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An Examination of Equity Market Linkages and the Benefits of International Portfolio Diversification

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A dissertation submitted in fulfilment of the requirements for the Degree of Doctor of Philosophy in Business Studies

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2016

Declaration

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Abstract

The extent of global equity market integration in a post-crisis world is an important consideration for investors and academics alike. While market integration has received substantial attention in the extant literature, until now, relatively little has been done to characterise world equity market linkages beyond the global crisis. Modern portfolio theory informs us that a low return correlation between national stock markets should motivate diversification strategy (Markowitz, 1952; Grubel 1968). It stands to reason that diversification benefits are greatest when markets are not positively correlated; if markets respond symmetrically to shocks, diversification benefits may not exist when they are needed most. Furthermore, the trend toward trade and capital market liberalisation, as well as monetary policy coordination, has led to an increasingly globalised and interdependent world (Goetzmann et al., 2005; Coelho et al., 2007; Quinn and Voth, 2008), with equity market integration posing a direct challenge to the international diversification of portfolios.

The global nature of the recent crisis mandates an analysis across a complete set of developed and emerging markets that assesses, in explicit detail, the ramifications of the crisis period for global linkages. This thesis examines equity market linkages across a sample of forty-six markets between January 1995 and December 2013. I compare levels of market integration across developed and emerging market samples, and conduct an explicit analysis of the implications of the recent crisis period for the integration of these markets. Crisis dates are determined using the structural break-point procedure of Bai and Perron (1998). I use the Johansen and Juselius (1990), Hansen and Johansen (1993), and Gregory and Hansen (1996) tests of cointegration in my analysis of market linkages, and further examine conditional correlations using the DCC-GARCH model of Engle (2002). I find market linkages to be time-varying and volatile across developed and

emerging market samples. I further find that the crisis period is associated with a strengthening of links among some groups (Asia, APEC) with a move towards greater segmentation among others (Europe, the G7).

If times of crisis can be associated with heightened levels of equity market integration, then investors diversifying internationally across affected markets may not be receiving the benefits of diversification when they are needed most. Following the work of Heston and Rouwenhorst (1994), and similar studies by Flavin (2004) and Bai et al. (2012), I compare the benefits of international and industrial portfolio diversification within a panel-data framework. Using firm-level stock returns for 6,183 firms across developed and emerging markets, I form a factor model and examine the relative importance of the competing industry and country effects. A sub-period and recursive analysis further allows me to examine how the relative importance of these competing factors has evolved over time, and how the benefits of industrial and international diversification compare in times of crisis. Ultimately I find that country effects remain dominant over industry effects for emerging markets, while industry effects are larger across a sample of developed markets.

I further examine the relative merits of country and industry motivated diversification in terms of mean-variance optimality. I use country-level returns across a sample of twemty-three developed and twenty-one emerging equity markets to examine the mean-variance efficiency of country and industry only portfolios, relative to a portfolio combining both industries and countries. Mean-variance spanning analysis (Huberman and Kandel, 1987; Kan and Zhou, 2012) investigates if conditional on a set of benchmark assets the addition of a set of test assets can shift the mean-variance efficient frontier. This amounts to examining if a sub-set of the benchmark industry *or* country returns yields the same diversification benefits as the extended set of industry *and* country

returns. I establish that neither a country- or industry-only portfolio is sufficient to achieve full diversification benefits, but a strategy mixing both industries and countries should be pursued.

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Chapter 1 Introduction and Overview

1.1 Introduction

This thesis comprises three essays that explore the global inter-connectedness of national equity markets, and that examine the implications of market linkages for the international diversification of equity portfolios. It further explores the implications of the global financial crisis for equity market linkages, and for the on-going debate on the relative importance of industry and country factors in portfolio diversification. In this opening chapter, I offer an introduction to the topic of equity market integration and international portfolio analysis.

Theories of diversification, and the benefits therein, pre-date academic contributions. The idea that, as risk-averse economic agents, we must not place all of our eggs into the same basket has been referenced in biblical works: "*divide your investments among many places, for you do not know what risks might lie ahead*" (Ecclesiastes 11:2) and even in William Shakespeare's The Merchant of Venice, in which the titular character reveals his efforts to preserve his good fortune: "*my ventures are not in one bottom trusted, nor to one place; nor is my whole estate, upon the fortune of this present year: therefore, my merchandise makes me not sad.*" Notwithstanding these earliest contributors, Markowitz (1952) and Tobin (1956) are the first to formalise this concept with their pioneering papers, which have since become the cornerstones of Modern Portfolio Theory.

The benefits to diversification are predicated on the assumption that the underlying instruments are sufficiently uncorrelated, or negatively so. In the context of listed equities, investment across a multitude of national equity markets presents an opportunity for investors to improve their risk-return trade-off. However, as documented in much of the surrounding literature, achieving these benefits is not straightforward.

Identifying the extent to which national equity markets are appropriate diversification tools, and examining the relative benefits of diversifying across these markets, forms the basis for this thesis.

The remainder of this chapter is structured as follows. In Section 1.2 I state and discuss my central research questions, and explore my research motivation in each case. Section 1.3 discusses the structure of the thesis and presents the main findings of my work. In Section 1.4 I outline my efforts in disseminating this research, and in Section 1.5 I provide a brief summary and offer some concluding remarks.

1.2 Central Research Questions, Motivation, and Contribution

I conduct my analysis across several central research questions. These questions, and the myriad of sub-questions that relate to them, are discussed below. I further justify these questions in the context of the surrounding literature. I state the contribution that the analysis of each question makes to the relevant literature, and offer a brief overview of my approach to answering each question.

The linkages that exist between national equity markets have been the subject of considerable debate in the academic literature. Previous efforts to empirically assess the merits of holding an internationally diversified portfolio have revealed a general trend toward strengthening market linkages over time. Enhanced trade links, financial market liberalisation, monetary integration, excessive volatility, and cultural symmetries, have all been identified as important contributors to this trend. Kearney and Lucey (2004) synthetise the vast literature on equity market integration, and conclude that despite dissimilar findings throughout, the bulk of the work in this area suggests that international equity market integration has progressed over time. Other oft-cited examples include Longin and Solnik (1995), De Santis and Gerard (1997) and Goetzmann et al. (2005). Against the backdrop of previous literature, I explore the state

of equity market integration using a long-term and global sample. My first central research question can be summarised as follows.

Q1 Are equity markets integrated?

I explore many different avenues in answering this question, and attempt to provide answers for the following related sub-questions.

1.1 Are patterns of integration different among developed versus emerging markets, and how do integration levels compare across different economic groups and geographical regions of the world?

A substantial number of studies examine the integration of emerging markets with major developed markets, or with developed market groups. Furthermore, a significant volume of previous work characterises market linkages within specific time-periods, or within specific geographical regions. For example, the emerging markets of Central Europe (Gilmore and McManus, 2002; Syriopoulos, 2004; Voronkova, 2004; Wang and Moore, 2008), Asia (Wang et al., 2003; Phylaktis and Ravazzolo, 2005; Hyde et al., 2007; Royfaizal et al., 2009), developed Europe (Corhay et al., 1993; Byers and Peel, 1993; Kanas, 1998; Gerrits and Yuve, 1999; Dickinson, 2000; Fraser and Oyefeso, 2005), the G7 (Barari et al., 2008; Menezes et al., 2012), and the BRICS (Barari et al., 2008; Zhong et al., 2014) have all been examined extensively. These and other relevant studies are discussed in greater detail in Chapter 2.2. However, little has been done to synthesise these studies, and compare market linkages across these various groupings that are of obvious interest to academics and investors.

I examine linkages among the markets of a multitude of different geographic and economic groups that individually, have received considerable attention in the literature. Specifically, I examine five groups of developed markets (Western Europe, Asia-Pacific,

PIIS, the G7, and the G7 without continental Europe), and seven groups of emerging markets (the Americas, Middle East and Africa, Asia and Asia-Pacific, Emerging (Southern and Eastern) Europe, Asia-Pacific Economic Cooperation (APEC), BRICS (Brazil, Russia, India, China, and South Africa), and the Emerging and Growth Leading Economies (EAGLEs – Brazil, China, India, Indonesia, Mexico, Russia, South Korea, and Turkey).

The need to separate and distinguish between developed and emerging markets is reinforced in a recent working paper by Bekaert and Harvey (2014). They identify that emerging markets are not integrated fully integrated into world capital markets, and should continue to be treated as a separate asset class. I separately analyse samples of twenty-three developed and twenty-two emerging markets to determine the extent to which integration levels differ between these two classifications. I examine the nineteen-year period from January 1995 to December 2013. To my knowledge, no previous studies exist that compare patterns of integration among developed and emerging markets on this scale. Differences in market and economic development, market capitalisation, and liquidity, are all important considerations that justify this separate analysis. I classify markets in line with the MSCI market classification system, as of June 2013.

My approach facilitates a comparative study of the level of market integration across different regions of the world, and offers a contribution to existing studies that consider a single region or group only.

1.2 Are market linkages time-varying, and what temporal patterns emerge? Has the global financial crisis impacted on equity market linkages?

I assess time variation in market linkages, by utilising a longitudinal sample, (from January 1995 to December 2013) that explores the dynamics of integration in a sub-

period and recursive framework. Until now, little has been done to characterise linkages among equity markets surrounding the global financial crisis. I separate my sample into different sub-periods as determined using the Bai-Perron break-point procedure, detailed in Chapter 3.8, and examine integration levels among markets within each sub-period. This allows me to disentangle the crisis period from the wider sample, and to examine if the crisis can be associated with material changes in integration levels. In the context of this sub-period and recursive analysis, I examine whether the global financial crisis has materially altered equity market linkages.

A substantial body of literature examines the roots of the benefits to international portfolio diversification. This is an important consideration in the context of an increasingly integrated world. I follow several key studies (Heston and Rouwenhorst, 1994; Griffin and Karolyi, 1998; Baca et al., 2000; Serra, 2000; Flavin, 2004; Ferreira and Ferreira, 2006; Bai and Green, 2011; Graff, 2011) discussed in detail in Chapter 2.3, that propose a separation of the return on a stock into an industry and a country component. The estimation of these two components offers an invaluable insight into their relative importance in stock return variability. I examine the following second central research question.

Q2. Do the benefits of international portfolio diversification stem from industry- or country-level differences?

This is an important consideration for the international investor and several studies have examined this issue. I explore this central research question across the following related sub-questions.

2.1 Are there substantial differences in the relative size of industry and country effects between developed and emerging market samples?

Using firm-level panel data for 6,183 firms across ten industrial groupings and forty-six countries, I separately analyse samples of developed and emerging markets to determine if the relative size of industry and country factors differs substantially by market classification. No previous studies directly compare the relative importance of industry and country factors between developed and emerging markets in this way, and this represents an important contribution to the literature. The theoretical basis of my analysis is rooted in the seminal paper by Heston and Rouwenhorst (1994) but draws heavily on the adaptation by Flavin (2004) which allows for both statistical and economic significance among the estimated industry and country effects.

2.2 In a dynamic framework, how has the relative importance of these two factors evolved over time, particularly surrounding the onset of the global financial crisis?

I use a novel approach in examining the evolution of the relative importance of industry and country factors. I adapt my panel data analysis to a recursive framework, and run 940 total regressions for both the developed and the emerging market samples. I examine the period from January 1995 to December 2013. The resulting time series of the industry-to-country effect ratio is plotted to show the dynamics of the relative importance of these competing factors. This examination of the inter-temporal stability of the relative importance of industry and country factors represents a novel and valuable contribution to the literature. It allows me to trace changes in the relative importance of industry and country factors, and allows me to directly compare my findings with those of earlier studies that examined historical time-periods, with the benefit of an extended and more recent sample. This allows me to identify if previous findings regarding the relative importance of industry and country factors were the result of temporary fluctuations, or more persistent effects.

I identify sub-periods using the Bai-Perron break-point procedure and examine the industry-to-country effect ratio within each of these sub-periods. In particular, I examine the relative size of industry and country effects in the sub-period encompassing the global financial crisis, and compare this result to the result from the preceding sub-periods. This allows me to determine any material changes in the relative importance of industries and countries surrounding the global financial crisis. To my knowledge, no previous studies have examined the implications of the global financial crisis for the relative importance of industry and country effects.

In addition to the traditional factor model, I follow more recent studies (Gerard et al., 2002; Eiling et al., 2012; Kan and Zhou, 2012; that seek to examine the relative benefits of industry- and country-focused diversification. I examine the merits of pursuing an industry- versus a country-focused strategy in mean-variance space.

Q3. Using tests of mean-variance spanning, is investment in industry- or country-focused portfolios sufficient to achieve full diversification benefits?

I examine the mean-variance efficiency of industry- and country-based diversification strategies across the following sub-questions.

3.1 Is it beneficial to diversify portfolios across both industries and countries rather than use a diversification strategy focussed exclusively on industries or countries?

I use a wealth of alternative spanning tests and a Sharpe ratio analysis that is previously unused in the examination of industry and country factors in portfolio diversification. Specifically, in addition to traditional OLS based spanning tests, I use GMM based tests, and several test statistics to explore the robustness of my results. No previous studies of industry and country factors have used such a wide array of spanning tests in their analysis. I use a novel approach to testing for significant differences between the

maximum Sharpe ratio of the benchmark and the extended set of assets that has not been previously applied in studies of industry and country factors in portfolio diversification. I follow the method of Ledoit and Wolf (2008) detailed in Chapter 3.7.1 and I examine the case with and without short-sales constraints. By using this combination of methods, and such a large sample of forty-four equity markets, across the period from January 1998 to December 2013, I am able to contribute a rigorous study and offer a reliable and robust perspective on this on-going debate.

3.2 Has the global crisis impacted on the mean-variance efficiency of industry- or country-based diversification strategies?

I further investigate if the global crisis impacted on the mean-variance efficiency of industry- or country-based diversification strategies. I conduct a sub-period analysis that allows for time-variation in the relative mean-variance efficiency of industry- and country-based diversification strategies. This approach further allows me to identify meaningful changes in the mean-variance efficiency of these two strategies with the onset of the global financial crisis. To my knowledge, there are no current studies that examine the implications of the global financial crisis for the mean-variance efficiency of industry- or country-based diversification strategies.

1.3 Structure of Thesis and Main Findings

The remainder of this thesis is structured as follows. In Chapter 2, I present and discuss the surrounding literature across three important areas: the literature that examines equity market integration, the previous work done on determining the relative importance of industries and countries in portfolio diversification, and the research that currently exists on examining the implications of crisis periods for market linkages and the benefits of international portfolio diversification.

In Chapter 3, I present and discuss the data and methods used in the analysis of my central research questions. I present some summary statistics and preliminary analysis for this data. I also provide my theoretical and econometric framework for the analysis of each research question, and attempt to justify my choice of method in each case.

In Chapter 4, I examine my first of the three research questions outlined above. I characterise global equity market linkages. Using a global and longitudinal sample of country-level price indices, I use a variety of cointegration based methods, alongside a dynamic conditional correlation analysis, to track the evolution of global equity market integration using a sample of forty-five equity markets (twenty-three developed and twenty-two emerging) over the past nineteen years (from January 1995 to December 2013). I further examine if the recent global crisis, or indeed any previous crisis periods captured by my sample, has materially altered the nature of these underlying relationships. I find that market integration is time-varying and volatile across both developed and emerging markets. The first half of the 2000s can be associated with stable levels of integration, with significant volatility throughout the rest of the sample. Market linkages are present throughout. The sub-period characterising the crisis and its aftermath, is marked by strong and stable market linkages among European markets. While linkages between Asian-Pacific markets during this time are noticeably more volatile, they are strong and rising. The linkages between the developed markets of Europe, and those of the Asia-Pacific, imply that there are few gains to diversifying across the developed markets of these regions.

In Chapter 5 I examine the second of my central research questions outlined above. I present my analysis of industry and country effects in the context of a factor model. I adapt the contribution by Flavin (2004), as an alternative to the Heston and Rouwenhorst (1994) method, to a dynamic framework. I thus examine changes in the relative

importance of these competing factors throughout the sample period. I find that industry effects are marginally bigger for developed markets across the full-period, while country effects dominate in emerging markets during this time. Examining the temporal stability of these factors, I find that the relative importance of industry and country effects is time-varying. Among developed markets, country factors are more important between January 1995 and November 1997, and between October 2008 and December 2013. However, industry effects dominate significantly in the time between these two sub-periods. Country effects remain dominant of industry effects in every sub-period for the emerging market sample. Furthermore, a recursive analysis highlights the inter-temporal instability of the relative importance of these competing factors.

In Chapter 6 I examine the third of my central research questions outlined above. I present the results of my spanning analysis. I use a variety of spanning tests, not commonly used together in the surrounding literature, to ensure a robust and thorough analysis of the mean-variance efficiency of industry- and country-focused diversification strategies. I find that an expanded set of assets, including both industries and countries is generally preferable to a set that focuses exclusively on industries or countries. A sub-period analysis suggests that for global and developed market samples, the evidence in favour of mixing both countries and industries, rather than investing exclusively in either countries or industries, is strengthening over time. I find that there is stronger evidence of the economic benefits to pursuing a mixed strategy once short-selling is allowed, however, in relaxing short-sales constraints, it is apparent that these benefits exist. Finally, in Chapter 7 I offer some concluding remarks to finish this thesis.

1.4 Dissemination Efforts

The analysis and findings from Chapters 4 and 5 relating to research questions 1 and 2 were presented at the following conferences.

"Assessing the Relative Benefits of International and Industrial Portfolio Diversification"

- Academy of International Business – UK and Ireland, Birmingham UK, 2013

This paper won the Michael Z Brooke prize for the best doctoral paper at this conference.

- Irish Academy of Management, Waterford Ireland, 2013

The analysis and findings from Chapter 6 relating to research question 3 were presented at the following conference.

"An Examination of the Implications of the Global Crisis for Industry and Country Based Diversification Strategies"

- Academy of International Business – UK and Ireland Stream, York UK, 2014

The analysis and findings from Chapter 4 relating to research question 1 were presented at the following conferences.

"The Integration of Developed Equity Markets: Evidence from the Global Crisis"

- European Economics and Finance Society, Brussels Belgium, 2015
- Irish Academy of Management, Galway Ireland, 2015

I am in the process of submitting three papers from this thesis for publication in high-ranking journals of international finance.

1.5 Conclusion

In this Chapter, I gave a brief introduction to my research topic. I followed this with a discussion of my central research questions, and all related sub-questions. I also detailed the structure of the remainder of this thesis and outlined my work in disseminating the knowledge generated from my research efforts. I proceed with a review of the surrounding literature.

Chapter 2 Literature Review

In this chapter I present a discussion of the various literatures of relevance to this thesis. I separately present the literature on equity market integration, the debate on industry and country effects in portfolio diversification, and the implications of crisis periods for market linkages and the benefits of international portfolio diversification.

I begin with an overview of these literatures in Section 2.1. I follow this with a discussion of the literature on equity market integration in Section 2.2. I then present my review of the literature on the relative importance of industries and countries in portfolio diversification in Section 2.3. I discuss the literature on crises and their implications for market linkages and international portfolio diversification in Section 2.4. Finally, in Section 2.5 I offer some concluding remarks.

2.1 Introduction and Overview of the Surrounding Literature

This chapter discusses the relevant literature on international equity market linkages and the relative benefits of industrial and international portfolio diversification. I use this analysis of the surrounding literature to frame and justify my own research, and to highlight the novel contribution that this research is making to the wider field.

Since the pioneering work of Markowitz (1952), investment theory has advanced the view that investors should seek to diversify their holdings to reduce their risk exposure. Underlying modern portfolio theory is the idea that the investment decision should be based not only on the risk-return profile of an individual asset, but on the relationship between that asset and the various other assets that the investor wants to hold. Following the work of Markowitz (1952), Tobin (1956) conceives his separation theorem, which profiles the investment decision of the risk-averse investor, and establishes independence between the optimum allocation among risky asset classes, and the optimum allocation

between risky asset classes and risk-free assets. Building on the work of his predecessors, Sharpe (1964) formalises the Capital Asset Pricing Model (CAPM) and the beta relationship, characterising the degree to which equities move alongside the wider market. This triad of theoretical contributions underpins modern portfolio theory, and the vast body of empirical literature that seeks to define and measure the benefits of international portfolio diversification in a continuously evolving financial landscape.

The benefits of investing across different national equity markets have received substantial empirical support in the literature. A sufficiently low return correlation between national equity markets rewards a better risk-return trade-off for fund managers or investors who diversify internationally. Among the earliest to document these benefits are Grubel (1968), and Levy and Sarnat (1970). Grubel (1968) examines monthly data from eleven major national equity markets over the period between January 1959 and December 1966, while Levy and Sarnat (1970) examine a larger sample of annual returns from twenty-eight national equity markets over the period from 1951 to 1967. Both establish convincing evidence of the benefits of international portfolio diversification for US investors – Grubel (1968) finds greater benefits when investing in more distant markets, while Levy and Sarnat (1970) analyse optimal portfolios and efficiency frontiers to find that the inclusion of emerging markets into the investment opportunity set improves the risk-return position of the investor.

Later studies reinforce these findings. Solnik (1974) considers weekly data for seven European equity markets and the US, between 1966 and 1971, and finds substantial evidence of diversification benefits, advocating the development of US-based international mutual funds. Lessard (1975) uses monthly data on sixteen national equity markets across thirty industries from January 1959 to October 1973, and for fourteen national equity markets and fourteen industries from January 1969 to October 1973, and

establishes the benefits of international portfolio diversification despite a preference for domestic investment, for US investors. This early indication of what is termed the home-bias problem, has received substantial attention in the literature (French and Poterba, 1991; Tesar and Werner, 1995; Morse and Shive, 2011) the majority of which confirms the existence of a preference for home based investments.

