-1069.7
Log Likelihood three regimes	**-1243.2**	**-1291.2**	-1203.3 NC	**-1242.3**	**-1077.5**	**-1045.2**	**-1063.2**
LR Chi square (^)	16.6***	14.0*	2.40	5.6*	1.80	9.6***	13.0***
	[0.00]	[0.00]	[0.30]	[0.06]	[0.40]	[0.001]	[0.002]
	DF=2	DF=2	DF=2	DF=2	DF=2	DF=2	DF=2
Log Likelihood ARCH	-1259.4	-1309.3	-1223.9	-1268.8	-1102.5	-1072.0	-1089.6
LR Chi square SWARCH/ARCH	32.4***	36.2***	38.8***	53.0***	50.0***	53.6***	52.8***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
	DF=4	DF=4	DF=4	DF=4	DF=4	DF=4	DF=4

Notes: for the MVP USEM portfolio the three-regime model did not achieve convergence (NC= not converging). (^) The count of the number of parameters for the SWARCH specifications does not include the transition probabilities p_{ii} imputed to be zero. The p-value for a likelihood ratio test of that model against the preceding specification would be under the assumption that twice the difference in log-likelihoods is distributed χ_2 with degrees of freedom equal to the difference in number of parameters between the null and alternative. *P-values* are reported in brackets ***,**, * indicate significance at the 1%, 5%, and 10% level, respectively.

Table A11 – Robustness of conditional mean equation: controlling for lagged macroeconomic surprises.

Testing lags of macroeconomic news	US	US/EM			US/FM		
	Domestic only	EQWP	CET	MVP	EQWP	MVP	CET
ARCH adding one lag to all macroeconomic news to all ARCH models (1,2,3)	None of the lagged news was statistically significant	None of the lagged news was statistically significant	Out of three lagged news, only one was SS 10% in the ARCH1 model (^)	None of the lagged news was statistically significant	None of the lagged news was statistically significant	None of the lagged news was statistically significant	None of the lagged news was statistically significant

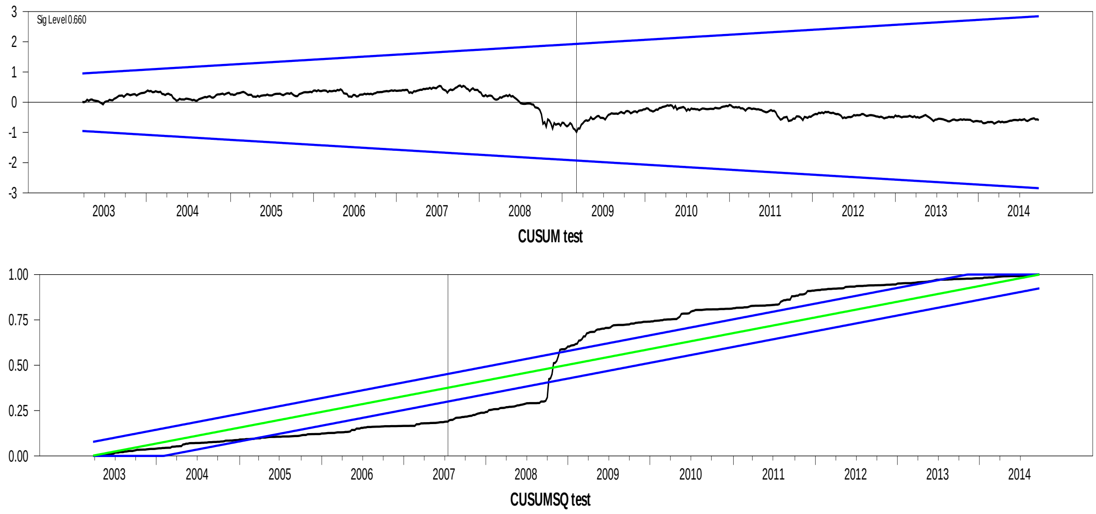
SWARCH adding one lag to all macroeconomic news of the final SWARCH model	None of the lagged news was statistically significant	The model did not achieve convergence; and none of the lagged news was statistically significant	Out of 3 lagged news, only one lagged news was statistically significant at 10%. We rejected this model by using a LR test LR 2.6 P=0.457	The model did not achieve convergence; and none of the lagged news was statistically significant	The model did not achieve convergence; and none of the lagged news was statistically significant	None of the lagged news was statistically significant	None of the lagged news was statistically significant

Note: (^) out of the three added lagged macroeconomic variables, only one was statistically significant at 10% for the ARCH1 model; however, when we removed the other two non-statistically significant lagged news, the remaining lagged news became non-statistically relevant.