While there is a substantial volume of historical literature advancing the benefits of international portfolio diversification, there exists a growing body that seeks to question the existence of these benefits, or the degree to which they are actually realised by investors. The extent to which investors can benefit from international investments over and above home based investment remains a subject of discussion. For example, Driessen and Laeven (2007) use spanning tests and a Sharpe ratio analysis on a sample of monthly data for twenty-three developed markets and twenty-nine emerging markets. They establish that there are benefits to global diversification relative to home-based investment, but they also find that these benefits are shrinking over time. Errunza et al. (1999) use monthly data across seven developed markets and nine emerging markets over the period from 1976 to 1993 and establish insignificant benefits to international investment, beyond home-based investment. More recently, O'Hagan-Luff and Berrill (2015) use a multitude of US equity products to find that US based investors can replicate the returns of thirty-six countries from the period between 1996 and 2011. This home-bias phenomenon is a subject of on-going debate.

Another point of contention in the literature on international portfolio diversification is the growing integration of national equity markets, and the degree to which national equity markets move together. Monetary integration in Europe, globalisation, and trade and financial market liberalisation, have all been associated with a strengthening of market linkages. Kearney and Lucey (2004) offer a review of the literature on financial

market integration. They note the existence of some discrepancies in the findings of much of the literature, but reaffirm that the bulk of research in the area purports that equity market integration is strengthening over time. Studying the period between 1960 and 1990, Longin and Solnik (1995) use monthly data for seven national equity markets and find temporal instability in correlation matrices, growing correlation among the studied markets over time, and heightened levels of correlation surrounding periods of heightened volatility. This trend has persisted in more recent times, and is not exclusive to developed markets. Goetzmann et al. (2005) uses monthly returns on forty-five national equity markets across a 150 year period to highlight temporal instability in correlation matrices, and finds a persistent rise in correlation throughout the latter half of the 20th century. De Santis and Gerard (1997) use monthly data for the G7 group including Switzerland from January 1970 to December 1994. They identify that financial markets are increasingly more integrated, posing a threat to the benefits of international portfolio diversification.

Motivated by the prevailing evidence in support of the hypothesis that market linkages have been rising consistently in recent times, a large body of empirical literature seeks to determine the implication of these growing linkages for the benefits of international portfolio diversification. More precisely, the importance of the country factor in a globalised and integrated world is a subject of continuous debate (Ferreira and Ferreira, 2006; Bekaert et al., 2009). There is a shift in the literature at the turn of the century towards recognising the growing importance of the industry factor, given the heterogeneity of industrial structure across national equity markets. Lessard (1975) is among the first to consider the role of industry factors. He uses fifteen developed markets between 1959 and 1973 and finds that industry factors explain very little of the returns of national stock markets. However, studies throughout the 1990s and early 2000s find conflicting results.

In their paper, De Santis and Gerard (1997) also identify the potential for bearish markets to increase the co-movement among markets internationally. This means that benefits may be absent when they are needed most. The tendency for market linkages to strengthen during periods of excess volatility has received considerable attention. In their influential paper, Forbes and Rigobon (2002) make the distinction between what is commonly referred to as contagion, and interdependence. They examine twenty-eight developed and emerging markets during three crisis periods: the 1997 East Asian crisis, the 1994 Mexican peso collapse, and the US market crash in 1987. While contagion can be associated with a significant increase in the degree of co-movement following a shock, interdependence occurs in the event that this increase is insignificant.

My review of the literature is divided into three sub-sections, and I examine the issues outlined in this introductory section in greater detail throughout. In Section 2.2 I present a review of the literature on equity market integration and interdependence. Section 2.3 details the on-going debate on international versus industrial portfolio diversification. In Section 2.4 I discuss the literature on the implications of equity market volatility and times of crisis for market integration, and for the benefits of international portfolio diversification. Finally, Section 2.5 summarises this literature review and offers some concluding remarks.

2.2 Equity Market Integration

The literature has responded voluminously to the trend toward global interdependence with the emergence of a vast and growing body of research that seeks to measure equity market linkages, the macroeconomic determinants of equity market integration, and the implications of these interdependencies for international portfolio diversification. In this section, I offer a review of the literature on equity market linkages.

Early studies examine the correlation between national equity markets under the premise that negative or sufficiently low correlation between markets offers risk-reduction rewards to an investor diversifying internationally. Much of these early studies find little-to-no evidence of market co-movement. As early as the period between 1961 and 1966, Agmon (1972) identifies co-movement among the markets of the US, the UK, Germany and Japan. Granger and Morgenstern (1970) are among the first to characterise linkages between equity markets. They use a spectral analysis and find evidence of minimal inter-relationships among national equity markets. Also employing a spectral technique, Hilliard (1979) uses daily data for ten developed market indices from July 7th 1973 to April 30th 1974 and finds substantial evidence of intra-continental relationships among national equity markets. Ripley (1973) uses monthly data for nineteen developed markets and examines covariance patterns using a factor analysis. He identifies that over half of the movement in a developed market index is unique to that market, with North American and Western European markets having the highest levels of common variance, versus more isolated markets in Northern Europe and Asia. He infers that capital flows and trade relationships drive the interdependence of developed equity markets. Schollhammer and Sand (1985) identify interdependence among the US and four other developed markets using daily data. Eun and Shim (1989) use a vector autoregressive analysis of daily data from the US and eight other developed markets and establish substantial interdependence among these major markets. They further identify the absolute dominance of the US market.

Many studies in the 1970s and 1980s examine the inter-temporal stability of market linkages, with a substantial body of evidence indicating that market linkages are time-varying. Makridakis and Wheelwright (1974) point to the importance of predictability in the future relationships among the price movements of national equity indices. Panton et al. (1976) use weekly data for the US and eleven major developed markets for the period

between 1962 and 1973. They identify short-term stability (in the one- to two-year case), but long-term instability (in the five-year case) in the correlation between the studied markets, and strong ties between the US and Canada, with weaker ties among European markets. Haney and Lloyd (1978) use monthly data for twenty-two developed and emerging markets from January 1966 to June 1975, and identify inter-temporal instability among the correlation coefficients of the developed markets. They find that correlations are rising throughout the ten years studied. Maldonado and Saunders (1981) also explicitly examine and identify the temporal instability of equity market relationships. They use monthly returns for the US and four other developed equity markets over the period from 1957 to 1978. Longin and Solnik (1995) use monthly data for seven national equity markets and also find temporal instability in correlation matrices. However, Watson (1980) finds conflicting results. He examines the stationarity of inter-country correlation coefficients across the US and eight other developed markets, using monthly returns from January 1970 to December 1977. He does not find any evidence of significant variation in inter-country correlation coefficients during this time. A similar result is found by Philippatos et al. (1983). They use monthly data for fourteen major developed markets across the twenty-year period from January 1959 to December 1978. Using correlation and principal components analysis, they find evidence of inter-temporal stability in the relationships among national equity markets. In their review of the literature, Kearney and Lucey (2004) identify that despite some discrepancies in the surrounding literature, there is substantial evidence that linkages are strengthening over time.

The global stock market crash of October 1987 refocused studies of equity market integration. The fact that such a global decline in value had occurred, was counter-to much of the findings of the literature on the degree to which equity markets are globally interdependent. This led to the emergence of a number of studies that recognise and

examine the association between periods of excessive volatility and high market correlation. In particular, a number of studies explicitly examine times of financial crisis, namely the Asian and Russian crises in 1997 and 1998, and the implications for market linkages. I discuss this portion of the literature in greater detail in Section 2.4. The period surrounding the crash in 1987 is also characterised by advancements in the literature on the methods used to examine equity market linkages. In his seminal paper, Granger (1981) conceives the concept of cointegration – referring to the existence of a common stochastic trend between time series – with further development in Granger and Weiss (1983), Engle and Granger (1987), and Engle and Yoo (1987). Later contributions by Johansen (1988, 1991) expand the cointegration framework to the multivariate setting. Dolado et al. (1990) offers a thorough review of the early literature on unit-root testing and the cointegration of non-stationary variables, while Pagan (1996) presents a similarly thorough review of the developments in the financial econometrics literature at the time. I offer a more detailed discussion of cointegration in the methodology section in Chapter 3.

Among the first to employ cointegration testing in the analysis of equity market integration, Kasa (1992) studies the US and four major developed markets using data at the monthly and quarterly level. He applies the Johansen cointegration test and finds a single common stochastic trend among the studied groups from January 1974 to August 1990. The literature that employs cointegration techniques is significant and ever-expanding. Corhay et al. (1993) use biweekly data for five major European markets from March 1st 1975 to September 30th 1991 and also find evidence of a cointegration relationship among the studied markets. Leachman and Francis (1995) also study developed markets. They use monthly data for the G7 group from January 1975 to May 1993 and establish that there is an increasing number of cointegrating vectors using a sub-period analysis. Blackman et al. (1994) further establish the presence of

cointegration relationships from 1984 to 1989 using monthly data for seventeen national equity markets. Serletis and King (1997) use a sample of ten developed EU equity markets, and find substantial evidence of linkages among the ten markets studied, using the Johansen cointegration method. They further find that linkages among EU markets are strengthening over the period studied, from 1971 to 1992. Richards (1996) requests greater caution in the interpretation of the results of cointegration based analyses. He finds evidence of small-sample biases leading to a rejection of the null hypothesis of no cointegration, specifically in the earlier and significant study by Kasa (1992), which does not hold once these biases are controlled. Kanas (1998) uses daily data for the US and the six largest European markets from January 3rd 1983 to November 29th 1996. He uses both the popular Johansen method, and also the test by Bierens (1997) to find no evidence of pairwise cointegration between the US and any of the European markets. This echoes the results of previous work by Byers and Peel (1993). Gerrits and Yuve (1999) also use daily data for the US and three major developed markets – the UK, Germany and the Netherlands – from March 1st 1990 to October 5th 1994. They find significant linkages between the studied markets that persist in both the short- and long-term.

Dickinson (2000) examines the issues underlying the increasing integration of national equity markets reported in the literature. He examines the US, the UK, France and Germany using monthly data from January 1980 to December 1995. He also finds increased integration among these markets, with implications for both long-term linkages and the short-term transmission of noise. Several studies of the late 1980s and early 1990s report short-term linkages. Von Furstenberg and Jeon (1989) examine the period between January 1986 and November 1988 and establish linkages among the markets of the US, the UK, Germany and Japan. Hamao et al. (1990) also find evidence of growing linkages using daily and intraday data from April 1st 1985 to March 31st 1988, studying the US, the UK and Japan. This result is also echoed in Koch and Koch (1991) using the

US and seven other major national equity markets in 1972, 1980, and 1987. More recently, Fraser and Oyefeso (2005) examine monthly data from January 1974 to January 2001 for the US and eight major developed European markets and confirm the presence of a common stochastic trend among the group. Bentes and Menezes (2014) examines the US, the UK, Portugal, Spain and Japan using daily data from January 4th 1999 to September 19th 2014. They find evidence of only a single long-run relationship with short-term deviations from this relationship also present.

Many studies capitalise on these developments in the literature on measuring market linkages by refocusing their attention on the integration of emerging markets throughout the 1990s. The markets of Asia and Asia-Pacific receive considerable attention. Chung and Liu (1994) study the US and five East Asian markets using the Johansen cointegration method. They find evidence of two cointegration relationships, and conclude that the US and Taiwan are not in a common stock region with the four remaining East Asian markets. Chowdhury (1994) establishes linkages between the US and the markets of Hong Kong, Singapore and Japan, with the US exerting significant one-way influence over the major Asian markets. Manning (2002) examines the US and nine South-East Asian markets over the period from January 1988 to February 1999. He uses weekly data, and establishes the interdependence of markets in the region. Narayan et al. (2004) find evidence of the integration of a sample of emerging South Asian markets. Yu et al. (2010) examine integration among a sample of Asian equity markets using a variety of methods. They establish growing integration in the region, particularly between 2007 and 2008. They note substantial differences in the degree of integration among developed versus emerging markets in the region. Ali et al. (2014) examine linkages among emerging South Asian markets using monthly data from 1999 to 2009. They find no evidence of linkages between markets in this region using either correlation

or cointegration based methodologies. This reflects similar results found in Lamba (2005) concerning two major markets in the region: India and Pakistan.

The recursive cointegration framework of Hansen and Johansen (1992, 1998) has been used extensively to examine dynamic market linkages. This approach allows for the consideration that market linkages are time-varying and often volatile. Furthermore, the Gregory-Hansen (Gregory and Hansen, 1996) cointegration test facilitates an analysis of cointegration in the presence of a structural break of endogenous timing. This development allows the researcher to consider that a long-run relationship might hold in a system, before a change event occurs, shifting the system to a new long-run relationship. These, and other regime-switching models, have been used extensively in the literature. Rangvid (2001) employs the recursive cointegration technique introduced in Hansen and Johansen (1992, 1998) to examine the dynamics of market integration. He uses quarterly data for the UK, France and Germany from 1960 to 1999, and identifies increasing integration through the 1980s and 1990s. Bessler and Yang (2003) use an error correction model and directed acyclic graphs to examine the structure of interdependence among the US and eight major developed markets. They examine the period from June 5th 1997 to June 15th 1999 using daily data. They establish the dominance of the US in impacting the price movements of the other major developed markets and find partial segmentation among the major markets and thus the potential for benefits to international portfolio diversification. Yang et al. (2003) use monthly data on the US and fourteen other developed markets from January 1970 to December 2001. They employ the recursive approach of Hansen and Johansen (1993), using the US as a proxy for the world market and find little impact of financial market liberalisation on levels of market integration. Similar results are noted by Chelley-Steeley et al. (1998) and Bekaert and Harvey (2000), but contradictory to much of the surrounding literature throughout the 1980s and 1990s (in addition to previously discussed studies, see also the

findings of Jorion and Schwartz (1986) and Taylor and Tonks (1989) for example). Davies (2006) examines seven major equity markets, including the US, using monthly data in a regime-switching framework. He finds convincing evidence of market linkages once structural breaks are considered, indicating that the classical approach to measuring equity market integration should be reconsidered. Syllignakis and Kouretas (2010) examine linkages between seven emerging markets of Central and Eastern Europe, and the US and Germany, using the recursive cointegration technique of Hansen and Johansen (1993). They find that financial linkages strengthen at the time of EU accession, but with a slowing down of this convergence surrounding the global financial crisis..

The emerging European markets have also received considerable attention. Gilmore and McManus (2002) find no evidence of cointegration between the US and the emerging markets of Central Europe. Using weekly data from July 1st 1995 to August 1st 2001, they establish no integration of the US with Hungary, Poland and the Czech Republic, but establish that correlation between the US and these markets is rising. Syriopoulos (2004) finds evidence of a long-run cointegration relationship between emerging Central European markets and two major developed markets – the US and Germany, with weaker integration among the individual Central European markets. Voronkova (2004) examines cointegration within a regime-switching framework. She studies three emerging Central European markets and three developed European markets plus the US, using daily data over the ten year period from September 7th 1993 to April 30th 2002. Employing the Gregory-Hansen cointegration test (Gregory and Hansen, 1996) which allows for a cointegration relationship in the presence of a structural break, she finds convincing evidence of the regional and global integration of emerging Central European markets. Wang and Moore (2008) examine integration between the transition economies of emerging Central and Eastern Europe and the wider Eurozone market, across the period

from 1994 to 2006. They use daily data and conduct an analysis of time-varying conditional correlations using the Dynamic Conditional Correlation Generalised Autoregressive Conditional Heteroskedasticity (DCC GARCH) model of Engle (2002). They find significant evidence of a rise in correlation during the Asian and Russian crises and in the aftermath of these crises. They conclude that EU entry can be associated with a strengthening of correlations between the emerging markets and the Eurozone market.

Focusing on the emerging markets of Latin America, Choudhry (1997) establishes a long-run relationship among the US and six Latin American markets between January 1989 and December 1993. Studying the markets of North America, Ewing et al. (1999) find no evidence of a cointegration relationship using monthly data from November 1987 to March 1997. They conclude that the establishment of North American Free Trade Agreement (NAFTA) did not materially alter market linkages in the region. However, Aggarwal and Kyaw (2005) find conflicting results using daily, weekly and monthly data over two sub-periods, from 1988 to 1993 and 1994 to 2001. Barari (2004) examines time-varying linkages among six emerging Latin American markets from January 1988 to December 2001. They find increasing integration at the regional level relative to the global level until the mid-1990s, with a greater emphasis on global integration beyond this point. Diamandis (2009) uses weekly data for the US and four emerging Latin American equity markets from January 1988 to July 2006. He finds evidence of integration among the studied group of markets with short-term deviations from the observed common stochastic trends recorded around the Mexican crisis between 1994 and 1996, and the financial crisis in 2001.

Other emerging market regions have also been analysed. Lagoarde-Segot and Lucey (2005) examine integration among the markets of the MENA region using daily data taken from the S&P IFC index alongside national market indices from January 1st 1998

to November 16th 2004. They find no evidence of a significant long-run relationship between the MENA markets and the EMU, the US, and a regional benchmark, but they note the existence of a trend toward financial market integration. Ozdemir et al. (2009) examine market linkages between the centre (proxied as the US market) and the periphery (the global set of fifteen emerging markets) from various dates up until March 24th 2006 using the Granger-causality method. They find that the US market Granger-causes the set of fifteen emerging markets. Marashdeh and Shrestha (2010) find that the GCC markets are not fully integrated, with no evidence of the integration of these markets with the US and Europe. Lucey and Muckley (2010) examine the largest Asian and European markets and the US using daily data from May 1988 to December 2007. They find substantial differences in linkages between the Asian and European markets, and the US. They find evidence of short-term comovements between the Asian markets and the US, with minimal short-term comovements between the European markets and the US. In contrast, long-term linkages are substantially stronger for European markets and the US than for Asian markets and the US. They conclude that the correlation statistic is insufficient to capture the potential benefits to international portfolio diversification.

Linkages among the G7 and the BRICS have also been assessed. Barari et al. (2008) use daily data on iShares for the US and the six remaining members of the G7 group alongside data on national equity market indices. They examine the period from March 18th 1996 to January 20th 2005. They find that short-term interdependencies, as indicated by conditional correlations, have been rising since 2001 while long-term interdependencies are time-varying. Other papers further confirm market linkages between the G7 markets. Menezes et al. (2012) find a similar result between 1973 and 2009 in the short- and long-term using a combination of cointegration methodologies, Mutual Information and Singular Spectrum Analysis. To a lesser extent, the linkages

among the BRICS, and between the BRICS and developed markets have also been examined. Zhong et al. (2014) examines linakges between the US and the BRICS markets over the period from July 1997 to March 2012. They use weekly data and the cointegration test by Bierens (1997) and find pairwise cointegration between the US market and the markets of the BRICS over this time.

Despite the overwhelming evidence in favour of the fact that equity market linkages exist and are growing, Guidi and Ugur (2014) emphasise the importance of specifically analysing diversification benefits before concluding that none exist, even in the presence of market integration. They find diversification benefits are present among a sample of markets from South-Eastern Europe, despite evidence of both the correlation of stock returns and the dynamic cointegration of prices. I continue this review with an analysis of the literature on the industry versus country debate in international portfolio diversification.

2.3 The Industry versus Country Debate

The trend toward global financial market integration in the 1980s and 1990s saw the emergence of a body of literature that explicitly examines the role of countries in achieving gains from international portfolio diversification. If the trend toward greater integration can be associated with a strengthening of equity market comovement, then there is reason to suggest that diversification across different equity markets may no longer be as beneficial as a risk-reduction strategy.