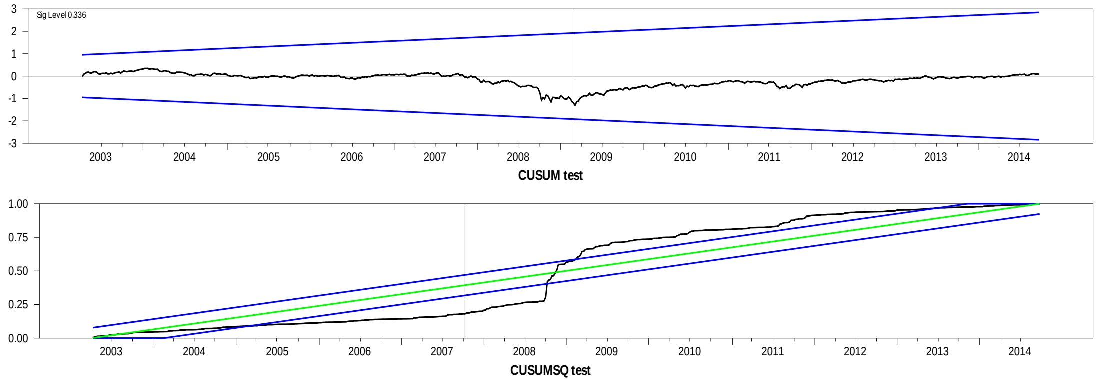
APPENDIX B

Figure B.1 – CUSUM test results for the US and emerging markets portfolio strategies