Despite the earliest empirical literature on market linkages finding minimal comovement among national equity markets, Lessard (1975), Solnik and De Freitas (1988), Grinold et al. (1989), Drummen and Zimmerman (1992), and Roll (1992) all examine the role of industrial composition in achieving diversification benefits. In the most recent of these studies, Roll (1992) finds that the industrial structure of each country plays an important

role in explaining stock price behaviour. He examines the source of differential volatility across national equity markets. He uses daily data on twenty-four developed and emerging markets from April 1988 to March 1991, a period that covers the aftermath of the market crash in 1987. This is a seminal paper in the area, giving rise to a vast body of empirical literature that further explores the role of the country factor in determining stock returns. Beckers et al. (1996) find less evidence in support of the importance of industry factors. Heston and Rouwenhorst (1994) use a sample of twelve European markets from 1978 to 1992, and find conflicting results to those of Roll (1992). They find that industrial structure has little explanatory power for cross-sectional differences in country return volatility. They conclude that diversification across countries within an industry is a more effective method of reducing risk than diversification across industries within a country. In their later seminal paper, Heston and Rouwenhorst (1995) conceive their popular model of stock returns that disentangles the global, industry and country effects. I discuss this model in greater detail in Chapter 3. Using monthly returns for twelve European markets from 1978 to 1992, they find that country effects dominate industry effects, with the implication that investors should focus more on geographical composition than industrial composition in forming their portfolios. Griffin and Karolyi (1998) revisit the issue given conflicting results from previous studies. They use a larger sample than used previously, consisting of the weekly returns of twenty-five markets. They confirm the previous findings of Heston and Rouwenhorst (1994) that industrial composition explains little of the variation in country returns. In a subsequent paper, Rouwenhorst (1999) uses a sample of twelve EMU countries covering a period up to 1998. Using weighted least squares, with weights corresponding to market capitalisation; he finds a higher standard deviation for country effects relative to industry effects. He also establishes an average country effect for the sample equal to 2.76 per cent per month and an average industry effect equal to 1.47 per cent per month reinforcing the

superiority of international diversification strategies. Baca et al. (2000) use a sample of monthly returns across ten industrial groupings in the seven largest equity markets. They study the period from March 31st 1979 to March 31st 1999, and find industry variation has been rising since the 1990s while country variation has declined; the ratio of the two dropping from 3.10 to 1.23. They find that the spread between the industry and country component variation is small enough to be statistically insignificant. Cavaglia et al. (2000) use weekly data on thirty-six industry level national indices for the period between January 1986 and November 1999. They establish greater importance for industry effects relative to country effects and find that diversification over industries provides superior risk reduction benefits to diversification over countries. They refer to enhanced geographical integration reported elsewhere in the literature as a probable cause for this rise in the relative importance of industry effects. This rise in the relative importance of industry effects is reported in several other studies, such as Kerneis and Williams (2000), Brooks and Catáo (2000). Serra (2000) is the first to examine the source of diversification benefits from investing across emerging markets. He uses weekly data on twenty-six emerging equity markets from 1990 to 1996, and finds that country factors drive emerging market indices, with industry factors having little impact on cross-market correlation. Among similar studies by Adjaoute and Danthine (2004) and Goetzmann et al. (2005), Flavin (2004) uses monthly returns for the eleven original members of the Eurozone. Using a sub-period analysis, he finds country effects dominate in euro-zone markets in periods prior to the introduction of the euro, while industry effects are relatively higher following monetary integration. He forms a factor model similar to that used in Heston and Rouwenhorst (1994), but instead uses panel data, allowing for statistical as well as economic significance among the estimated country and industry effects. Campa and Fernandes (2006) employ the method introduced by Heston and Rouwenhorst (1994). They use monthly data on fourty-eight countries (nineteen

emerging and twenty-seven developed) across thirty-six industries from January 1973 to December 2004 and find that financial market integration is the driving force behind the reported rise in industry effects in the literature at this time. Ferreira and Ferreira (2006) use daily data for eleven EMU countries across ten industry groupings from January 1st 1975 to July 31st 2001. They find that country effects dominate in the 1990s, with an increase in the relative importance of industry effects beyond the introduction of the Euro. However, in a more recent paper, Bekaert et al. (2009) find globalisation has not changed the correlation structure of international stocks, claiming increases in the importance of industry effects were temporary, advancing the continued significance of country factors in diversification. Graff (2011) examines 38 developed and emerging markets and finds that country effects are dominant over longer periods, than industry effects. He finds that industry effects did dominate among developed markets between 1999 and 2001, and again in 2007 and 2008, while country effects remain dominant among emerging markets in every period. More recently, Marcelo et al. (2013) examine the respective roles of industries and countries during volatile periods. The use the cross-sectional analysis proposed by Heston and Rouwnehorst (1994) on a sample of nine European countries from January 1990 to December 2008. They find that the country effect is no longer dominant. They also find that industries offer better protection to investors in times of heightened volatility. Their results are robust to the exclusion of industries heavily involved in the technology bubble, and to the exclusion of non-EMU markets.

The factor model by Heston and Rouwenhorst (1994) dominates the literature throughout the 1990s and 2000s. The fact that this model and its various derivatives are still employed today in the analysis of industry and country effects is a testament to its significance. However, advancements in the comparative analysis of alternative investment strategies have led to the emergence of a different approach to measuring the

relative benefits of industry and country based diversification strategies. Tests of spanning introduced by Huberman and Kandel (1987) and further developed by Kan and Zhou (2001; 2012) have dominated the literature in more recent times. Gerard, Hillion and De Roon (2002) use monthly data for the G7 group across ten industrial groupings for the period between December 1973 and November 1998. They compare country and industry portfolios using the Jensen measure and find no significant difference in terms of maximum Sharpe ratios. They find that the benefits from international diversification stem mostly from cross-country diversification. Ehling and Ramos (2003) also use tests of mean-variance spanning. They examine eleven EMU and eight non-EMU countries. They use weekly data from January 1st 1988 to December 31st 2001. They identify that industry strategies are an appropriate strategy for investors with low risk aversion, while those investors with relatively more risk aversion, who might prefer a safer investment strategy, benefit from mixing both industry and country portfolios. Similar results are found in Carrieri et al. (2002). Eiling et al. (2005) employ tests of mean-variance spanning and a Sharpe ratio analysis to examine the relative importance of industry and country factors. They use monthly returns for eleven EMU countries across ten industries from March 1990 to August 2003. They examine three sub-periods to analyse different states of EMU convergence. They find evidence that country- and industry-based portfolios are equal in terms of mean-variance efficiency, with this finding holding across the full period as well as in each of the studied sub-periods. They further find that country returns are more volatile and less correlated in the first half of the 1990s, while this is true of industry effects in the latter half of the 1990s. Eiling et al. (2012) examine monthly data for the G7 markets from February 1975 to February 2005 across ten industrial groupings. They find that country-only portfolios and industry-only portfolios both span the extended set of industries and countries, implying that neither an industry- or country-only portfolio is sufficient to achieve full diversification benefits. However, a

subsequent conditional analysis, using conditioning information, finds that equity returns are largely driven by industry and currency risk factors. They allude to the degree of market integration among the G7 to explain this result.

Phylaktis and Xia (2006a) use weekly data on thirty-four countries across fifty industrial groups January 8th 1992 to December 26th 2001. They establish the superiority of country effects in the 1980s and 1990s as reported widely in the literature of that time, however, they find that industry effects are in a process of convergence and catching up with country effects in terms of their relative importance. These results are echoed by others. L'Her (2002) et al. examines twenty countries across eleven industries from July 1989 to December 2000. They also find a decline in country effects in the 1990s, with industry effects growing in relative importance at the turn of the century. They conclude that the trend toward global integration has meant that industry-based diversification strategies are as effective as country-based diversification strategies. In a paper of the same time, Phylaktis and Xia (2006b) examine a sample of thirty-seven developed and emerging markets from 1990 to 2002. They find that emerging markets, compared to developed markets, have higher country effects and lower industry effects. They further note that industry effects are gaining prominence over time. Gilmore et al. (2008) examine co-movements between central European (CE) and developed EU markets using dynamic and static methods. They conduct a static analysis from July 1995 to February 2005. They establish relatively low levels of short-term correlations as well as a lack of statistically significant cointegration and conclude that the process of EU accession has not changed the co-movements between the CE equity markets in ways that would materially decrease diversification benefits for dollar based investors.

Brooks and Del Negro (2002) find that there is little evidence of a rise in industry effects around the time reported widely in the literature, at the turn of the century, once the

technology, media and communications industries have been removed. They link the reported rise in industry effects to the events of the technology bubble in 2001. Brooks and Del Negro (2004) use monthly returns for forty-two developed and emerging markets across the period from January 1985 to April 2003 using forty industrial groupings. Unlike much of the surrounding literature, they use an amended version of the Heston and Rouwenhorst (1994) factor model that further disentangles the country effect into region and within-region country effects. They find the same result for developed and emerging markets, that is, region effects are an important source of the variation in a stock's return, and explain more than half of the return variation accounted for by the Heston and Rouwenhorst (1994) country effects.

Bai and Green (2010) use monthly data for thirteen emerging markets across eleven industrial groups. They examine the period from August 1984 to July 2004. For the returns of each firm, they use a separate univariate ARMA-GARCH model to estimate the time series of the conditional standard deviation. They employ the factor model of Heston and Rouwenhorst (1994) in a cross-sectional framework to the conditional standard deviations in each month. They find country effects dominate from 1986 to 2004. They also report evidence of a rise in industry factors between 1996 and 2004, as reported widely in the surrounding literature. In a later paper, Bai and Green (2011) use data on thirteen emerging markets across eleven industries from 1984 to 2004. They examine the determinants of the estimated country and industry effects. They find macroeconomic fundamentals such as openness, exchange and interest rates, as well as financial development and legal origins all determine country effects. Meanwhile, beyond the Asian crisis, they find that industry concentration is an important determinant of industry effects. They argue that the continued development of the emerging markets will reduce the country effect in time, but that the size of this effect will depend on the underlying legal tradition in the individual country.

The debate continues on whether portfolio managers should focus their investment decisions on industry-based diversification strategies, as opposed to a country-based approach. The literature remains inconclusive regarding the relative importance of industry and country factors in stock return variability. Such differences stem largely from differences in methods used, and also in the markets and time-periods studied. This review suggests there is scope for a study that encompasses a large and global sample of markets, across a variety of market states, using a combination of robust methods.

2.4 Financial Crises, Market Integration, and Portfolio Diversification

In investigating linkages among national equity markets and the resulting impact on the benefits of international portfolio diversification, the propensity of financial crises to increase market comovement must be considered. If times of crisis are found to impact on the relationship between stock markets, then there are implications for the benefits of international portfolio diversification. More specifically, if a crisis can be associated with heightened levels of stock market integration, then investors diversifying internationally across affected markets may not be receiving the benefits of diversification when they are needed most. The global market crash in 1987 - in which nineteen global markets declined more than twenty per cent (Roll, 1988) - was met with a surge of academic papers examining the implications of these market conditions for equity market linkages and the benefits of an internationally diversified portfolio. Much of the discussion on enhanced market linkages surrounding times of market turmoil refer to financial contagion. Edwards (2000) draws on literature from the biological sciences in his definition and discussion of contagion, as the international transmission of a shock, the extent to which is in excess of what was expected ex ante. He claims a search of the *EconLit* database for the term "contagion" between 1969 and February 2000 returns 147 results. A replication of this search today, searching a considerably shorter period from March 2000 to September 2015, returns a significantly greater 2,028 results.

Indeed, several significant crisis periods, namely the Asian and Russian crises in 1997 and 1998, the bursting of the dot-com bubble and the September 11th attacks, and the most recent global crisis, have resulted in a surge in the number of papers addressing the topic. Forbes and Rigobon (2002) make the distinction between what is commonly referred to as contagion, and interdependence. While contagion can be associated with a significant increase in the degree of co-movement following a shock, we observe interdependence in the event that this increase is insignificant. The extent to which the recent and global financial crisis has impacted on the integration of global stock markets has received relatively little attention in the literature.

Arshanapalli and Doukas (1993) use daily data to study five of the G7 countries using cointegration methods on samples pre- and post- October 1987. They find a dramatic increase in co-movement following the crash in 1987, with a considerable impact on European markets by the US. Dwyer and Hafer (1988) use daily data for three months before and after the crash in 1987, and also monthly data from 1957 to 1987 to examine market co-movement for the US, Germany, Japan and UK. They do not find evidence that these markets move together using either dataset in terms of prices, with some evidence of the returns of these markets moving together over time. Chen et al. (2002) examine six emerging Latin American markets from February 1st 1995 to June 30th 2000. They find that the crash in Ocotber 1987 did not alter the statistical dependencies of markets in the region.

There is a vast body of literature addressing the implications of the Asian financial crisis for the integration of stock markets in the Asia-Pacific region. Wang et al. (2003) examine a subset of Asian markets and the US. They find evidence of contagion, also documented by Baig and Goldfajn (1999), detracting from the benefits of international diversification following the Asian crisis. They find the mean absolute deviation

regarding country and industry effects in the 1990s to fall to 0.188 and rise to 0.920 respectively. Masih and Masih (2001) similarly find evidence of enhanced integration across this period. They use a sample comprising OECD and emerging Asian markets. Wong et al. (2004) use weekly data for the US, the UK, and seven major Asian markets, from January 1st 1981 to December 31st 2002. They examine the interdependence between developed and emerging markets across three separate sub-periods – 1981 to 1986, 1987 to 1996, and 1997 to 2002. They find increasing interdependence between the developed and emerging markets after the 1987 stock market crash and the 1997 Asian financial crisis. Ratanapakorn and Sharma (2002) find evidence of enhanced integration among the markets of Europe, Asia, Latin America, Eastern Europe and the Middle East following the Asian crisis.

Phylaktis and Ravazzolo (2005) examine the US and seven major Asian markets, developed and emerging, to test if foreign exchange restrictions affected financial market linakges. They use monthly data from January 1980 to December 1998 and fail to establish any linkages among the studied markets throughout the 1980s and 1990s, and further find that the Asian crisis did not have a significant effect on the linkages among the Asian markets. Feirrera and Feirrera (2006) show that, in the period spanning the Asian crisis, emerging markets performed significantly worse than developed markets. Krause and Kutner (2006) argue that investors should not expect the same benefits from international diversification as those received prior to the Asian crisis. Hyde et al. (2007) examine correlation dynamics in the returns of Asia-Pacific countries, Europe and the US using the asymmetric dynamic conditional correlation GARCH model introduced by Cappiello, Engle and Sheppard (2006). They find (using the Asian crisis as a structural break) correlations increase between crisis countries during the period from 1991 to 2006. They document a general rise in correlation over the entire sample period indicative of greater global market integration. Royfaizal et al. (2009) further find that

Asian markets are more interdependent following the Asian crisis. They use a cointegration and Granger-Causality analysis, and find no evidence of market linkages prior to the crisis. In fact, the consensus has been that this period of heightened volatility can be associated with a strengthening of pre-existing links, and a notable rise in the integration of stock markets in the region (Sheng and Tu, 2000; Click and Plummer, 2005; Cheng and Glascock, 2006; Foo et al., 2008). Loh (2013) examines comovement among thirteen equity markets in the Asia-Pacific region with the markets of Europe and the US. He uses weekly data from January 5th 2001 to March 16th 2012 and investigate comovement using a wavelet analysis. He finds evidence of comovement between the Asia-Pacific markets and the US and Europe. He further establishes differences in the degree of comovement during different crisis periods, with the US sub-prime crisis associated with comovement concentrated at the medium time-scale, with comovement during the European debt crisis concentrated at the shorter time-scale. He establishes long-term comovement, but substantial differences in time and scale in terms of international diversification benefits. He finds some potential for diversification during crises, but with difficulties in forming a portfolio given the unstable comovement between equity markets during these periods. Bai et al. (2012) examine thirteen emerging markets, using monthly data from August 1984 to July 2004. Using the factor decomposition method of Heston and Rouwenhorst (1994), they find that industry effects increase between 1997 and 2002, indicating that, as reported elsewhere in the literature, the rise in industry effects is a temporary phenomenon linked to the contagion effect of the Asian crisis.

The Russian crisis has also received some attention in the literature. Yang et al. (2006) study the implications of the Russian crisis for the long-run relationship between the price indices of the US, Germany and four Eastern European emerging markets. They find a strengthening of long-run relationships after the crisis. Lucey and Voronkova

(2006) show increased evidence of integration after the Russian crisis. Using a Johansen cointegration test, they find evidence that the Russian equity market remains segmented for the most part from world equity markets and show, with the exception of the crisis period, there remains a benefit to international diversification by including holdings of Russian equities. Lucey and Voronkova (2008) examine the relationship between Russian and other equity markets over the period 1995-2004. Accounting for potential instability in the market relationships, they apply a number of cointegration approaches. They conclude that the Russian market does not show increased long-run convergence with regional or developed markets, however this is not true for short-term linkages. They find that the preceding Asian crisis affected short-term linkages between Russia and other markets, without any implications for the long-term relationship. Saleem (2009) find similar results regarding the Russian crisis. He finds partial integration between Russia and world equity markets, and strong evidence of volatility spillovers that are indicative of contagion following the crisis.

Several studies have analysed the implications of the global crisis for the integration of national equity markets. Dajcman and Festic (2012) examines daily data for three emerging and four developed European markets from April 1st 1997 to May 12th 2010. They find that European integration and the global financial crisis strengthened Central and Eastern Europe (CEE) and developed market interdependence. Baur (2012a) finds that the global financial crisis can be characterised by strong contagion on the sector level, particularly from the US financial sector to other countries financial sector, and from the domestic financial sector to non-financial sectors in these countries. The results show that portfolio diversification is a beneficial strategy even in a crisis, with no escape from the shocks associated with the global crisis. Baur (2012b) examines the structure and degree of dependence surrounding the recent global crisis. The structure of dependence is shown to change substantially for smaller industrial markets and emerging

markets in general, while the structure and the degree remain unchanged for large industrial markets. This implies there is no evidence of contagion among industrial markets, but rather, only interdependence. Vermeulen (2011) shows that international equity diversification brings large benefits to investors during the global financial crisis despite increasing stock market co-movements. He establishes that investors from countries with the lowest degree of home bias enjoy the largest benefits during the global crisis. The global crisis has been associated with a strengthening of market linkages across CEE and Southern Europe. Nikkinen et al. (2012) use a variance decomposition analysis to find that the Baltic markets of Estonia, Latvia and Lithuania are highly integrated with major European markets during the global crisis. These results are echoed by Babalos et al. (2014) who also analyse the integration of Baltic markets with major European markets, using nonparametric Granger causality tests. Several previous studies have found similar such results for the markets of emerging Europe (Voronkova, 2004; Gklezakou and Mylonakis, 2009; Kizys and Pierdzioch, 2011; Tudor, 2011). Mighri and Mansouri (2013) also find evidence of increased conditional correlation between the US and a sample of emerging and developed markets, following the onset of the global crisis. Guesimi et al. (2013) find evidence of increased conditional correlations between the US and a sample of Organisation for Economics Co-operation and Development (OECD) countries, and refer to the definition of financial contagion proposed by Forbes and Rigobon (2002) as a positive shift in the degree of return comovement. Marcelo and Quiros (2013) find that industries offer better protection to investors in times of heightened volatility.

2.5 Conclusion

This chapter synthesises the various literatures that inform and inspire my central research questions. Section 2.2 discusses the vast body of literature concerning the global integration of equity markets, and the implications for international portfolio diversification. It documents the trend toward greater integration, and outlines the ways in which this trend has influenced the emergence of a body of work that characterises these linkages, and investigates their effect on the benefits of diversifying a portfolio of equities internationally. Section 2.3 examines the literature that seeks to measure the relative importance of industry and country factors in stock return variability. It identifies the growth in the literature at the turn of the last century toward recognising a renewed potential for industry factors in an increasingly globalised world. It further addresses the current state of the literature in this area, addressing the contentious debate around the relative importance of industries and countries in more recent samples. Finally, Section 2.4 presents previous studies that attempt to model and identify the implications of heightened volatility for the integration of equity markets and the debate on country versus industry effects. It presents a myriad of studies that explore the implications of previous historical crises, such as the Asian and Russian crises, for regional and global linkages, and the knock-on effects for international portfolio diversification. It further summarises the studied that have examined the implications of the recent global crisis for market linkages and the benefits of international portfolio diversification.

Based on the foundations laid out in this chapter, I expand upon the current base of knowledge in each of these three areas. I contribute a robust and thorough investigation of equity market linkages, and I explore the importance of industry and country factors across a longitudinal and global sample. I further explore the implications of the global crisis for market linkages, and the debate on the relative importance of industry and country factors in international portfolio diversification.

Chapter 3 Data & Methodology

3.1 Introduction

This chapter describes the methods and data used throughout my thesis. In Section 3.2 I outline my research paradigm. Section 3.3 follows with a description of the data collected and used throughout Chapters 3, 4, 5 and 6, I provide summary statistics for this data in Section 3.4.

In Section 3.6 I discuss the various methods employed in assessing market linkages in Chapter 4. Specifically, I describe two tests of cointegration used in my analysis of market linkages: the Johansen-Juselius test and the Gregory-Hansen test. The Johansen-Juselius test allows me to test for cointegration within a system, and I apply it to different groups of developed and emerging markets to examine global market co-movements. The Gregory-Hansen test allows me to test for a long-term relationship among a group of markets, however, it also allows for time-varying market linkages. Implicit in the Gregory-Hansen test, is the assumption that there is a cointegration relation, but that this relation shifts at an endogenously determined point in time. In this section, I also describe the DCC-GARCH model used to examine time-varying conditional correlations.

In Section 3.7 I discuss the factor model used in Chapter 5 to examine the relative importance of industry and country effects in stock return determination. In examining the ratio of industry to country effects, it is possible to determine the relative importance of these competing factors and thus whether investors should pursue industry- or country-motivated diversification strategies. I use the popular decomposition of stock returns presented in Heston and Rouwenhorst (1994) and the subsequent expansion of this model to a panel data framework as proposed by Flavin (2004).

Following this, in Section 3.7, I detail the tests of spanning and the Sharpe ratio analysis that are used to examine the mean-variance efficiency of industry- and country-focused portfolios in Chapter 6. I use both Ordinary Least Squares (OLS) and Generalised Method of Moments (GMM) specifications, and examine whether the addition of countries or industries to an industry- or country-focused portfolio, can shift the mean-variance efficient frontier. I also use step-down tests of spanning to detect the source of any shift in the efficient frontier.

In Section 3.8 I describe my approach to selecting break-points with a discussion of the Bai-Perron break-point test. Finally, I end this chapter with some concluding remarks in Section 3.9.

3.2 Research Paradigm

To begin this sub-section, I refer to the discussion of the paradigm in Kuhn (1962, p. 45) as "*the set of common beliefs and agreements shared between scientists about how problems should be understood and addressed*". The paradigm is the nexus of my ontological, epistemological, and methodological approach. Academic finance is situated within the social sciences, but uses scientific methods typically associated with the natural sciences to research social issues. Research into international finance is dominated by positivism (Weir, 2013). Despite calls for the use of alternative paradigms (Ardalan, 2008) or the employment of different and possibly qualitative methods, (Bettner et al., 1994) the literature remains predominantly rooted in the positivist approach.

Ryan et al. (2002) offer a thorough discussion of the emergence of empiricist thought among academics of economics and finance. Empiricism, as a derivative of the positivist paradigm, refers to the idea that knowledge is determined by experience, while experience itself can represent a justification for one's beliefs about what one knows.

Underlying the empiricist position, is the idea that certainty of belief in what one knows, can only be reached through perception, and all knowledge is derived through sense perception. As such, a belief not justified either by experience, or mathematically derived implications of experience, is meaningless, and beliefs about the world cannot be justified by the use of reason alone. Empiricism thus advances the view that science should be free from beliefs which cannot be justified in terms of the objects of experience under study.