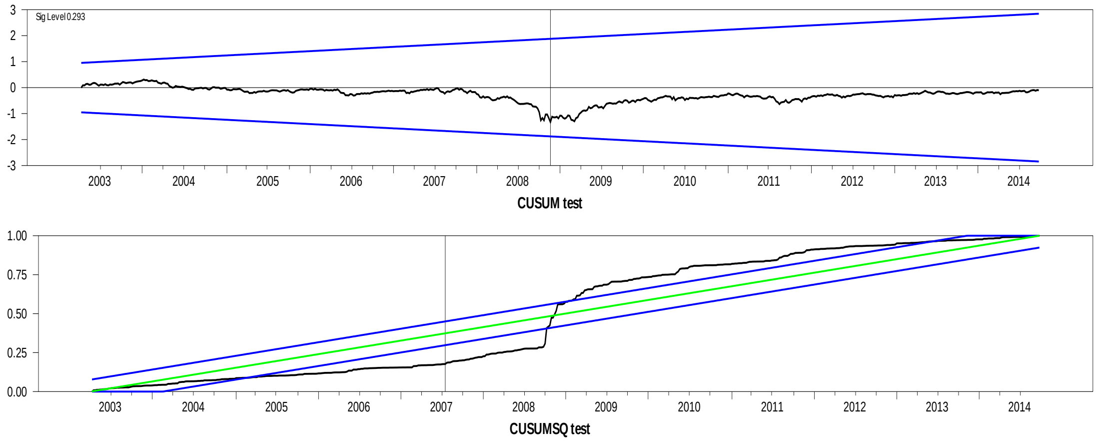
Panel A – EQWP_USEM



Panel B – MVP_USEM



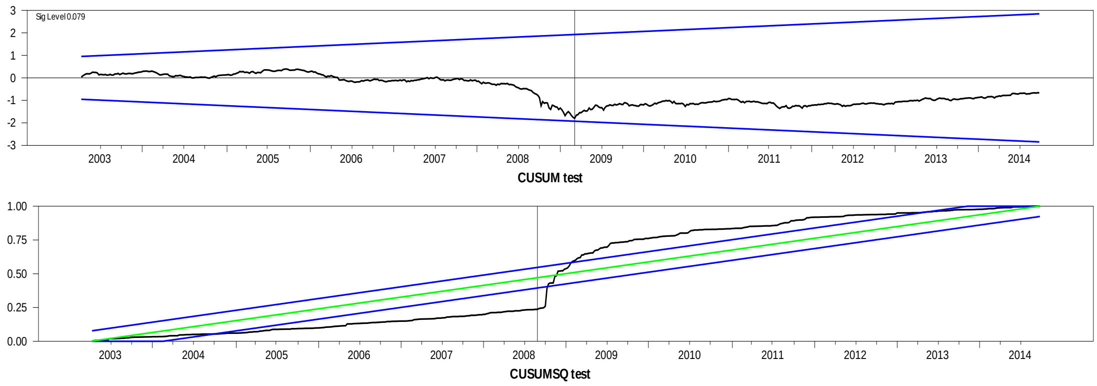
Panel C – CET_USEM



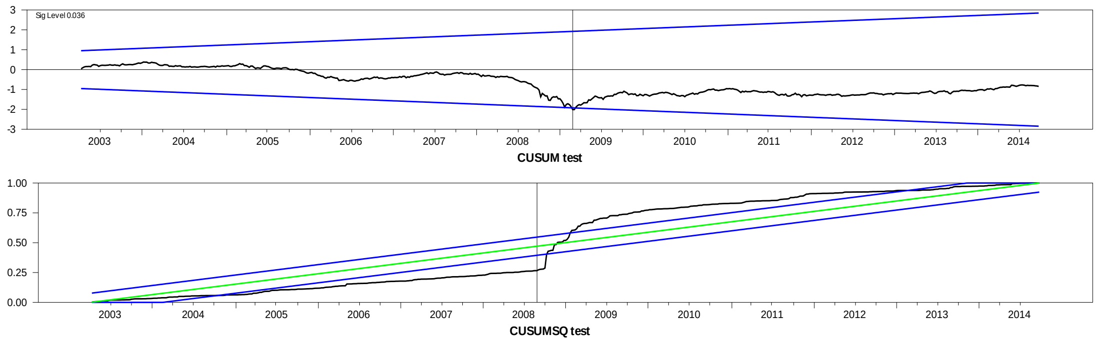
Notes: Panels A, B, and C illustrate the results of the CUSUSM test for the EQWP_USEM, MVP_USEM, and CET_USEM portfolio strategies respectively.

B.2 – CUSUM test results for the US and frontier markets portfolio strategies

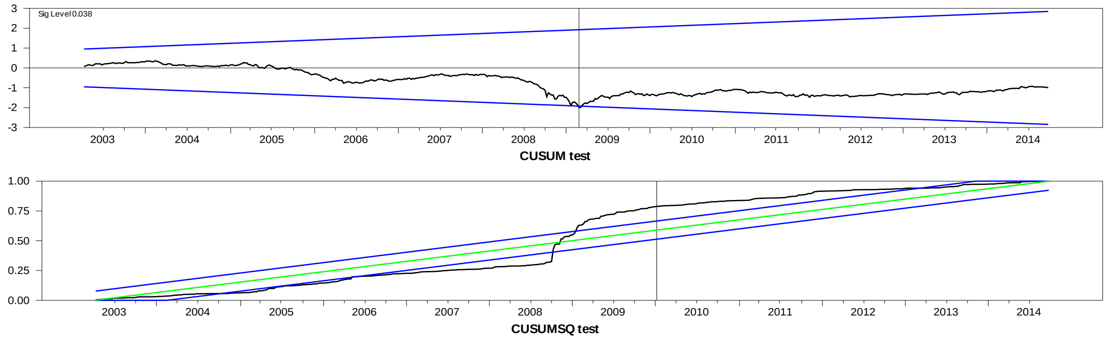
Panel A – EQWP_USFM



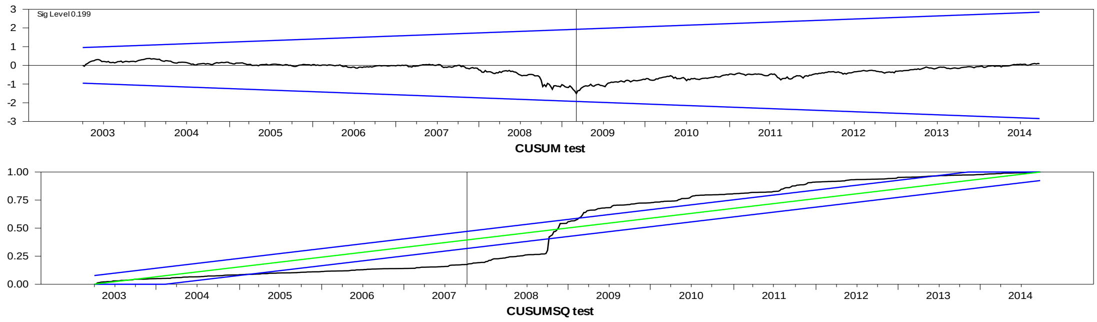
Panel B – MVP_USFM



Panel C – CET_USFM



Panel D – US_ONLY



CUSUM Test for US Portfolio

Notes: These figures illustrate the results of the CUSUM test for the EQWP_USFM (Panel A), MVP_USFM (Panel B), CET_USFM (Panel C), and US_ONLY respectively.