Following a wealth of studies in international finance, I assume that there is a universal truth, and an objective and independent reality, to be understood through the laws by which it is governed. My research approach is rooted in the three tenets of validity, generalisability, and reliability. Validity represents the degree to which reality is approximated (Johnston and Pennypacker, 1980), generalisability can be described as external validity, that is, the extent to which a finding is valid outside of its own setting, while reliability refers to replicability, or the agreement between two attempts to measure the same thing, with the same method (Hammersley, 1987).

Throughout this thesis I gather data and employ quantitative methods. The choice of each technique is conditional on the nature of the hypotheses to be tested, and these quantitative techniques follow widely used methods in previous empirical studies in international finance.

3.3 Data Collection & Preparation

The data used throughout this thesis is sourced from DataStream, and all statistical analysis is done using a combination of Matlab, Stata, EViews and Microsoft Excel. I use DataStream equity market price indices and market value data at the country, industry, and firm level. The risk free rate is the 3-month Treasury bill rate. Log returns are calculated in US dollars, and all analysis takes place at the weekly level to avoid issues

relating to non-synchronous trading. In total, forty-six equity markets are studied across Chapters 3, 4 and 5. However, not all forty-six markets are used in every chapter, given issues relating to data availability or the regional focus of a particular study. The specific number of markets used in each analysis is detailed in the relevant sections of this chapter. My full sample comprises all markets classified as developed (23 markets) or emerging (23 markets) by the Morgan Stanley Capital International (MSCI) classification system as of June 2014[1]. The MSCI classification system is an industry leader, and is consistently reviewed and updated to reflect changes in market development and the trading environment[2].Greece is the only market in the sample to have changed classification status during the period of study, having been demoted to emerging status in November 2013. The classification of each country included in this thesis is presented in Table 3.1.

Table 3.1 also highlights the global span of my data, with representation from all regions of the world. I study the period beginning on December 30th 1994 and ending on December 27th 2013 in terms of prices, while return data begins a week later on January 6th 1995[3]. This period captures many major events in world equity markets, and is sufficiently longitudinal to facilitate a sub-period and recursive dynamic analysis of each of my central research questions. This also allows me to conduct a comparative analysis of each central research question across periods of relative stability and volatility. Of particular note is the aftermath of regional crises in Asia and Russia in

[1] Classifications remain unchanged as of June 2015. The emerging market list has expanded to include Saudi Arabia, however, no market used in this study has been re-classified.

[2] Please see the MSCI Market Classification Framework (2015) publication for details on the criteria used to classify markets. The criteria include economic development, size and liquidity requirements, and market accessibility issues.

[3] In some cases DataStream indices begin later than the period of study. These are detailed as follows: data for Egypt begins on October 4th 1996; data for Russia begins on January 30th 1998; data for the UAE and Qatar begins on January 2nd 2004. This is dealt with as described in the relevant sections throughout the remainder of this chapter.

1997 and 1998 respectively, the introduction of the Euro in 1999, the September 11th attacks in the US and resulting volatility, as well as the dot-com crash in 2001 and the recent global crisis in 2008.

In terms of index construction, DataStream indices are calculated on a representative list of the stocks for each market, while the number of stocks included for each market is determined by market size. The sample covers a minimum of 75 – 80 per cent of total market capitalisation. The indices exclude fixed interest stocks, temporary issues, warrants, unit trusts, mutual funds, investment funds, and foreign listings including ADRs. The largest value stocks for each market are included, while stocks with more than one equity issue are valued on each issue. Indices are value weighted and are calculated as:

$$I_t = I_{t-1} \times \frac{\sum_1^n (P_t \times N_t)}{\sum_1^n (P_{t-1} \times N_t \times f)}, \qquad (3.1)$$

where I_t and I_{t-1} are index values on days t and t_{-1}, P_t and P_{t-1} are prices on days t and t_{-1}, N_t is the number of shares in issue on day t, and n is the number of constituents in the index. For each index, I compute log or continuously compounded returns as:

$$r_t = ln\frac{P_t}{P_{t-1}} = ln(P_t) - ln(P_{t-1}) . \qquad (3.2)$$

The analysis of market linkages in Chapter 3 considers price indices at the country level. I examine the markets listed in Table 3.1 with the exception of Israel. I organise developed and emerging markets into geographical and economic groupings. This allows me to examine linkages among developed and emerging markets with a greater degree of specificity, and to compare the integration levels of these two classifications.

Table 3.1 MSCI Developed and Emerging Market Classifications

Market	Developed	Emerging
Australia	✓	
Austria	✓	
Belgium	✓	
Brazil		✓
Canada	✓	
Chile		✓
China		✓
Colombia		✓
Czech Republic		✓
Denmark	✓	
Egypt		✓
Finland	✓	
France	✓	
Germany	✓	
Greece		✓
Hong Kong	✓	
Hungary		✓
India		✓
Indonesia		✓
Ireland	✓	
Israel	✓	
Italy	✓	
Japan	✓	
Malaysia		✓
Mexico		✓
Netherlands	✓	
New Zealand	✓	
Norway	✓	
Peru		✓
Philippines		✓
Poland		✓
Portugal	✓	
Qatar		✓
Russia		✓
Singapore	✓	
South Africa		✓
South Korea		✓
Spain	✓	
Sweden	✓	
Switzerland	✓	
Taiwan		✓
Thailand		✓
Turkey		✓
UAE		✓
UK	✓	
US	✓	

Notes. The table above shows the classification of each market used in my study. Each market is classified as either developed or emerging in line with the MSCI market classification system. This is an exhaustive list of developed and emerging markets according to the classification in June 2013, and none of the markets listed above have been re-classified as of June 2015.

Using this approach, I can determine the degree of market integration, or segmentation, across many different global regions or groupings that are of significant interest to academics and investors alike. I analyse eleven different groups in total; five developed market groupings and six emerging market groupings.

The developed market groupings and their constituent lists are presented in Table 3.2. The division between the markets of Western Europe and the Asia-Pacific is an intuitive one – these markets comprise separate geographical regions of the world. The Asia-Pacific group contains all of the developed market members of the Asia-Pacific Economic Cooperation (Developed APEC). The PIIS group (Portugal, Ireland, Italy and Spain)[4] are analysed separately from the core given the severity of their problems and their shared financial instability and economic fragility during the global financial crisis. The PIIGS economies have received substantial attention in both the academic literature and the financial media (see media articles by: Holloway, 2008; Dawber, 2015, while for recent academic examples see: Kumar and Maheswaran, 2015; Bali and Demir, 2015). The G7 group represents the wealthiest developed markets, and are among the largest and most influential markets in the sample[5]. I further analyse the G7 group without the influence of France, Germany and Italy, to examine if any market linkages found to exist between the G7 markets are being driven by linkages between these core European markets.

[4] Together with Greece, this group is commonly referred to using the jargonistic, often derogatory term: PIIGS. I do not study Greece alongside these markets, given its recent declassification from developed to emerging market status by the MSCI classification system in November 2013.

[5] The G8 (the G7 plus Russia) is not studied as a group, given the disparity between the starting point of the G7 indices versus the Russian index, and also because Russia is classified as an emerging market.

Table 3.2 Constituent list for each of the developed market groups

	Western Europe	Developed APEC	PIIS	G7	G7 – Ex. Europe
Australia		✓			
Austria	✓				
Belgium	✓				
Canada		✓		✓	✓
Denmark	✓				
Finland	✓				
France	✓			✓	
Germany	✓			✓	
Hong Kong		✓			
Ireland			✓		
Italy			✓	✓	
Japan		✓		✓	✓
Netherlands	✓				
New Zealand		✓			
Norway	✓				
Portugal			✓		
Singapore		✓			
Spain			✓		
Sweden	✓				
Switzerland	✓				
UK	✓			✓	✓
US		✓		✓	✓
Total	**11**	**7**	**4**	**7**	**4**

Notes. The table above shows the allocation of each developed market to the different groups studied in my analysis of market linkages in Chapter 4. These markets are all classified as developed in line with the MSCI classification system, as of June 2015.

The emerging market groupings and their constituent lists are presented in Table 3.3. I use similarly intuitive geographical groupings for the emerging market sample, with a separation of Europe, Asia-Pacific, and the Middle-East and Africa. The Emerging Europe group contains the emerging markets of Southern and Eastern Europe. The Emerging APEC group contains all emerging market members of the Asia-Pacific Economic Cooperation group.

The BRICS (Brazil, Russia, India, China, and South Africa) are studied frequently in the academic literature, typically shortened to BRIC, with the formal addition of South Africa in 2010. The Emerging and Growth Leading Economies (EAGLE) group, conceived by Spanish bank Banco Bilbao Vizcaya Argentaria (BBVA)[6] comprises those emerging markets tipped to be at the fore of global growth over the next decade, and are of significant and growing interest to international investors. The EAGLEs also contain frontier equity markets, but as my study focuses exclusively on developed and emerging markets, these are not included in my analysis. In examining the relative importance of industry and country effects in the determination of a stock's return in Chapter 5, I use firm level data. The sample comprises 6,183 firms – 4,708 firms from developed markets and 1,475 firms from emerging markets. Firms are taken from the forty-six equity markets listed in Table 3.1. I study the period from January 6th 1995 to December 27th 2013.

[6] See the BBVA Annual Report 2015. Dow Jones and BBVA launched two indices that facilitate investment into the EAGLE group, on September 9th 2011.

Table 3.3 Constituent list for each of the emerging market groups

	The Americas	Middle East & Africa	Asia-Pacific	Emerging Europe	Emerging APEC	BRICS	EAGLE
Brazil	✓					✓	✓
Chile	✓				✓		
China			✓		✓	✓	✓
Colombia	✓						
Czech Republic				✓			
Egypt		✓					
Greece				✓			
Hungary				✓			
India			✓			✓	✓
Indonesia			✓		✓		✓
Malaysia			✓		✓		
Mexico	✓				✓		✓
Peru	✓						
Philippines			✓		✓		
Poland				✓			
Qatar		✓					
Russia				✓	✓	✓	✓
South Africa		✓				✓	
South Korea			✓		✓		✓
Taiwan			✓		✓		
Thailand			✓				
Turkey		✓					✓
UAE		✓					
Total	**5**	**5**	**8**	**5**	**9**	**5**	**8**

Notes. The table above shows the allocation of each emerging market to the different groups studied in my analysis of market linkages in Chapter 4. These markets are all classified as developed in line with the MSCI classification system, as of June 2015.

Firms are classified by industry using the Industrial Classification Benchmark (ICB), and are deemed to belong to one of the following ten industrial groupings: basic materials, consumer goods, consumer services, financials, healthcare, industrials, oil and gas, technology, telecommunications, and utilities.

Firm level log-returns are used to form a weekly panel dataset with 4,663,893 total observations – 3,690,856 in the developed market sample, and 973,037 in the emerging market sample. For each observation, fifty-six dummy variables are used to indicate a firm's presence or absence from a particular country and industry. As an example, for each weekly return for Allied Irish Bank, an Irish firm operating in the financials sector, the dummy variables for *Ireland*, and *Financials*, will each take a value of 1, while the remaining fifty-four dummy variables will take a value of 0. The total number of firms in each country and industry is presented in Table 3.4. In terms of firm numbers, *Financials* and *Industrials* dominate other industries, while the *US* and *Japan* lead amongst countries.

I compare and analyse the mean-variance efficiency of country- and industry-focused portfolios using tests of mean-variance spanning in Chapter 6. In this analysis, I use country-level price indices for those countries listed in Table 3.1 with the exception of the UAE and Qatar. I study the period from February 6th 1998 to December 27th 2013. At the industry level, I obtain weekly price indices for the ten ICB industries listed previously, for each of these forty-four markets. This results in 440 price indices. I calculate log-returns for each of these indices, and use these returns to compile value-weighted global, developed, and emerging market industry returns for each of the ten ICB groupings. This effectively results in three separate datasets. Firstly, a developed market sample comprising twenty-three developed markets and ten developed market value-weighted industry return series with 830 weekly observations.

Table 3.4 Firm distribution across countries and industries

	BM	CG	CS	FN	HC	ID	OG	TY	TC	UT	**Total**
Developed Markets											
Australia	20	6	30	48	8	26	7	3	4	6	**138**
Austria	3	8	1	17	0	15	2	0	1	3	**50**
Belgium	6	10	7	31	9	16	1	5	2	2	**89**
Canada	41	8	29	49	2	32	59	8	6	13	**247**
Denmark	1	7	2	10	13	13	1	1	1	0	**49**
Finland	8	5	4	6	2	17	1	4	1	1	**49**
France	6	42	34	49	21	53	9	23	1	9	**247**
Germany	20	34	27	43	18	61	6	27	4	8	**248**
Hong Kong	5	23	16	38	3	18	6	6	4	10	**129**
Ireland	5	7	7	6	1	3	5	1	1	0	**36**
Israel	3	3	4	22	1	2	9	2	3	1	**50**
Italy	3	27	17	42	5	39	6	6	2	11	**158**
Japan	86	171	159	164	60	247	10	71	6	19	**993**
Netherlands	6	13	11	29	4	29	2	18	2	1	**115**
New	1	4	9	10	6	8	4	0	2	4	**48**
Norway	2	7	2	7	0	11	16	3	1	1	**50**
Portugal	5	5	12	8	1	11	1	3	2	2	**50**
Singapore	1	12	10	46	3	15	6	1	3	2	**99**
Spain	9	13	13	27	9	23	6	5	4	7	**116**
Sweden	5	7	5	23	4	18	1	3	2	0	**68**
Switzerland	6	13	9	46	18	41	0	8	1	6	**148**
UK	29	37	85	217	13	105	22	20	8	8	**544**
US	44	96	141	191	86	167	102	105	11	44	**987**
Total	**315**	**558**	**634**	**1129**	**287**	**970**	**282**	**323**	**72**	**158**	**4708**
Emerging Markets											
Brazil	10	12	13	24	2	9	3	1	5	21	**100**
Chile	7	6	3	16	2	2	1	1	1	11	**50**
China	4	7	1	18	3	10	4	0	1	2	**50**
Colombia	5	4	4	19	1	8	2	0	1	6	**50**
Czech	2	2	3	2	1	3	1	0	1	2	**17**
Egypt	7	7	1	18	1	11	1	0	4	0	**50**
Greece	5	5	9	11	0	9	2	3	1	5	**50**
Hungary	1	4	3	16	3	7	3	5	4	3	**49**
India	18	33	6	45	19	39	10	10	5	15	**200**
Indonesia	5	12	5	13	1	6	0	3	4	1	**50**
Malaysia	4	16	14	25	4	12	7	0	4	4	**90**
Mexico	11	14	21	22	1	16	0	0	2	1	**88**
Peru	5	5	9	11	0	9	2	3	1	5	**50**
Philippines	3	4	7	19	1	6	2	1	2	5	**50**
Poland	10	5	6	16	0	3	3	1	2	4	**50**
Qatar	0	3	2	23	2	8	2	0	2	1	**43**
Russia	13	0	2	10	1	1	13	0	4	6	**50**
South Africa	15	7	11	21	4	7	1	0	3	0	**69**
South Korea	8	24	8	16	1	27	5	5	3	2	**99**
Taiwan	4	11	2	17	0	10	1	21	4	0	**70**
Thailand	3	2	10	13	2	6	5	1	3	5	**50**
Turkey	4	12	5	15	0	7	3	1	2	1	**50**
UAE	0	2	4	30	2	8	0	0	2	2	**50**
Total	**144**	**197**	**149**	**420**	**51**	**224**	**71**	**56**	**61**	**102**	**1475**
Grand Tot.	**459**	**755**	**783**	**1549**	**338**	**1194**	**353**	**379**	**133**	**260**	**6183**

Notes. This table shows the number of firms in each country and industry. BM = Basic Materials, CG = Consumer Goods, CS = Consumer Services, FN = Financials, HC = Healthcare, ID = Industrials, OG = Oil & Gas, TY = Technology, TC = Telecommunications, UT = Utilities

Secondly, an emerging market data set comprising twenty-one emerging markets and ten emerging market value-weighted industry return series, with 830 weekly observations, and finally, a global data set that comprises forty-four markets, and ten global value-weighted industry return series, also with 830 weekly observations.

3.4 Summary Statistics & Preliminary Analysis

3.4.1 Country Analysis

I present summary statistics for the returns of the developed and emerging markets in Table 3.5. I use both the augmented dickey-fuller test (ADF) and the Kwiatkowski-Phillips-

Schmidt-Shin (KPSS) test to examine if a unit root exists in each of the price indices and the corresponding return series. The ADF test amends the regular Dickey-Fuller test to control for serial correlation. It tests the null hypothesis that a unit root exists, and the time series follows a random walk. The test fits the following model:

$$\Delta y_t = \alpha + \beta y_{t-1} + \delta_t + \vartheta_1 y_{t-1} + \vartheta_2 y_{t-1} + \cdots + \vartheta_k y_{t-k} + \epsilon_t \qquad (3.3)$$

using ordinary least squares (OLS) with k equal to the number of lags. A test of $\beta = 0$ amounts to a test that y_t follows a unit root process. I test the robustness of the results of the ADF analysis using the KPSS test. The KPSS test differs to the ADF test, in that it tests the null hypothesis that the time series is stationary. I establish that the price indices are I(1) and the corresponding returns are I(0).

Table 3.5 Summary Statistics for Market Indices

	Mean	Std. Dev.	Mean :SD	Min	Max	Skew.	Kurtosis	ADF
Developed Markets								
Australia	0.13%	3.23%	4.02%	-35.61%	13.42%	-0.02	0.20	-1.24
Austria	0.08%	3.19%	2.51%	-33.24%	13.15%	-0.02	0.18	-1.16
Belgium	0.12%	2.98%	4.03%	-25.87%	11.22%	-0.01	0.11	-1.25
Canada	0.18%	3.07%	5.86%	-26.25%	16.52%	-0.01	0.12	-1.16
Denmark	0.20%	3.02%	6.62%	-24.70%	12.54%	-0.01	0.12	-0.28
Finland	0.15%	4.35%	3.45%	-22.88%	19.43%	-0.01	0.06	-2.06
France	0.12%	3.09%	3.88%	-25.58%	11.80%	-0.01	0.10	-1.70
Germany	0.11%	3.15%	3.49%	-22.33%	16.22%	-0.01	0.09	-1.34
Hong Kong	0.11%	3.35%	3.28%	-20.15%	14.08%	0.00	0.07	-1.33
Ireland	0.11%	3.28%	3.35%	-32.66%	12.37%	-0.02	0.16	-1.57
Israel	0.12%	3.26%	3.68%	-17.37%	10.34%	-0.01	0.05	-1.49
Italy	0.06%	3.45%	1.74%	-26.20%	17.26%	-0.01	0.09	-1.79
Japan	-0.01%	2.87%	-0.35%	-16.47%	11.59%	0.00	0.05	-2.33
Netherlands	0.09%	3.15%	2.86%	-30.16%	13.58%	-0.01	0.13	-2.18
New Zealand	0.09%	2.70%	3.33%	-22.40%	9.95%	-0.01	0.10	-0.85
Norway	0.15%	3.76%	3.99%	-27.71%	18.12%	-0.01	0.10	-1.22
Portugal	0.06%	2.97%	2.02%	-22.21%	13.41%	-0.01	0.09	-1.74
Singapore	0.07%	3.12%	2.24%	-22.74%	15.67%	-0.01	0.10	-0.49
Spain	0.14%	3.36%	4.17%	-24.14%	14.40%	-0.01	0.08	-1.73
Sweden	0.18%	3.87%	4.65%	-24.29%	21.64%	-0.01	0.08	-1.10
Switzerland	0.16%	2.61%	6.13%	-22.60%	11.93%	-0.01	0.11	-0.59
UK	0.10%	2.78%	3.60%	-26.75%	16.00%	-0.01	0.15	-1.96
US	0.15%	2.54%	5.91%	-20.06%	11.75%	-0.01	0.10	-1.39
Average	0.12%	3.18%%	3.67%	-24.89%	14.19%%			
Emerging Markets								
Brazil	0.10%	4.85%	2.06%	-30.98%	23.72%	-0.75	7.33	-1.18
Chile	0.07%	2.98%	2.35%	-29.18%	14.09%	-1.28	14.00	-0.76
China	0.13%	4.59%	2.83%	-24.52%	20.29%	-0.21	5.60	-1.00
Colombia	0.11%	3.85%	2.86%	-25.59%	11.78%	-0.77	8.18	0.11
Czech Republic	0.13%	3.61%	3.60%	-27.67%	21.12%	-0.63	9.14	-1.15
Egypt	0.08%	3.94%	2.03%	-28.76%	20.48%	-0.74	10.11	-1.27
Greece	0.02%	4.35%	0.46%	-24.92%	16.37%	-0.37	5.42	-1.34
Hungary	0.12%	4.74%	2.53%	-37.44%	20.41%	-1.04	10.42	-1.82
India	0.11%	3.93%	2.80%	-19.65%	21.62%	-0.38	5.74	-1.08
Indonesia	0.00%	12.44%	0.00%	-69.31%	69.31%	0.00	24.98	-2.54
Korea	0.08%	5.88%	1.36%	-55.96%	28.77%	-0.91	13.93	-0.92
Malaysia	0.05%	3.85%	1.30%	-38.98%	30.92%	-1.00	26.97	-0.29
Mexico	0.18%	4.01%	4.49%	-28.65%	20.23%	-0.50	8.43	-0.21
Peru	0.12%	2.75%	4.36%	-20.24%	15.64%	-0.50	8.78	-0.53
Philippines	0.03%	3.74%	0.80%	-29.39%	15.99%	-0.79	9.68	-0.50
Poland	0.13%	4.53%	2.87%	-24.58%	20.82%	-0.55	5.96	-1.55
Qatar	0.20%	3.91%	5.12%	-20.56%	18.01%	-0.35	8.67	-2.27
Russia	0.21%	6.69%	3.14%	-47.79%	38.39%	-0.62	11.46	-1.33
South Africa	0.11%	3.91%	2.81%	-22.87%	22.36%	-0.54	7.19	-1.00
Taiwan	0.01%	3.71%	0.27%	-14.82%	19.67%	-0.06	5.17	-2.55
Thailand	-0.01%	4.71%	-0.21%	-28.38%	23.48%	-0.19	6.85	-1.29
Turkey	0.14%	6.99%	2.00%	-72.72%	38.55%	-1.09	17.08	-1.95
UAE	0.20%	3.46%	5.78%	-19.55%	13.85%	-0.69	7.92	-1.56
Average	0.10%	4.67%	2.42%	-32.28%	23.73%			
Overall Average	0.11%	3.93%	3.67%	-28.58%	18.96%			

Notes. This table presents the summary statistics for the developed and emerging market log weekly returns. *ADF* refers to the Augmented Dickey-Fuller test statistic for the null hypothesis of a unit root in each of the price indices. *Average* refers to average figures for each of the developed and emerging market samples. *Overall* provides average figures for the global sample.

Denmark has the highest mean weekly log-return in the developed market sample (0.20 per cent) while Japan, the only developed market with a negative mean weekly log-return, has the lowest (-0.01 per cent). US returns are the least volatile (2.54 per cent) of the developed markets, while the Finnish market is the most volatile (4.35 per cent). This is likely due to the extent to which the Finish market was weighted in technology stocks at the time of the dot-com bubble and subsequent crash in 2000.

Among the emerging markets, Russia has the highest mean weekly log-return (0.21 per cent) while Indonesia has the lowest (0.00 per cent). The Indonesian market is also the most volatile, by a large margin, with a standard deviation of 12.44 per cent, while Peru is the least volatile market with a standard deviation of 2.75 per cent. On average, the developed markets offer a higher mean return and lower standard deviation than the emerging markets. This is unsurprising, as the volatility of emerging markets, relative to developed markets has long been established in the academic literature.

In terms of the mean to standard deviation ratio, Denmark (6.62 per cent) is the best performing overall, while Japan (-0.35 per cent) is the worst performing overall. Thailand (-0.21 per cent) also performs poorly, while the best performing of the emerging markets is the UAE (5.78 per cent). The emerging markets also have a much greater spread between minimum and maximum values than the developed markets. Skewness and kurtosis figures are substantially higher for the emerging market sample, compared to the developed market sample.

In Tables 3.6 and 3.7 I present the correlation coefficient for the returns of the developed and emerging market samples. I observe the highest level of correlation among geographical neighbours and major trading partners, for example, European markets tend to be most highly correlated with the remainder of the European sample, such as Ireland and the UK at 0.75, and Ireland and the Netherlands also at 0.75.

Table 3.6 Developed Market Correlation

	Aus.	Au.	Bel.	Can.	Den.	Fin.	Fra.	Ger.	HK.	Ire.	Isr.	Ita.	Jap.	Net.	NZ.	Nor.	Por.	Sing.	Spa.	Swe.	Swi.	UK	US
Aus.	1.00																						
Au.	0.71	1.00																					
Bel.	0.66	0.76	1.00																				
Can.	0.74	0.65	0.63	1.00																			
Den.	0.70	0.72	0.73	0.67	1.00																		
Fin.	0.56	0.54	0.56	0.66	0.59	1.00																	
Fra.	0.71	0.74	0.82	0.75	0.75	0.73	1.00																
Ger.	0.70	0.74	0.79	0.73	0.77	0.71	0.90	1.00															
HK.	0.62	0.47	0.48	0.54	0.49	0.48	0.56	0.57	1.00														
Ire.	0.65	0.70	0.72	0.60	0.69	0.55	0.74	0.73	0.47	1.00													
Isr.	0.41	0.39	0.41	0.50	0.43	0.44	0.53	0.52	0.35	0.41	1.00												
Ita.	0.67	0.70	0.74	0.68	0.71	0.64	0.86	0.81	0.47	0.68	0.48	1.00											
Jap.	0.48	0.40	0.37	0.40	0.40	0.37	0.44	0.42	0.45	0.36	0.23	0.36	1.00										
Net.	0.72	0.76	0.86	0.75	0.76	0.68	0.91	0.89	0.56	0.75	0.50	0.82	0.43	1.00									
NZ.	0.76	0.59	0.56	0.61	0.57	0.47	0.59	0.59	0.51	0.54	0.32	0.55	0.41	0.60	1.00								
Nor.	0.70	0.74	0.68	0.75	0.73	0.61	0.74	0.72	0.50	0.65	0.46	0.69	0.36	0.77	0.57	1.00							
Por.	0.62	0.72	0.70	0.61	0.68	0.59	0.76	0.75	0.42	0.63	0.41	0.72	0.35	0.72	0.56	0.65	1.00						
Sing.	0.63	0.52	0.53	0.56	0.53	0.44	0.56	0.58	0.74	0.51	0.37	0.49	0.47	0.59	0.55	0.54	0.46	1.00					
Spa.	0.65	0.73	0.76	0.65	0.70	0.64	0.85	0.82	0.48	0.67	0.45	0.83	0.37	0.81	0.55	0.66	0.77	0.49	1.00				
Swe.	0.69	0.67	0.72	0.74	0.73	0.76	0.84	0.84	0.54	0.67	0.52	0.77	0.40	0.82	0.56	0.74	0.69	0.55	0.75	1.00			
Swi.	0.67	0.71	0.78	0.66	0.71	0.60	0.82	0.81	0.49	0.68	0.42	0.73	0.43	0.83	0.56	0.67	0.70	0.51	0.76	0.73	1.00		
UK	0.77	0.74	0.77	0.77	0.77	0.67	0.86	0.83	0.59	0.75	0.49	0.77	0.41	0.86	0.61	0.75	0.68	0.60	0.76	0.79	0.79	1.00	
US	0.62	0.53	0.61	0.77	0.58	0.66	0.74	0.74	0.52	0.62	0.56	0.66	0.36	0.73	0.50	0.60	0.51	0.50	0.63	0.72	0.64	0.75	1.00

Notes. This table shows the correlation coefficient between the returns of the developed market indices. Aus = Australia, Au = Austria, Bel = Belgium, Can = Canada, Den = Denmark, Fin = Finland, Fra = France, Ger = Germany , HK = Hong Kong, Ire = Ireland, Isr = Israel, Ita = Italy, Jap = Japan, Net = Netherlands, NZ = New Zealand, Nor = Norway, Por = Portugal, Sing = Singapore, Spa = Spain, Swe = Sweden, Swi = Switzerland

Table 3.7 Emerging Market Correlation

	Bra.	Chi.	Col.	Cz.	Gr.	Hun.	Ind.	Indn.	Kor.	Mal.	Mex.	Per.	Ph.	Pol.	S.Af.	Tai.	Thai.	Tur.	Egy.	Rus.	Qat.	UAE	Chn.
Bra.	1.00																						
Chi.	0.65	1.00																					
Col.	0.36	0.38	1.00																				
Cz.	0.48	0.42	0.32	1.00																			
Gr.	0.42	0.37	0.26	0.53	1.00																		
Hun.	0.54	0.48	0.32	0.67	0.53	1.00																	
Ind.	0.40	0.39	0.26	0.35	0.38	0.41	1.00																
Indn.	0.07	0.12	0.11	0.09	0.13	0.09	0.14	1.00															
Kor.	0.43	0.36	0.18	0.36	0.34	0.39	0.38	0.05	1.00														
Mal.	0.23	0.27	0.13	0.27	0.20	0.23	0.26	0.22	0.30	1.00													
Mex.	0.69	0.58	0.32	0.45	0.41	0.54	0.38	0.08	0.41	0.28	1.00												
Per.	0.49	0.50	0.29	0.37	0.30	0.40	0.30	0.10	0.28	0.21	0.45	1.00											
Ph.	0.40	0.41	0.27	0.32	0.28	0.37	0.32	0.21	0.41	0.46	0.42	0.30	1.00										
Pol.	0.48	0.47	0.38	0.65	0.51	0.70	0.39	0.07	0.42	0.28	0.51	0.35	0.35	1.00									
S.Af.	0.61	0.51	0.32	0.56	0.49	0.62	0.43	0.09	0.47	0.28	0.59	0.44	0.43	0.61	1.00								
Tai.	0.39	0.39	0.20	0.32	0.29	0.34	0.37	0.06	0.44	0.33	0.37	0.28	0.39	0.32	0.39	1.00							
Thai.	0.38	0.41	0.25	0.32	0.29	0.34	0.33	0.25	0.48	0.42	0.37	0.29	0.54	0.38	0.43	0.39	1.00						
Tur.	0.43	0.35	0.27	0.39	0.35	0.47	0.29	0.05	0.31	0.14	0.41	0.29	0.26	0.44	0.44	0.26	0.27	1.00					
Egy.	0.26	0.28	0.22	0.30	0.27	0.29	0.30	0.04	0.22	0.22	0.29	0.24	0.20	0.33	0.29	0.16	0.17	0.23	1.00				
Rus.	0.46	0.43	0.33	0.46	0.37	0.51	0.33	0.05	0.36	0.25	0.46	0.36	0.32	0.52	0.51	0.38	0.38	0.39	0.21	1.00			
Qat.	0.33	0.23	0.30	0.29	0.24	0.28	0.29	0.11	0.29	0.25	0.36	0.30	0.20	0.24	0.25	0.24	0.27	0.27	0.32	0.31	1.00		
UAE	0.22	0.20	0.19	0.21	0.20	0.19	0.19	0.04	0.10	0.17	0.19	0.19	0.13	0.20	0.15	0.14	0.23	0.17	0.33	0.22	0.44	1.00	
Chn.	0.38	0.40	0.18	0.35	0.34	0.38	0.40	0.13	0.41	0.38	0.38	0.29	0.43	0.40	0.45	0.44	0.40	0.25	0.23	0.33	0.23	0.14	1.00

Notes. This table shows the correlation coefficient between the returns of the emerging market indices. Bra = Brazil, Chi = Chile, Col = Colombia, Cz = Czech Republic, Gr = Greece, Hun = Hungary, Ind = India, Indn = Indonesia, Kor = South Korea, Mal = Malaysia, Mex = Mexico, Per = Peru, Ph = Philippines, Pol = Poland, SAf = South Africa, Tai = Taiwan, Thai = Thailand, Tur = Turkey, Egy = Egypt, Rus = Russia, Qat = Qatar, Chn = China.

3.4.2 Industry Analysis

I present the summary statistics for the value weighted developed, emerging and global industry returns in Table 3.8. The emerging market industries have significantly higher returns across all ten industrial groupings, compared to the developed market sample. However, these industries are also more volatile than the industries of the developed markets. In both the developed and emerging market samples, the highest mean return is observed for the oil and gas, and the industrials industries, alongside the consumer goods industry in the case of the developed markets. The utilities, telecommunications, and financials industries offer the lowest mean return across both the developed and emerging market samples, and this is reflected in the global sample. The technology industry is the most volatile across both market classifications; this is likely driven by the collapse of the dot-com bubble in March 2000. The healthcare industry is the least volatile across both samples, and this is also observed in the global sample. Overall, ranking the industries by mean return and by standard deviation, I observe a similar risk-return profile across the ten industrial groupings in each sample. The emerging market industries offer a better return-to-standard deviation ratio on average, than the developed market industries, 6.40 per cent to 2.33 per cent respectively. The spread between minimum and maximum values is higher for the emerging market industries. Skewness and Kurtosis figures are higher for developed market industries.

I examine the correlation coefficient between all pairs of industries in the developed, emerging and global sample, and present the results in Table 3.9. Correlations are higher between the developed market industries than the emerging market industries. This reflects the results of the correlation analysis of developed and emerging market country returns. In the developed market sample, correlation is strongest between the industrials and the consumer services industries at 0.91. This result is reflected in the global sample. The financials and basic materials industries are the most correlated of the emerging

market sample, at 0.83. Overall, the industrials, basic materials, and financials industries appear to be the most correlated with other industries, while the technology and telecommunications industries appear to be the least correlated.

Table 3.8 Summary Statistics for the Industry Returns

	Mean	Std. Dev.	Mean:SD	Min	Max	Skewness	Kurtosis
Developed Markets Industry Returns							
Oil and Gas	0.12%	3.31%	3.63%	-29.98%	14.41%	-1.21	12.77
Basic Materials	0.07%	3.40%	2.06%	-23.86%	15.61%	-0.89	9.21
Industrials	0.09%	2.83%	3.18%	-17.41%	11.64%	-0.79	7.05
Consumer Goods	0.08%	2.41%	3.32%	-17.61%	11.03%	-0.96	9.71
Healthcare	0.10%	2.07%	4.83%	-20.96%	9.24%	-1.63	17.97
Consumer Services	0.08%	2.37%	3.38%	-19.75%	9.47%	-1.05	10.41
Telecommunication	-0.01%	2.63%	-0.38%	-20.79%	11.01%	-0.91	8.93
Utilities	0.03%	2.18%	1.38%	-26.08%	10.30%	-2.33	28.6
Financials	0.01%	3.11%	0.32%	-25.40%	17.06%	-1.03	12.59
Technology	0.06%	3.81%	1.57%	-24.83%	16.25%	-0.66	6.51
Average	**0.06%**	**2.81%**	**2.33%**	**-22.67%**	**12.60%**		
Emerging Markets Industry Returns							
Oil and Gas	0.27%	3.81%	7.09%	-27.85%	24.30%	-0.72	10.25
Basic Materials	0.23%	3.66%	6.28%	-24.91%	21.05%	-0.80	9.56
Industrials	0.27%	3.74%	7.22%	-25.01%	14.55%	-0.65	7.11
Consumer Goods	0.27%	2.86%	9.44%	-20.46%	14.15%	-0.90	8.73
Healthcare	0.23%	2.84%	8.10%	-15.66%	11.69%	-0.57	6.11
Consumer Services	0.19%	2.89%	6.57%	-21.03%	15.91%	-0.85	9.11
Telecommunication	0.17%	3.24%	5.25%	-17.91%	15.38%	-0.50	7.39
Utilities	0.14%	3.03%	4.62%	-23.13%	13.27%	-0.97	9.19
Financials	0.17%	3.31%	5.14%	-24.03%	18.48%	-0.80	9.22
Technology	0.20%	4.66%	4.29%	-17.32%	20.21%	0.08	4.80
Average	**0.22%**	**3.40%**	**6.40%**	**-21.73%**	**16.90%**		
Global Markets Industry Returns							
Oil and Gas	0.17%	3.28%	5.18%	-29.24%	16.05%	-1.11	12.72
Basic Materials	0.15%	3.37%	4.45%	-23.73%	16.12%	-0.83	9.60
Industrials	0.14%	2.82%	4.96%	-18.04%	11.25%	-0.79	7.24
Consumer Goods	0.14%	2.38%	5.88%	-17.58%	11.58%	-0.91	9.90
Healthcare	0.12%	2.06%	5.83%	-20.80%	9.10%	-1.60	17.86
Consumer Services	0.12%	2.41%	4.98%	-20.10%	10.27%	-1.03	10.57
Telecommunication	0.10%	2.65%	3.77%	-20.26%	11.93%	-0.82	8.71
Utilities	0.08%	2.15%	3.72%	-25.51%	9.20%	-2.30	27.93
Financials	0.07%	3.15%	2.22%	-26.04%	16.82%	-1.01	12.48
Technology	0.12%	3.78%	3.17%	-24.25%	16.65%	-0.61	6.36
Average	**0.12%**	**2.80%**	**4.42%**	**-22.55%**	**12.90%**		

Notes. This table presents the summary statistics for the weekly log returns of the developed, emerging and global market samples. The global sample is a combined sample of developed and emerging markets. The markets covered and their classification is listed in Table 3.1. The emerging market industries have a higher mean return, but also a higher standard deviation, than the developed market industries. The emerging market industries offer a better return-to-standard deviation ratio on average at 6.40 per cent to 2.33 per cent respectively.

Table 3.9 Correlation Matrices for Developed, Emerging, and Global Industries

Panel A: Developed Markets										
	OG	BM	ID	CG	HC	CS	TC	UT	FN	TY
OG	1.00									
BM	0.80	1.00								
ID	0.71	0.86	1.00							
CG	0.64	0.77	0.87	1.00						
HC	0.60	0.62	0.68	0.65	1.00					
CS	0.64	0.76	0.91	0.84	0.72	1.00				
TC	0.48	0.58	0.73	0.66	0.55	0.76	1.00			
UT	0.73	0.70	0.67	0.62	0.71	0.65	0.56	1.00		
FN	0.68	0.80	0.88	0.81	0.73	0.87	0.68	0.70	1.00	
TY	0.45	0.55	0.78	0.65	0.47	0.78	0.69	0.41	0.63	1.00
Panel B: Emerging Markets										
	OG	BM	ID	CG	HC	CS	TC	UT	FN	TY
OG	1.00									
BM	0.66	1.00								
ID	0.36	0.63	1.00							
CG	0.31	0.53	0.67	1.00						
HC	0.46	0.55	0.25	0.03	1.00					
CS	0.56	0.74	0.58	0.44	0.55	1.00				
TC	0.47	0.59	0.47	0.37	0.43	0.59	1.00			
UT	0.57	0.71	0.57	0.49	0.50	0.72	0.61	1.00		
FN	0.57	0.83	0.65	0.51	0.55	0.79	0.61	0.74	1.00	
TY	0.30	0.49	0.37	0.30	0.34	0.44	0.46	0.39	0.48	1.00
Panel C: Global										
	OG	BM	ID	CG	HC	CS	TC	UT	FN	TY
OG	1.00									
BM	0.77	1.00								
ID	0.70	0.86	1.00							
CG	0.62	0.79	0.86	1.00						
HC	0.59	0.62	0.68	0.64	1.00					
CS	0.62	0.76	0.91	0.83	0.71	1.00				
TC	0.43	0.54	0.70	0.63	0.51	0.74	1.00			
UT	0.71	0.68	0.65	0.60	0.70	0.63	0.51	1.00		
FN	0.66	0.79	0.88	0.81	0.73	0.87	0.66	0.68	1.00	
TY	0.42	0.53	0.76	0.63	0.45	0.77	0.69	0.37	0.62	1.00

Notes. This table presents the correlation coefficient between pairs of industries in the developed (Panel A), emerging (Panel B) and global (Panel C) samples. BM = Basic Materials, CG = Consumer Goods, CS = Consumer Services, FN = Financials, HC = Healthcare, ID = Industrials, OG = Oil & Gas, TY = Technology, TC = Telecommunications, UT = Utilities

I follow this correlation analysis with an illustration of the changing proportions of total market value, in US dollars, that each of the ten industries occupies. The results are presented in Figures 3.1 to 3.3. As indicated by share of total market value, the financials industry largely dominates throughout the sample, and is the most prominent of the ten industries in terms of market value. The effects of the dot-com bubble and subsequent collapse in the technology industry between 2001 and 2002, are particularly striking. While the market value of the technology industry grows significantly relative to each other global industry in 2000, it rapidly contracts later that year. The total proportion of global market value allocated to the healthcare industry shrinks by over 50 per cent at the end of 2005, while the consumer goods industry doubles at the same time. I also observe the effects of the global financial crisis in 2008, with almost every industry growing relative to the financials industry at the time of the crisis. However, the distribution of market value appears to stabilise in 2009 until the end of the sample in December 2013.

While the results of the global and the developed market samples are largely similar, the emerging market sample differs significantly. I do not observe the same rapid expansion and subsequent decline in the technology industry of the emerging markets. However, although modest, the effects of the dot-com bubble do manifest in the telecommunications industry, which is considerably larger in the case of the emerging markets, compared to the sample of developed markets.

Figure 3.1 Industry Distribution of the Global Industry Returns

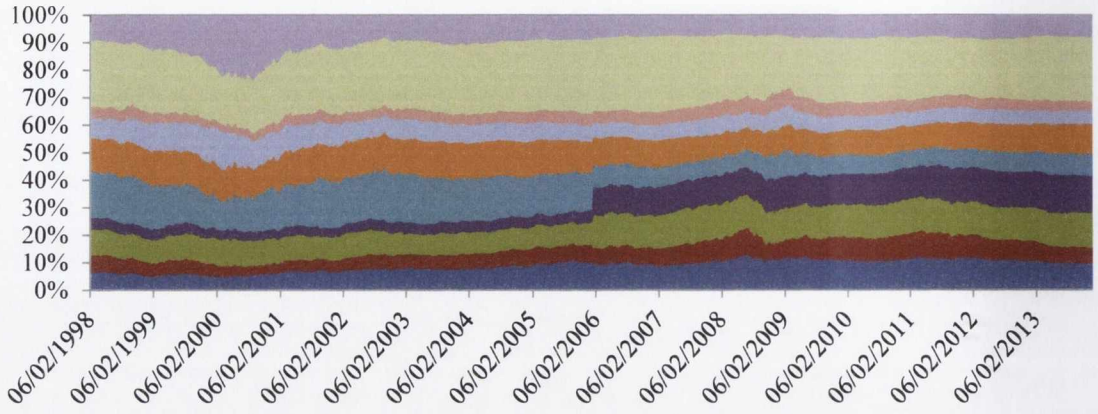


Figure 3.2 Industry Distribution of the Developed Market Industry Returns

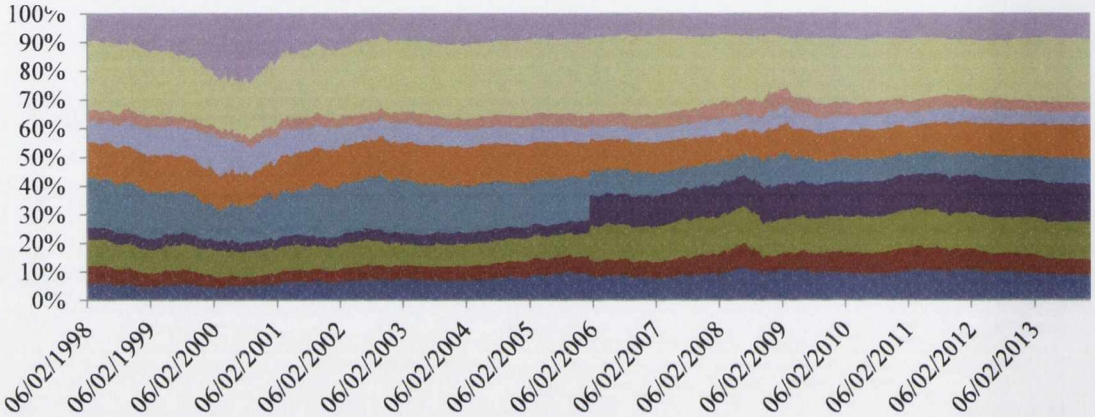
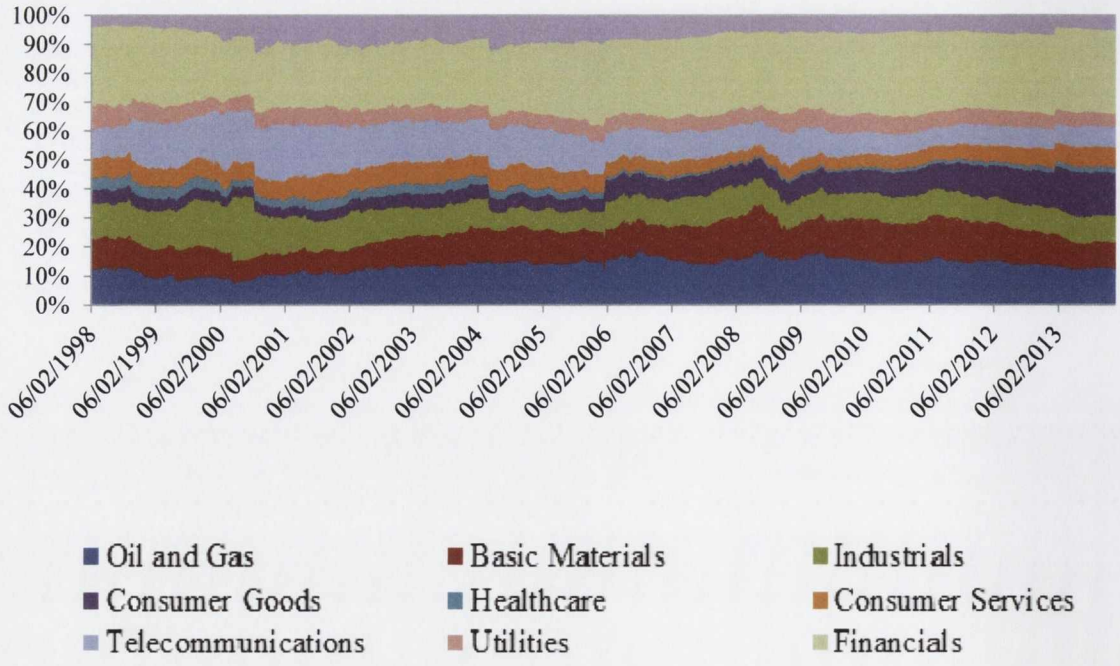


Figure 3.3 Industry Distribution of the Emerging Market Industry Returns



Furthermore, the emerging market financials industry does not contract in terms of market value to the same degree surrounding the global financial crisis, compared to the developed market sample. I also note that, compared to the developed market and global samples, the consumer services and healthcare industries are considerably smaller throughout the period of study, while the basic materials and industrials industries are somewhat larger.

3.5 Examining Equity Market Linkages

This section describes the various methods used to examine global linkages between equity markets, the results of which are presented in Chapter 4.

Long-term relationships between international equity markets are popularly modelled in the literature as a cointegration relationship between stock price indices. The Johansen (1988) cointegration test is widely used, and the subsequent work by Hansen and Johansen (1993) adds a time-varying dynamic component to the standard test. The regime-switching cointegration framework of Gregory and Hansen (1996) has also been employed. Guidi and Ugur (2014) and Lucey and Voronkova (2008) use both the Johansen and Gregory-Hansen tests to assess cointegration among South-Eastern European, and Central and Eastern European markets respectively. In terms of short-term linkages, time-varying conditional correlations based upon the multivariate dynamic conditional correlation (DCC) generalised autoregressive conditional heteroskedasticity (GARCH) model proposed by Engle (2002) are generally used. Guesimi et al. (2013) find evidence of increased conditional correlations between the US and a sample of OECD countries, and refer to the definition of financial contagion proposed by Forbes and Rigobon (2002) as a positive shift in the degree of return comovement. Mighri and Mansouri (2013) also use the DCC method to find evidence of increased conditional correlation between the US and a sample of emerging and developed markets, following

the onset of the global crisis. My study of equity market linkages combines the Johansen-Juselius and the Gregory-Hansen tests to examine long-term linkages between markets. I further assess short-term dynamics using the DCC model of Engle (2002).

3.5.1 Johansen-Juselius Cointegration test

I model long-term linkages between equity markets as cointegrating relations using the Johansen-Juselius (1990) test. Consider the vector autoregression (VAR), of order p given below:

$$\Delta y_t = \mu = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \, \Delta y_{t-1} + \varepsilon_t \,, \qquad (3.4)$$

with:

$$\Pi = \sum_{i=1}^{p} \mathrm{A}_i - \mathrm{I} \text{ and } \Gamma_i = \sum_{j=i+1}^{p} \mathrm{A}_j, \qquad (3.5)$$

If Π, the coefficient matrix has reduced rank such that $r < n$ then there exists n x r matrices α and β with rank r such that the coefficient matrix $\Pi = \alpha\beta'$ and $\beta' y_t$ is stationary. The elements of α are the adjustment parameters in the vector error correction model (VECM) and each column of β is a cointegrating vector, while r is the number of cointegrating relationships. It is possible to show, that for a given r, the maximum likelihood estimator of β defines the combination of y_{t-1} that yields the r largest canonical correlations of Δy_t with y_{t-1}, after correcting for lagged differences and deterministic variables. Both a trace statistic and a maximum eigenvalue statistic (likelihood ratio tests) are proposed to test the significance of the canonical correlations, and therefore, the reduced rank of the coefficient matrix Π:

$$J_{trace\ statistic} = -T \sum_{i=r+1}^{n} \ln(1 - \widehat{\delta_i}), \qquad (3.6)$$

$$J_{max.\ eigenvalue\ statistic} = -T \sum_{i=r+1}^{n} \ln(1 - \widehat{\delta_{r+1}}), \qquad (3.7)$$

where T is the sample size and $\widehat{\delta_i}$ is the i_{th} largest canonical correlation.

While the trace statistic examines the null hypothesis of r cointegrating vectors against the alternative hypothesis of n cointegrating vectors, the maximum eigenvalue statistic considers the null hypothesis of r cointegrating vectors against the alternative of $r + 1$ cointegrating vectors. Johansen and Juselius (1990) provide asympototic critical values. The Juselius-Johansen test is predicated on an assumption that the series contain a unit root, which I have pre-determined using both an ADF and KPSS test, for both the developed and emerging market samples in Section 3.4 of this Chapter.

I initially study linkages across the whole sample period (December 30th 1994 to December 27th 2013). I follow this with a sub-period analysis using sub-periods determined by the Bai-Perron procedure described in Section 3.8, in which I separate the samples of developed and emerging markets into different regimes, to compare market integration levels in different time-periods. Finally, I follow Hansen and Johansen (1993), Lucey and Voronkova (2005), and Yunus (2013) in conducting a recursive cointegration analysis using the Johansen-Juselius test. This involves estimation over an initial period of size t, before expanding this period by a single unit of time to period t_{+1} and re-estimating. I continue in this way until I reach the end of the sample such that the final estimation is over the whole period. The trace statistic of the null hypothesis that there is no cointegration is then scaled to the 90 per cent critical value in each case. Finally, this time series of trace statistics is plotted in order to observe the dynamics of cointegration across the full sample period. This recursive analysis allows me to examine the dynamics of market integration across all of my studied groups, and enables me to identify temporal instability in market interdependencies and to discern if there is an upward or downward trend in levels of integration across the studied groups.

3.5.2 Gregory-Hansen Cointegration Test

Equity market linkages have been found to be time-varying in most of the surrounding literature (Bekaert and Harvey, 1997; Aggarwal et al., 2004; Lucey and Voronkova, 2008). When examining the cointegation of equity markets over time, it is necessary to allow for the possibility of a regime shift. That is, it may be the case that a structural break has caused a shift in the cointegrating vector, with a move to a new long-run relationship. Standard tests of cointegration may incorrectly lead to a failure to reject the null hypothesis of no cointegration, when a structural break is present. Following from this, I conduct an analysis using the procedure proposed by Gregory and Hansen (1996). The Gregory-Hansen test considers the case in which the series is cointegrated but the cointegrating vector has shifted at a single unknown point. This allows for the consideration that a cointegrating relation holds over a long period, before shifting to a new long-run relationship.

Gregory and Hansen (1996) describe this structural change in terms of a change in intercept and (or) slope. The timing of this structural change is estimated endogenously. Given the standard model:

$$y_{it} = \mu + \alpha y_{2t} + e_t, \qquad (3.8)$$

with $t = 1 \ldots n$, a structural change is captured by changes in μ and α, defying the usual assumption of μ and α time invariance. Consider:

$$\varphi_{t\tau} = \begin{cases} 0, & and \quad t \leq [n\tau] \\ 1, & and \quad t > [n\tau] \end{cases}, \qquad (3.9)$$

where $\tau \in (0,1)$ denotes the timing of the change point. Gregory and Hansen (1996) propose three models. These capture changes in intercept only:

$$y_{1t} = \mu_1 + \mu_2\varphi_{t\tau} + \alpha' y_{2t} + e_t, \quad (3.10)$$

as well as a level shift with trend:

$$y_{1t} = \mu_1 + \grave{\imath}_2\varphi_{t\tau} + \beta_t + \alpha' y_{2t} + e_t, \quad (3.11)$$

and allowing for a change in both the intercept and slope of the cointegration vector with:

$$y_{1t} = \mu_1 + \mu_2\varphi_{t\tau} + \alpha_1' y_{1t} + \alpha_2' y_{2t}\varphi_{t\tau} + e_t, \quad (3.12)$$

where μ_1 is the pre-shift intercept, μ_2 is the change in intercept at the time of the shift, α_1' is the cointegrating slope of the coefficients before the regime shift, α_2' is the change in slope of the coefficients.

Following Andrews (1993) and Lucey and Voronkova (2008) Augmented Dickey-Fuller and Phillips-Perron tests are used to check the non-stationarity of residuals as expected under the null hypothesis. The break point is selected as the value constituting the strongest evidence against H_o setting the test statistics denoted as ADF*, Z_a* and Z_t* at the smallest values of the ADF, Z_a, Z_t statistics in the sequence.

3.5.3 Dynamic Conditional Correlation

I supplement my analysis of long-run relationships with an examination of short-term linkages. I use the dynamic conditional correlation (DCC) approach of Engle (2002) in which short-term linkages are modelled as time-varying conditional correlations. This involves a two-step procedure, whereby I first estimate a univariate GARCH model for each return series, and I use the residuals from this first step to estimate a time-varying correlation matrix. The model assumes the returns from k series are multivariate normally distributed with zero mean and covariance matrix:

$$Hi: r_t|F_{t-1} \sim N(0, H_t), \quad (3.13)$$

where

$$H_t \equiv D_t R_t D_t, \quad (3.14)$$

and D_t is a K x K matrix of time varying standard deviations from a univariate GARCH model with $\sqrt{hit}$ on the i_{th} diagonal, where

$$h_{it} = w_i + \sum_{p=1}^{P_i} a_{ip} r_{it-p}^2 + \sum_{q=1}^{Q_i} \beta_{iq} h_{it-q} \quad (3.15)$$

The proposed dynamic correlations structure is

$$R_t = (Q^*_t)^{-1} Q_t (Q^*_t)^{-1}, \quad (3.16)$$

where Q^*_t is a diagonal matrix composed of the square root of the diagonal elements of the Q_t, and Q_t follows a GARCH-type process:

$$Q_t = (1 - \sum_{m=1}^{m} \alpha_m - \sum_{n=1}^{n} \beta_n)\bar{Q} + \sum_{m=1}^{m} \alpha_m (\varepsilon' t \varepsilon t) + \sum_{n=1}^{n} \beta_n Q_{t-n}, \quad (3.17)$$

where $\overline{Qt}$ is an unconditional covariance matrix of the standardised residuals from the first stage estimation.

3.6 Industry and Country Effects in Developed and Emerging Market Returns

In this section, I describe my approach to examining the relative importance of industry and country effects, the results of which are presented in Chapter 5. Modern portfolio theory informs that a risk-averse investor will diversify a portfolio of assets to minimise their exposure to risk for a given level of return. When attempting to identify the relative importance of two competing factors in the variation of stock returns a model that facilitates the decomposition of a stock's return into multiple components for independent analysis is desirable. The factor model proposed by Heston and Rouwenhorst (1994) offers an intuitively appealing decomposition of the return on a firm's stock. The return on stock i at time t can be disentangled to allow a separation of four factors:

$$R_{it} = \alpha + \beta_j + \gamma_k + \varepsilon_{it} \quad (3.18)$$

α is the factor common to all stocks, β is the industry effect, γ is the country effect, and ε is a random error with mean 0 and finite variance. Industry and country dummy variables are coded a value of 1 if the stock belongs to a particular country or industry, and 0 otherwise. This allows (3.18) to be rewritten as:

$$R_{it} = \alpha + \beta_1 I_{i1} + \cdots + \beta_n I_{in} + \gamma_1 C_{i1} + \cdots + \gamma_m C_{im} + e_{it} \quad (3.19)$$

A cross-section is estimated for each time t with the resulting time series of country and industry effects averaged to obtain estimates over the entire sample period. Despite an emphasis on economic as opposed to statistical significance, the model remains the theoretical base upon which the empirical literature continues to build and expand (Griffin and Karolyi, 1998; Cavaglia et al., 2000; Baca et al., 2000; Flavin, 2004; Campa and Fernandes, 2005; Phylaktis and Xia, 2006; Bai and Green, 2011, 2014).

Flavin (2004) establishes statistical as well as economic significance across the estimated industry and country effects. The portfolio tracking errors interpreted by Heston and Rouwenhorst (1994) in their preeminent work are less convincing from an investor perspective in the absence of statistical significance – it cannot be argued that the estimates are statistically different from 0. The panel data framework used by Flavin (2004) allows for greater precision in estimation of the country and industry effects, and so makes an empirical improvement over the cross-sectional analysis conducted by Heston and Rouwenhorst (1994). The general form of this panel model involves the estimation of n industry and m country dummy variables:

$$R_{it} = \alpha + \beta_1 I_{i1,t} + \cdots + \beta_n I_{in,t} + \gamma_1 C_{i1,t} + \cdots + \gamma_m C_{im,t} + e_{it} \quad (3.20)$$

In my analysis of industry and country effects across developed and emerging market samples, I estimate the following equation for each sample:

$$R_{it} = \alpha + \beta_1 I_{i1,t} + \cdots + \beta_{10} I_{i10,t} + \gamma_1 C_{i1,t} + \cdots + \gamma_{23} C_{i23,t} + e_{it} \quad (3.21)$$

However, it is not possible to proceed without addressing the perfect multicollinearity issue that persists across the independent variables. This multicollinearity arises from the fact that stocks belong to a single country and industry only. This means that an Irish stock taking a value of 1 for *Ireland* is perfectly correlated to that stock taking a value of 0 for *France*, as this stock cannot be present in both markets. Likewise, a stock from the healthcare industry taking a value of 0 for *Utilities* is perfectly correlated to that same stock taking a value of 1 for *Healthcare*, as this stock cannot be present in both of these industries. The traditional approach to tackling the issue of multicollinearity in empirical research is to proceed by dropping an arbitrary country and industry variable prior to estimation, and measuring relative to these missing variables.

An alternative approach taken in the surrounding literature, most notably by Heston and Rouwenhorst (1994) and also in the paper by Flavin (2004), involves estimating a constrained dummy variable regression that ensures the industry and country dummies do not sum to unity. These studies draw upon the paper by Suits (1984), and the amendment in Kennedy (1986), in which a constant of value k is added to each of the estimates, where k satisfies the constraint that the resulting coefficients average 0. This results in ease of interpretation for the case when an arbitrary dummy variable must be dropped to abate the issue of multicollinearity. I weight the industries and countries by to market value, allowing measurement relative to a value weighted benchmark:

$$\sum_{j=1}^{10} \partial j \beta j = 0$$

$$\sum_{k=1}^{23} \emptyset k \gamma k = 0 \qquad (3.22)$$

where ∂j and $\emptyset k$ are weights on industry j and country k respectively.

For this panel data analysis, the choice must be made between fixed and random effects modelling. At the crux of this decision, is my assumption about the nature of the individual specific effects and their correlation with the independent variables in the model, that is, the country and industry dummies. With fixed effects, I assume that the individual specific effects are correlated with the independent variables, while random effects assume that there is no such correlation. Depending on which of these assumptions hold, there are implications for my model in terms of efficiency and consistency. The choice of a random effects model is intuitive. The regressors are time invariant, that is, the country and industry that a stock belongs to does not change over time. The aim is to separately identify country and industry differences in stock returns, implying that a fixed effects model is inappropriate - the fixed affect would absorb all industry and country level variation.

I confirm the superiority of a random effects model over a fixed effects model in this context using the Hausman test. If I consider the basic model:

$$y = bX + e \qquad (3.23)$$

where X is a vector of independent variables, b is a vector of coefficients and e is the error term. Under the null hypothesis, both estimators of b, b_0 and b_1, are consistent, but b_1 is efficient, while under the alternative hypothesis b_0 is consistent whereas b_1 is not. The Hausman test statistic is given by:

$$H = (b_1 - b_0)\,' \,(Var(b_0) - Var\,(b_1))^{\dagger} (b_1 - b_0) \qquad (3.24)$$

where † denotes the Moore-Penrose pseudoinverse. Under the null hypothesis, the test statistic has asymptotically the chi-squared distribution, with degrees of freedom equal to the rank of the $Var(b_0) - Var\,(b_1)$ matrix. A rejection of the null hypothesis favours the fixed effects model, while a failure to reject the null hypothesis suggests the random effects model. In the context of the Hausman test, I fail to reject the null hypothesis, and so a random effects model is preferred.

Following this, the choice of whether to use pooled ordinary least squares (OLS) or random effects remains. The random effects model assumes that the unobserved heterogeneity is not correlated with the regressor terms, that is, the country and industry dummies. Under this assumption, the coefficients of an OLS regression are unbiased. However, the OLS estimator is inefficient – that is, the standard errors are estimated based on the incorrect variance term. Generalised least squares (GLS) is used to correct this. I proceed with a random effects model estimated by GLS given its greater efficiency over pooled OLS.

The resulting country and industry estimates convey the consequences of over-investing in specific countries and industries relative to the value weighted benchmark. To measure

the relative importance of the competing factors, the average absolute value of country and industry effects is compared. Specifically, following Flavin (2004), I calculate a ratio of the absolute average of country effects to the absolute average of industry effects. A ratio in excess of 1 warrants a greater emphasis by investors on industry based diversification, while a ratio below 1 suggests the dominance of country factors.

The first stage of this factor analysis involves a full period estimation for the developed and emerging market samples. Following this, I extend the analysis to a recursive framework, in which I estimate equation (3.21) over an initial window of fifty-two weeks, before extending the window by increments of one week and repeating the estimation after each incremental expansion. This continues until the end of the sample is reached, and the entire sample is being estimated. This allows me to examine the dynamics of the industry-to-country effect ratio and the evolution of the relative importance of industries and countries in equity market returns throughout the sample period. It represents a novel contribution and has not been done elsewhere in the literature. Finally, I conduct a sub-period analysis to discern the relative importance of country and industry factors surrounding the global financial crisis.

3.7 Mean-Variance Efficiency of Industrial and International Portfolio Diversification

Using a factor decomposition model, Chapter 5 directly quantifies the extent to which the country and industry of the stock contributes to the determination of its return. In contrast, Chapter 6 compares the merits of pursuing a strategy of countries or industries, relative to a mixed strategy, in mean-variance space. In other words: is the industry or country more important for determining the return of the stock? Naturally, diversification across a complete set of both industries and countries is theoretically possible, but the

relative size of the country and industry factors is primarily of interest here, rather than the merits of diversifying across both industries and countries.

Following from this, Chapter 6 involves the use of spanning tests, to quantify the extent to which diversification across both industries and countries is beneficial, relative to an industry or country focused strategy. Can industries or countries individually achieve the diversification potential of a combination of both? If neither is individually sufficient, there are diversification benefits from mixing. Chapter 6 is a natural follow-on to the preceding analysis in Chapter 5. While Chapter 5 establishes whether industries or countries are more important in the diversification decision of the investor, Chapter 6 then asks if either of these two is individually sufficient to achieve full diversification benefits.

This section describes the tests of spanning used to examine the mean-variance efficiency of country- and industry-focused diversification strategies. The results of this analysis are presented in Chapter 6. Tests of mean-variance spanning are used extensively in international portfolio analysis. I employ this approach in examining the mean-variance efficiency of industry-only and country-only portfolios, compared to a portfolio that combines both industries and countries.

I follow the analyses by Huberman and Kandel (1987), Roon and Nijman (2001) and Kan and Zhou (2012), further employed in international portfolio analysis by Errunza et al. (1999) Berril and Kearney (2008), Eiling et al. (2012), and O'Hagan-Luff and Berrill (2015). Mean variance spanning analysis involves a set of K benchmark and N test assets, and investigates if; conditional on K benchmark assets, the addition of N test assets can shift the mean-variance efficient frontier. This amounts to examining if a sub-set of the benchmark industry *or* country returns, yield the same diversification benefits

as the extended set of industry *and* country returns. In other words, does the benchmark set span the extended set, as indicated by the coinciding of the two efficient frontiers?

The typical spanning test involves the regression of the N test asset returns on the returns of the K benchmark assets as follows:

$$R_{2,t} = \alpha + \beta R_{1,t} + \varepsilon_t \quad (3.25)$$

with $\varepsilon_t \sim N(0, \sum)$, $\alpha = \mathrm{E}[R_{2,t}] - \beta E[R_{1,t}] = \mu_2 - \beta\mu_1$ and $\beta = V_{21}V_{11}^{-1}$. In defining $\delta = 1_N - \beta 1_K$, Huberman and Kandel (1987) and Kan and Zhou (2012) provide the necessary and sufficient conditions for spanning in terms of a restriction on α and δ such that:

$$H^1{}_o{:}\ \alpha = 0_N, \quad H^2{}_0{:}\ \delta = 0_N \quad (3.26)$$

it follows that a test of whether the K benchmark assets span the extended set of K+N benchmark plus test assets involves jointly testing the above hypotheses. A failure to reject the null hypothesis implies that for each test asset N, it is possible to form a portfolio of the benchmark assets K, that has the same expected return (because $\alpha = 0_N$ and $\beta 1_K = 1_N$) but a lower variance (as $R_{1,t}$ and ε_t are uncorrelated while $Var\ (\varepsilon_t)$ is positive definite).

Tests of spanning can be derived as follows. Consider the following model in matrix notation:

$$R = X\beta + \sum, \quad (3.27)$$

with the unconstrained maximum likelihood estimates of β and $\sum$ determined by

$$\hat{\beta} = (X'X)^{-1}(X'R) \text{ and } \hat{\sum} = \frac{1}{T}(R - X\hat{\beta})'(R - X\hat{\beta}), \quad (3.28)$$

The spanning test can be derived by defining $\hat{\mu} = \sum_{t=1}^{T} \frac{R_t}{T}$ and $\hat{V} = \frac{1}{T}\sum_{t=1}^{T}(R_t - \hat{\mu})(R_t - \hat{\mu})'$, and four constants *a, b, c* and *d* that allow for a graphical discussion of the spanning test. I consider the two efficient frontiers – the frontier for *K* assets, and the frontier for *K+N* assets. Firstly, for the *K* benchmark assets:

$$\hat{a}_K = \hat{\mu}'_K \hat{V}^{-1}{}_{11} \hat{\mu}_K \qquad \hat{b}_K = \hat{\mu}'_K \hat{V}^{-1}{}_{11} 1_K \qquad \hat{c}_K = \hat{1}'_K \hat{V}^{-1}{}_{11} \hat{1}_K \qquad \hat{d}_K = \hat{a}_K \hat{c}_K - \hat{b}^2{}_K$$

While for the *K+N* assets:

$$\hat{a}_{K+N} = \hat{\mu}'_{K+N} \hat{V}^{-1}{}_{11} \hat{\mu}_{K+N} \qquad \hat{b}_{K+N} = \hat{\mu}'_{K+N} \hat{V}^{-1}{}_{11} 1_{K+N}$$

$$\hat{c}_{K+N} = \hat{1}'_{K+N} \hat{V}^{-1}{}_{11} \hat{1}_{K+N} \qquad \hat{d}_{K+N} = \hat{a}_{K+N} \hat{c}_{K+N} - \hat{b}^2{}_{K+N}$$

In moving to the frontier of the extended set of assets, *K+N,* from the frontier of the benchmark assets, *K,* the above constants change by

$$\Delta\hat{a} = \hat{a}_{K+N} - \hat{a}_K \qquad \Delta\hat{b} = \hat{b}_{K+N} - \hat{b}_K \qquad \Delta\hat{c} = \hat{c}_{K+N} - \hat{c}_K \qquad \Delta\hat{d} = \hat{d}_{K+N} - \hat{d}_K$$

I then form the following matrices:

$$\hat{G} = \begin{vmatrix} 1 + \widehat{a_K} & \widehat{b_K} \\ \widehat{b_K} & \hat{c}_K \end{vmatrix} \text{ and } \hat{H} = \begin{vmatrix} \Delta\hat{a} & \Delta\hat{b} \\ \Delta\hat{b} & \Delta\hat{c} \end{vmatrix} \qquad (3.29)$$

Combining these two matrices, allowing $\hat{\sum}$ to denote the unconstrained maximum likelihood estimate of $\sum$ (with *K+N* assets) in (3.28), and allowing $\tilde{\sum}$ to denote the constrained maximum likelihood estimate of $\sum$ (with *K* assets) in (3.28), and defining $U = \left|\hat{\sum} \quad \widetilde{\sum^{-1}}\right|$, then the likelihood ratio test of whether the *K* benchmark assets spans the extended set of *K+N* benchmark and test assets is given by:

$$LR = -T \ln(U) \qquad (3.30)$$

where

$$U = \left|\widehat{\Sigma} \quad \widetilde{\Sigma^{-1}}\right| = \frac{|\hat{G}|}{|\hat{G}+\hat{H}|} = \frac{(1+\widehat{a_K})\hat{c}_K - \widehat{b^2}_K}{(1+\hat{a}_{K+N})\hat{c}_{K+N} - \widehat{b^2}_{K+N}} = \left(\frac{\hat{c}_K}{\hat{c}_{K+N}}\right)\left(\frac{1+\frac{\hat{d}_K}{\hat{c}_K}}{1+\frac{\hat{d}_{K+N}}{\hat{c}_{K+N}}}\right)$$

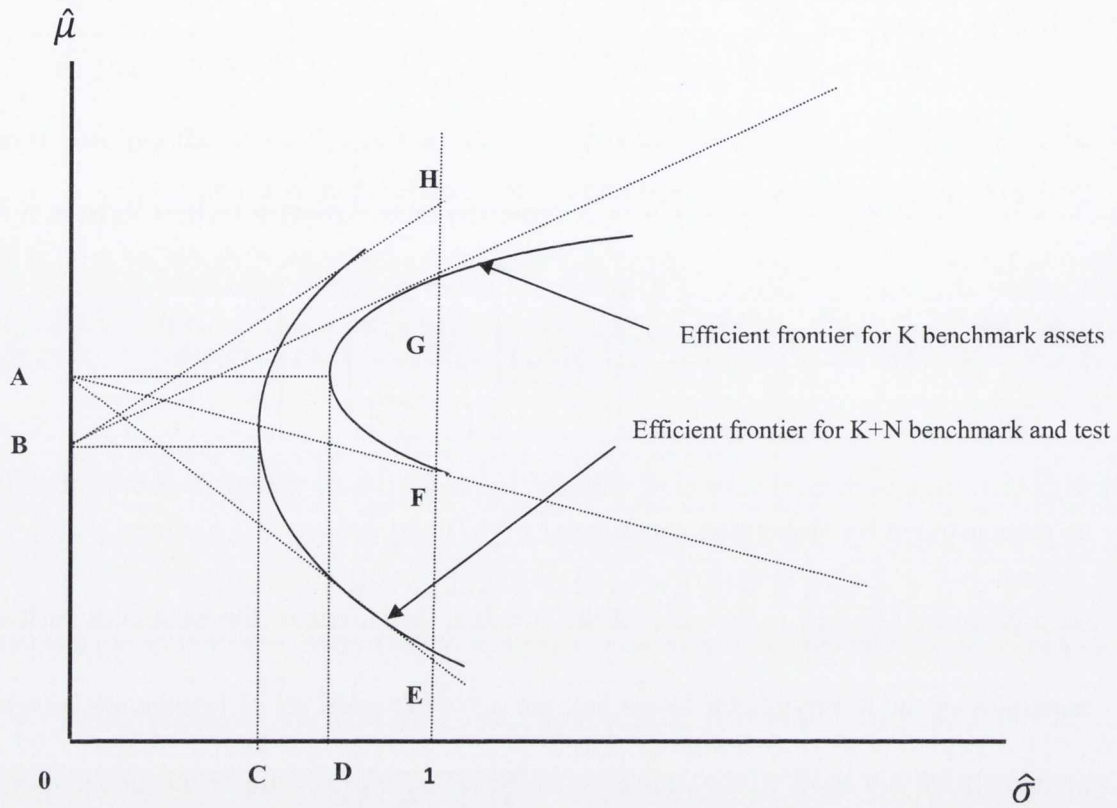
Under the null hypothesis, the distribution of the likelihood ratio test is:

$$F = \left(\frac{T-K-N}{N}\right)\left(U^{-\frac{1}{2}} - 1\right) = \left(\frac{T-K-N}{N}\right)\left[\left(\frac{\sqrt{\hat{c}_K}}{\sqrt{\hat{c}_{K+N}}}\right)\left(\frac{\sqrt{1+\frac{\hat{a}_K}{\hat{c}_K}}}{\sqrt{1+\frac{\hat{a}_{K+N}}{\hat{c}_{K+N}}}}\right) - 1\right] \quad (3.31)$$

as demonstrated by Huberman and Kandel (1987) and Jobson and Korkie (1989). The ratio given by $\left(\frac{\sqrt{\hat{c}_K}}{\sqrt{\hat{c}_{K+N}}}\right)$ is the ratio of the standard deviations of the minimum variance portfolios of the K benchmark assets and the $K+N$ extended set of benchmark plus test assets, bound below by 1. The ratio given by $\left(\frac{\sqrt{1+\frac{\hat{a}_K}{\hat{c}_K}}}{\sqrt{1+\frac{\hat{a}_{K+N}}{\hat{c}_{K+N}}}}\right)$ is the length of the asymptote to the $K+N$ efficient frontier divided by the equivalent to the restricted frontier of the K benchmark assets, bound below by 1, as shown by Kan and Zhou (2001, 2012).

Kan and Zhou (2001, 2012) offer a visualisation of the likelihood ratio, Wald, and Lagrange multiplier (LM) tests, which shows that these tests are closely related spanning tests. See Figure 3.4.

Figure 3.4 Geometry of the MVSTests



Notes. The geometry of the Wald, LM, and LR spanning tests, taken from Kan and Zhou (2012), are as below:

$$W = \left(\frac{OC}{OD}\right)^2 - 1 + \left(\frac{AE}{AF}\right)^2 - 1$$

$$LM = 1 - \left(\frac{OD}{OC}\right)^2 + 1 - \left(\frac{BG}{BH}\right)^2$$

$$LR = \frac{T - K - 1}{2}\left(\frac{OC}{OD}\right)^2 \left(\frac{BH}{AF}\right)^2 - 1$$

While Huberman and Kandel (1987) suggest testing the imposed constraints on a and β using the likelihood ratio (LR) test. Kan and Zhou (2012) demonstrate that the likelihood ratio, Lagrange multiplier (LM), and Wald (W) tests are closely related spanning tests. In testing the joint spanning hypothesis, I use OLS estimation initially, and then carry out a Wald test, to examine the restrictions on a and β. I then test the robustness of these results using the LR and LM tests.

The distributions of the asymptotic Wald test, the LM test, and the LR test statistic of the null hypothesis are given below:

$$W = T(\lambda_1 + \lambda_2) \sim X^2_{2n} \qquad (3.32)$$

$$LM = T\sum_{i=1}^{2} \frac{\lambda_i}{1+\lambda_i} \sim X^2_n \qquad (3.33)$$

$$LR = T\sum_{i=1}^{2} \ln(1 + \lambda_i) \qquad (3.34)$$

Asymptotic tests have good power when considering test assets that can reduce the variance of the global minimum-variance portfolio, however, they suffer from a loss in power against test assets that only offer an improvement in the tangency portfolio (Kan and Zhou, 2001, 2012). Kan and Zhou (2012) show that spanning tests place heavy weights on $\hat{\delta}$ and too little weight on $\hat{\alpha}$. Ultimately this causes a divide between statistical and economic significance whereby large differences in the tangency portfolio can be economically very important but difficult to test statistically, while small differences in the global minimum variance portfolio can be statistically significant but not economically important. As a remedy, they propose a step-down spanning test. The step-down Wald test decomposes the joint Wald test such that it is possible to identify the source of the rejection of the joint Wald test. It involves testing the constraint that $\alpha = 0_n$, to identify if the tangency portfolios are statistically different, before then testing the constraint that $\delta = 0_n$ conditional on $\alpha = 0_n$, to identify if the global minimum

variance portfolios are statistically different. This is an important distinction for the investor's investment decision. The Wald test could be rejected on the basis that I reject the null hypothesis of $\beta = 1$ conditional on $\alpha = 0$, despite a failure to reject the first step-down hypothesis that $\alpha = 0$. While the joint Wald test would advocate that there is no spanning, the step-down Wald test in this case suggests that it is not possible to reject spanning of the tangency portfolios, but only to reject spanning of the global minimum variance portfolios.

I begin by reformulating the Wald test statistic as:

$$W = T\left(\frac{(\hat{\sigma}_{R_1})^2}{(\hat{\sigma}_R)^2} - 1\right) + T\left(\frac{1+\hat{\theta}_R({R_1}^{GMV})^2}{1+\hat{\theta}_{R_1}({R_1}^{GMV})^2} - 1\right) \qquad (3.35)$$

where $(\hat{\sigma}_{R_1})^2$ and $(\hat{\sigma}_R)^2$ are the global minimum-variance of the benchmark assets, and the extended set of benchmark plus test assets, respectively, while $\hat{\theta}_{R_1}({R_1}^{GMV})^2$ is the slope of the asymptote of the mean-variance frontier for the benchmark assets, and $\hat{\theta}_R({R_1}^{GMV})^2$ is the slope of the tangency line of the mean-variance frontier for the extended set of benchmark plus test assets. The step-down asymptotic Wald test is written as below:

$$W_1 = T(\lambda_3) \sim X_n^2$$
$$W_2 = T(\lambda_4) \sim X_n^2 \qquad (3.36)$$

where W_1 and W_2 test for differences in the tangency portfolios, and for differences in the global minimum variance portfolios, respectively.

I replicate my spanning analysis using the Generalised Method of Moments (GMM) approach to examine the robustness of the results once the assumption of normally

distributed and homoscedastic error terms, implicit in OLS estimation, has been relaxed. In addition, the GMM approach does not require information regarding the exact distribution of the error terms. Following Kan and Zhou (2012), the asymptotic chi-squared distribution of the GMM Wald test is:

$$W_a = T \times vec(\widehat{\Theta}')' \left[(\mathrm{A}_T \otimes \mathrm{I}_N)\mathrm{S}_T \, (\mathrm{A'}_T \otimes \mathrm{I}_N)\right]^{-1} \mathrm{vec}(\widehat{\Theta}') \sim \chi^2_{2N} \qquad (3.37)$$

with the moment condition:

$$E[g_t] = E(X \otimes \mathrm{E}) = 0_{n(1+k)} \qquad (3.38)$$

$$S_T = E[g'_t g_t] \qquad (3.39)$$

$$A_T = \begin{bmatrix} 1 + \hat{a}_1 & -\hat{\mu}_1' \hat{V}_{11}^{-1} \\ \hat{b}_1 & -1_k' \hat{V}_{11}^{-1} \end{bmatrix} \qquad (3.40)$$

This GMM approach produces standard errors that are robust to heteroskedasticity and autocorrelation, making it an appropriate tool for robustness analysis in this case.

I analyse the mean-variance efficiency of industry- and country-focused diversification in the vein of Eiling et al. (2012). I consider the following regressions:

$$r_t^x = \alpha_x + \beta_x r_t^y + \varepsilon_t^x \qquad (3.41)$$

$$r_t^y = \alpha_y + \beta_y r_t^x + \varepsilon_t^y \qquad (3.42)$$

where r_t^y describes a vector of returns on M industry portfolios, and r_t^x describes returns on L country portfolios. I follow Ehling and Ramos (2004) and Eiling et al. (2012) in using the country portfolios as benchmark assets and the industry portfolios as test assets, before reversing this and replicating the analysis. In the context of the step-down Wald test, if $\alpha = 0_N$ is not rejected for α_x (if $\alpha = 0_N$ is not rejected for α_y) investors preferring the tangency portfolio can base their strategies on industry (country) portfolios. If $\alpha = 0_N$

and $\delta = 0_N$ are not rejected, industry (country) diversification is an optimal strategy for any investor since industries (countries) span countries (industries). If $\alpha = 0_N$ for both regressions is not rejected I can conclude that both are statistically equivalent around the tangency portfolio.

While tests of mean-variance spanning facilitate an investigation into the statistical significance of a shift in the efficient frontier, I also use a Sharpe ratio (1966) analysis to examine the economic significance of any shift in the efficient frontier. By comparing the maximum Sharpe ratio of the industry- or country-only portfolio to the maximum Sharpe ratio of the portfolio of the extended set, I can infer whether or not there are significant economic benefits from expanding to the extended set of assets. The Sharpe ratio is calculated for the mean-variance efficient portfolio of the K benchmark assets (and a risk-free asset) and also for the mean-variance efficient portfolio of the extended set of $K + N$ benchmark and test assets (and a risk-free asset). These efficient portfolios are determined by solving the optimisation problem below:

$$Max\theta \equiv \frac{\bar{R}_P - R_f}{\sigma_P} = \frac{\sum_{i=1}^{N} x_i(\bar{R}_i - R_f)}{[\sum_{i=1}^{N}\sum_{j=1}^{N} x_i x_j \sigma_{ij}]^{\frac{1}{2}}} \quad (3.43)$$

subject to: $\sum_{i=1}^{N} x_i = 1$ and $x_i > 0$ without short sales constraints, where

θ = the ex-ante Sharpe ratio,

x_i = the fraction of the portfolio invested in the i^{th} index,

$\bar{R}_i$ = the expected return on the i^{th} index,

$\bar{R}_P$ = the expected return on the portfolio,

R_f = the risk-free rate

σ_{ij} = the covariance of returns between the i^{th} and j^{th} index,

σ_P = the standard deviation of returns on the portfolio.

A difference in the Sharpe ratios of the benchmark and extended set of assets implies that there is an improvement in the risk-return trade-off from investing in the additional set of N risky assets.

To test the significance of any changes in the maximum Sharpe ratio, I employ the procedure of Ledoit and Wolf (2008). This method of examining statistical differences between maximum Sharpe ratios has yet to be applied in studies of industrial and international portfolio diversification and represents a novel contribution of this thesis. In fact, the majority of papers do not employ tests of the stastistical significance of any changes in the Sharpe ratio. The approach of Jobson and Korkie (1981) and Memmel (2003) is used in the surrounding literature, but this relies on an assumption of normality and no serial correlation. The test proposed by Ledoit and Wolf (2008) allows me to relax these assumptions using a bootstrapping technique. In essence, they propose constructing a studentised time series bootstrap confidence interval for differences in the maximum Sharpe ratios. The two ratios are different if 0 is not contained within that confidence interval[7].

3.8 Break-Point Selection

I use two primary methods of detecting break-dates in the data. The purpose of this, is to establish appropriate sub-periods that enable me to examine each of my central research questions in different market states and in response to different major events in world equity markets. The first of these tests is the Bai-Perron procedure which uses return data to detect breaks in the mean of the dynamic conditional correlation coefficient for pairs of markets. The second, is the Gregory-Hansen test, which uses price data to detect breaks in the cointegration vector between pairs of markets. It is reasonably common in the literature to determine break-points exogenously when conducting sub-period

[7] See Ledoit and Wolf (2008) for a more detailed discussion of their technique and of the limitations of the method by Jobson and Korkie (1981) and Memmel (2003).

analyses, with a visual inspection of the plotted returns, for example. This is a perfectly acceptable approach, as the timing of the global crisis, and other major events in world equity markets, has been extensively studied and discussion in the literature and the media alike. My use of econometric techniques to endogenously determine break-dates, while not extraneous, is also not the crux of my analysis. However, it is appropriate given my use of weekly data, as it ensures that I do not select some arbitrary week to represent the beginning of the crisis period. Ultimately, across both procedures, I find break-dates that reflect those we might expect to find based on common knowledge of the etiology of the global crisis, and the introduction of the euro, for example. Break-dates from both of these tests are combined and collated, alongside more general knowledge about the timing of different major events, to inform my choice of sub-periods.

There is a great diversity of break dates between the Bai-Perron and Gregory-Hansen procedures, but this is largely unsurprising. They are different statistical tests applied to different data series. Of course, using break-dates determined in a correlation-based test for a sub-period cointegration analysis is inexact. However, I employ each test as a complementary measure to examine both breaks in correlation and breaks in cointegration, among the studied groups. There are several overlapping break-points, and also a series of points unique to each test. When choosing likely crisis periods, I draw upon the results from both tests alongside more general knowledge about the etioloy of the crisis to select appropriate crisis dates for sub-period inspection.

Several tests exist for the identification of multiple regimes in a time series. However, there is little consensus in the literature on the best approach to determining break-points. The Chow test (Chow, 1960) is popular alongside the Andrews-Quandt test (Quandt, 1960; Andrews, 1993; Andrews and Ploberger, 1996) but both require prior knowledge

regarding the timing of suspected breaks and the former allows for the determination of a single break-point only. The Gregory-Hansen test (Gregory and Hansen, 1996) reports a single endogenously determined break-point in the event that there has been a regime shift in a cointegration relation. To identify the existence of multiple regimes with the endogenous determination of break-points, I use the procedure proposed by Bai and Perron (1998).

The Bai-Perron procedure involves a sequential test of $L+1$ versus L structural breaks. For a model with l breaks, the estimated break points, denoted $\hat{T}_i,\ldots \hat{T}_l$ are obtained by a global minimization of the sum of squared residuals. Bai and Perron (1998) propose testing each $(l + 1)$ segment, obtained from the estimated petition $\hat{T}_i,\ldots \hat{T}_l$ for the presence of an additional break. The test involves the application of $(l + 1)$ tests of the null hypothesis of no structural change versus an alternative hypothesis of a single structural change. The test is applied to each segment containing the observations $\hat{T}_{i-1} + 1$ to $\hat{T}_i$ $(i = 1, \ldots, l + 1)$ using the convention that $\hat{T}_0 = 0$ and $\hat{T}_{i+1} = T$. If the overall minimal value of the sum of squared residuals is sufficiently smaller than the sum of squared residuals from the l break model, I reject in favor of a model with $(l + 1)$ breaks. The selected break date is the one associated with this overall minimum. The test is defined as follows:

$$F_T(l+1|l) = \{S_T(\hat{T}_1,\ldots,\hat{T}_l) - min_{1\le i\le l+1}\ inf_{\tau\epsilon\Lambda i,\varepsilon}\ S_T(\hat{T}_1,\ldots,\hat{T}_{i-1},\tau,\hat{T}_i,\ldots\hat{T}_l)\} / \hat{\sigma}^2, \quad (3.44)$$

where

$$\hat{\Lambda}_{i,\eta} = \{\tau; \hat{T}_{i-1} + (\hat{T}_1 - \hat{T}_{i-1})\eta \le \tau \le \hat{T}_i - (\hat{T}_1 - \hat{T}_{i-1})\eta\}, \quad (3.45)$$

where $S_T(\hat{T}_1,\ldots,\hat{T}_{i-1},\tau,\hat{T}_i,\ldots\hat{T}_l)$ is the sum of squared residuals resulting from the least-squares estimation from each m-partition $(T_1,\ldots,T_m)$, and $\hat{\sigma}^2$ is a consistent estimate of σ^2

under the null hypothesis. For $i = 1$, $S_T(\hat{T}_1,\ldots,\hat{T}_{i-1},\tau,\hat{T}_i,\ldots\hat{T}_l)$ is understood as $S_T(\tau,\hat{T}_1,\ldots,\hat{T}_l)$ and for $i = l + 1$ as $S_T(\hat{T}_1,\ldots,\hat{T}_l,\tau)$.

The Bai-Perron test is first applied to each individual series to test for multiple breaks in the mean return of each market. Following this, I use the Bai-Perron procedure to test for the existence of multiple breaks in the mean of the dynamic conditional correlation coefficient. Any break-dates reported by the Bai-Perron procedure indicate the beginning of a new regime, and a shift in the mean of the dynamic conditional correlation series analysed. This approach to determining break-dates and crisis periods is a novel contribution of this thesis and has not been done elsewhere.

I use reported break-dates to form multiple regimes across which I conduct a sub-period cointegration analysis to identify the implications of the global crisis for equity market linkages. I further superimpose these estimated break-dates onto the graphical representation of my recursive analysis. In this way, the Bai-Perron multiple break-point test is particularly suited to a large sample, such as the one used in this thesis, that encompasses so many potentially break-inducing shocks.

3.8.1 Bai-Perron Breakpoint Results

I examine the data for break-points in two ways. Firstly, I apply the Bai-Perron break-point procedure to test for a break in the mean of each return series for the forty-six studied markets. However, I do not find evidence of a structural break using this approach. Next, I examine the dynamic conditional correlation series between each pair of markets, using the method of Engle (2002), detailed previously. I restrict my analysis to a sub-set of these results, for ease of exposition. I focus on all pairings of the US and the developed G7 group, and all pairings of the US and the emerging BRICS. The plots of these DCC series is presented and discussed in Section 4 of Chapter 4. I apply the Bai-

Perron procedure to these estimated DCC series and find a number of interesting break-dates. These results are shown in Table 3.10.

I find the break-date of November 28th 1997 in the case of France. This date closely follows a global stock market crash in response to the Asian crisis, and also marks the exact date on which South Korean debt was downgraded from A1 to A3 by Moody's. I further find a break with France on March 1st 2002. I also find breaks on December 12th 1997 and January 13th 2006 in the case of the UK. I find a break-date on February 23rd 2001 for Germany, and another, one week later, on March 2nd 2001 in the case of Italy. This follows the crash of the Dot-Com bubble, and also marks the date at which the NBER reports the US economy reaches peak activity before entering into recession. I further establish a break-date with Japan on September 26th 2003. Finally, a break is found with Canada on the 10th of October 2008. In general, the month of October was an exceptionally busy time in the etiology of the financial crisis. October 10th 2008 saw large losses in European and Asian markets, while the Dow reached a five-year low the previous day.

For the emerging BRICS, several break-dates are reported in the mid-2000s. Furthermore, these reported break-dates differ substantially to those found when examining the developed G7 markets. Nonetheless, a common break-date of October 10th 2008 is found for Canada and Russia. These break-dates are used to identify different regimes for sub-period analysis throughout Chapters 4, 5, and 6 of the thesis.

Table 3.10. Bai-Perron Breakpoint test results

Country	Breakpoints		
Canada			10-Oct-08
France	28-Nov-97	01-Mar-02	
Germany		23-Feb-01	
Italy		02-Mar-01	
Japan		26-Sep-03	
UK	12-Dec-97	13–Jan-06	03-Oct-08
Brazil		19-Mar-04	
Russia			10-Oct-08
India		26-Dec-03	
China	16-Jan-98	09-Apr-04	
South Africa		07-Oct-05	

Notes. This table contains the results for the Bai-Perron breakpoint analysis of a break in the mean of the DCC coefficients between the US and each other G7 and BRICS market. The Bai-Perron test is a sequential test of $L+1$ versus L structural breaks. Each reported break-date refers to the start of a new regime. All reported break-dates are statistically significant at the 5 per cent level.

3.9 A Note on Cointegration and Correlation

A fundamental part of my analysis involves the measurement of integration among equity markets. I select two key way of doing this: correlation and cointegration. I preface the next section with a short primer distinguishing between these two very different methods. This further allows me to justify the use of each method in the context of the wider thesis and facilitates the interpretation of my results later in the document.

It is important to note the distinct differences between correlation and cointegration. Measures of correlation guide our understanding of how the returns on a pair of stocks move together in the short-term. If the returns between two stocks are substantially correlated, we would expect that these stocks rise and fall together intertemporally. However, correlation falls short of providing us with the bigger picture. Cointegration allows us to examine mean reversion in the differences between asset prices. These assets may be correlated in their returns, implying regular short-term comovements, however, such short-term comovements may not be present, yet the extent to which the asset prices diverge will revert to some constant value in the long term. The pair is cointegrated if they share that common stochastic drift, that is, individually, they are non-stationary but their linear combination will be stationary.

I examine correlations to assess how markets move in relation to one another in the short-term. I then examine cointegration to examine if there is evidence of a common stochastic drift among pairs or sets of markets. For correlation, I use the DCC method and Pearson's correlation coefficient. For cointegration, I use Johansen-Juselius and Gregory-Hansen tests. While we can observe impacts in the short term with correlation, cointegration is more suited to establish longer term changes in the underlying nature of the relationship.

3.10 Conclusion

In this chapter, I introduce my research paradigm. I also discuss the data used throughout the thesis, and conduct some preliminary statistical analysis. I then give an in-depth discussion of the various methods employed throughout. My approach to analysing equity market linkages in Chapter 4 using the Johansen-Juselius and Gregory-Hansen cointegration tests is described in detail. I also present and discuss the factor model used in my examination of industry and country effects in Chapter 5. I outline the various spanning tests employed in my analysis of the mean-variance efficiency of industry- and country-focused portfolios in Chapter 6. Finally, I discuss and present the results of my method for determining the end-points of different sub-periods to facilitate sub-period analyses in Chapters 4, 5, and 6.

Chapter 4 Characterising International Equity Market Linkages: Evidence from the Global Crisis

4.1 Introduction

The extent of global equity market integration in a post-crisis world is an important consideration for investors and academics alike. While market integration has received substantial attention in the extant literature, until now, relatively little has been done to characterise world equity market linkages beyond the global financial crisis. The discourse surrounding market integration in the associated literature occurs within the context of international portfolio diversification. Modern portfolio theory informs us that a low return correlation between national stock markets should motivate diversification strategy (Markowitz, 1952; Grubel 1968). It stands to reason that diversification benefits are greatest when markets are not positively correlated; if markets respond symmetrically to shocks, diversification benefits may not exist when they are needed most (Forbes and Rigobon, 2002; Krause and Kutner, 2006; Lucey and Voronkova, 2006). Indeed, time-variation in equity market linkages has been widely reported in the literature (Bekaert and Harvey, 1997; Aggarwal et al., 2004; Lucey and Voronkova, 2008). The trend toward trade and capital market liberalisation, as well as monetary policy coordination, has led to an increasingly globalised and interdependent world (Goetzmann et al., 2005; Coelho et al., 2007; Quinn and Voth, 2008), with equity market integration posing a direct challenge to the international diversification of portfolios.

The global nature of the recent crisis mandates an analysis across a complete set of developed and emerging markets that assesses, in explicit detail, the ramifications of the crisis for global linkages. If times of crisis are found to impact on the relationship between stock markets, then there are implications for the benefits of international portfolio diversification. I use a sample of forty-five developed and emerging equity

price indices beginning on December 30th 1994 and ending on December 27th 2013. The rationale for analysing developed and emerging markets separately can be understood from a closer inspection of the criteria used in classifying equity markets. The set of emerging markets represents a set of inherently riskier investment opportunities, given heightened levels of financial market volatility, economic uncertainty, and political instability, compared to the relatively more stable set of developed markets. Bekaert and Harvey (2014) provide further justification for the separate analysis of emerging and developed market samples. They identify that emerging markets are not fully integrated into world capital markets, and should continue to be treated as a separate asset class.

While many previous studies focus on the Asia-Pacific region (Foo et al, 2008; In et al, 2009; Royfaizal et al, 2009), the G7 group (Barari et al, 2005; Morelli, 2009; Baumohl, 2013), or on the set of European markets (Lucey and Voronkova, 2008; Buttner, 2009; Bekaert, 2012; Guidi and Ugur, 2014), this study is not specific to one region, and includes an almost exhaustive list of developed and emerging markets, facilitating a multi-region analysis. To my knowledge, no previous studies exist that characterise equity market linkages using evidence from the global crisis. This represents the first important contribution of this chapter. Furthermore, as noted previously, a substantial number of previous studies focus on specific regions or groups. My global sample facilitates a comparative analysis across a multitude of different groups and regions that are of interest to the international investor. This is the second important contribution of this chapter. To summarise, no previous studies exist that examine equity market linkages across such a wide range of different market groupings, and that also draws upon evidence from the recent crisis.

I analyse long-term relationships using the Johansen-Juselius multivariate cointegration test (Johansen and Juselius; 1990). This test is detailed in Section 5.1 of Chapter 3. I

examine each group of markets, the constituents of which are detailed in Table 3.2 and Table 3.3, across the full sample period and across different sub-periods. I also employ the recursive cointegration method of Hansen and Johansen (1992, 1998). This combination of a sub-period and recursive analysis allows me to identify how market linkages have changed over time in response to different market conditions.

I follow this with an analysis of the G7 and BRICS groups using the Gregory-Hansen test (Gregory and Hansen, 1996), as outlined in Section 3.5.2 of Chapter 3. This regime-switching approach allows for the possibility that there has been a shift in the long-run relationship between markets at an endogenously determined structural break-date. Conditional correlations are analysed for the G7 and BRICS groups in a dynamic framework using the DCC-GARCH method of Engle (2002) outlined in Section 3.5.3 of Chapter 3. I focus this part of my analysis on these two groups for several reasons. Gregory and Hansen (1996) provide critical values for up to four independent variables. Furthermore, an analysis involving all pairs of markets in the sample would produce an unwieldy amount of results. As will be shown and discussed in Section 4.2, I also find ample evidence of cointegration among Western European markets using the standard Johansen-Juselius test, so it is clear that these groups have not suffered from the shortcomings associated with tests of cointegration in the presence of a regime shift. However, I find only a single cointegrating relation in each of the G7, PIIS, and Asia-Pacific groups. The G7 countries are also regionally diverse, representative of developed markets, and commonly used in the literature. For relevant examples, see previous studies of the G7 by Leachman and Francis (1995), De Santis and Gerard (1997), Barari et al. (2008) and Menezes et al. (2012). These papers are discussed in greater detail in Chapter 2. The BRICS are analogous to the developed G7 group in terms of their size and influence over the rest of the emerging markets set, and also in terms of the interest and attention they have received in the surrounding literature. For a recent example see

Zhong et al. (2014). Furthermore, among the emerging market groups studied using the Johansen-Juselius test, the BRICS are among those with the weakest evidence of market integration, and could therefore be adversely affected by the assumption of temporal stability in the cointegration vector. Furthermore, the BRICS are regionally diverse and represent much of what is interesting about emerging markets to an international investor.

I find that long-term relationships are time-varying, and are largely unstable throughout the sample period across both developed and emerging markets. A sub-period analysis reveals that integration is greatest for European markets following the introduction of the Euro and prior to the onset of the global crisis between March 2000 and September 2008. The sub-period characterising the crisis and its aftermath, is marked by strong and stable market linkages among European markets. However, the markets of the Asia-Pacific region are more closely integrated in a post-crisis sample from September 2008 to December 2013, with linkages that are noticeably more volatile and rising. A recursive study reveals evidence of market integration throughout the sample period, with integration levels stabilising beyond the global crisis. Developed markets are generally more integrated. Emerging markets integrate later than developed markets, but do appear to converge. In terms of dynamic conditional correlations, I find that linkages are strongest in the period encompassing the global crisis. Furthermore, conditional correlations rise consistently across each of the sub-periods for both developed and emerging markets.

The remainder of this chapter is structured as follows. In Section 4.2 I present the results of the Johansen-Juselius cointegration analysis. The Gregory-Hansen test results are discussed in Section 4.3, while I present the results of the DCC analysis in Section 4.4. Finally, Section 4.5 concludes.

4.2 Johansen-Juselius Cointegration Analysis

The following analysis uses the Johansen-Juselius cointegration test described in Section 3.5.1 of Chapter 3. The trace and maximum eigenvalue statistics used in this analysis are detailed in equations 3.9 and 3.10.

4.2.1 Static Full-Period Analysis

I present the results of the Johansen-Juselius cointegration test for the full period for each of the developed market groups in Table 4.1. While the same pattern emerges across the results of both the trace statistic and the maximum eigenvalue statistic, the trace statistic offers a more conservative interpretation of the level of cointegration within the studied groups. With this, I focus my analysis on the trace statistic. I reject the null hypothesis that there are at most two cointegration relations between the markets of Western Europe. I further reject the null hypothesis of no cointegration for Asia-Pacific, the PIIS, and the G7 markets. However, no cointegration is found among the markets of the G7 group once the European members of the G7 have been excluded. This implies that the cointegration established between the complete G7 set, is driven by linkages among the European G7 members. This analysis establishes the integration of developed markets across the period from December 30th 1995 to December 27th 2013, particularly among European markets.

Table 4.1. Johansen-Juselius multivariate test results: developed markets

H_0	Western Europe	Developed APEC	PIIS	G7	G7 – Ex. Europe
			Trace Statistic		
r = 0	709.35***	217.04***	48.94**	326.79***	40.18
r ≤ 1	343.56***	31.54	4.65	87.98	6.14
r ≤ 2	227.16***	13.84	0.56	41.38	0.97
r ≤ 3	139.67	4.79	0.00	10.62	0.01
r ≤ 4	85.051	1.45		3.89	
r ≤ 5	42.55	0.22		0.20	
			Maximum Eigenvalue Statistic		
r = 0	365.79***	185.50***	44.30***	238.81***	34.05***
r = 1	116.40***	17.70	4.09	46.61***	5.16
r = 2	87.49***	9.05	0.56	30.76	0.97
r = 3	54.62**	3.33	0.00	6.73	0.01
r = 4	42.50*	1.23		3.69	
r = 5	35.98	0.22		0.20	

Notes. This table contains the test statistics for the Johansen-Juselius (1990) multivariate cointegration test for each group of developed markets. The markets present in each group are detailed in Table 3.2 of Chapter 3. The trace statistic tests the null hypothesis of τ cointegrating relations versus the alternative hypothesis of k cointegrating relations, with k = the number of endogenous variables, for $\tau = 1, 2,\ldots,k - 1$. The maximum eigenvalue statistic tests the null hypothesis of τ cointegrating relations versus the alternative hypothesis of $\tau + 1$ cointegrating relations. The results are based on a single lag specification, determined by the Bayesian Information Criterion (BIC). Results are for vector autoregressive (VAR) specification. ***, **, * denote statistical significance at the 1, 5 and 10% levels respectively.

Table 4.2. Johansen-Juselius multivariate cointegration test results: emerging markets

H_0	The Americas	Middle East & Africa	Asia-Pacific	Emerging Europe	APEC	BRICS	EAGLE
			Trace Statistics				
r = 0	147.51*	71.18**	300.79	79.45***	489.96	93.12*	318.80**
r ≤ 1	46.30*	25.28	156.11	24.79	290.82	29.86	154.31**
r ≤ 2	9.01	5.07	55.77	4.09	167.49	14.57	88.69
r ≤ 3	1.94	1.05	20.65	0.18	79.63	1.21	41.10
r ≤ 4	0.09	0.19	2.86	0.04	36.92	0.00	21.79
r ≤ 5			0.83		14.04		8.93
			Maximum Eigenvalue Statistic				
r = 0	101.21*	45.90***	144.68	54.66***	199.15	63.26*	164.49**
r = 1	37.29**	20.20	100.34	20.70	123.33	15.29	65.62***
r = 2	7.06	4.02	35.12	3.91	87.86*	13.37	47.59***
r = 3	1.86	0.87	17.79	0.13	42.71	1.20	19.30
r = 4	0.09	0.19	2.03	0.04	22.88	0.00	12.86
r = 5			0.76		7.33		6.74

Notes. This table contains the test statistics for the Johansen-Juselius (1990) multivariate cointegration test for each group of emerging markets. The markets present in each group are detailed in Table 3.2 of Chapter 3. The trace statistic tests the null hypothesis of τ cointegrating relations versus the alternative hypothesis of k cointegrating relations, with k = the number of endogenous variables, for $\tau = 1, 2,\ldots,k-1$. The maximum eigenvalue statistic tests the null hypothesis of τ cointegrating relations versus the alternative hypothesis of $\tau + 1$ cointegrating relations. The results are based on a single lag specification, determined by the Bayesian Information Criterion (BIC). Results are for vector autoregressive (VAR) specification. ***, **, * denote statistical significance at the 1, 5 and 10% respectively.

As with the analysis of developed markets, the trace statistics and the maximum eigenvalue statistics do not differ substantially, and so I elect to focus the discussion on the trace statistics. There is evidence of market integration in every group; I reject the null hypothesis of no cointegration across the seven studied groups.

The strongest evidence of market integration is found within the Americas, the Asia-Pacific, the Emerging APEC group, and the EAGLE group. The degree of integration established among the members of the EAGLE group is likely influenced by the BRICS, which are a sub-set of the EAGLEs, given the evidence of a single cointegration relationship among the BRICS alone. I further find evidence of a single cointegration relationship among the Emerging European markets, and among the markets of the Middle East and Africa.

The markets of emerging Asia are more integrated than those of developed Asia. The G7 and BRICS groups are similarly integrated, while the developed markets of Western Europe are considerably more integrated than the Emerging European markets of the South and East. The most integrated group is Western Europe, while the G7 group excluding Europe is the least integrated. This has implications for the international diversification of a portfolio of equities across these markets - linkages between equity markets are a threat to the benefits of international portfolio diversification. The results indicate that there is greater potential for diversification across the markets of emerging Europe versus the developed European markets. However, the reverse is true for Asian markets. There is greater potential for international diversification benefits across developed Asia compared to emerging Asia.

4.2.2 Sub-Period Analysis

I proceed with a sub-period analysis, and replicate the Johansen-Juselius test within each of the regimes identified in Section 3.8.1 of Chapter 3. The results for the developed market sample can be seen in Table 4.3. I observe substantial time variation in the level of market integration across each group. The markets of Western Europe and the G7 are the most integrated in the third regime. However, further study reveals that this integration among the G7 group is largely driven by European linkages. When I conduct additional testing on the G7 group, by removing the continental European markets of France, Germany and Italy, I establish significantly less integration among the remaining G7 markets. This further suggests that integration is limited to the core markets of Western Europe. The message is clear; market integration is strongest in Europe in this third sub-period between March 2nd 2001 and September 26th 2008. The presence of many long-run relationships between the markets of Western Europe during this time is unsurprising. This period encompasses a post-euro world with the currency being introduced in January 1999 before physical circulation in 2002. It is also characterised by a trend toward heightened levels of trade and financial liberalisation, and is positioned between the bursting of the dot-com bubble in March 2000 and the onset of the global financial crisis in September 2008.

The level of integration for Western Europe and the G7 drops significantly when moving from the third regime into the fourth regime – that which is characterised by the global financial crisis. There is evidence of only a single cointegrating relation for Western Europe in this final regime. In contrast, the Asia-Pacific region sees a growth in the number of cointegrating relations in the fourth regime, relative to all previous regimes. I perform additional testing on a sub-set of Asian-only markets: Hong Kong, Japan, and Singapore. In doing so, I find evidence of cointegration in the final regime only. Again, this supports the idea that the markets of the Asia-Pacific region are most integrated in

the final regime, between October 3rd 2008 and December 27th 2013. For the remainder of the groups, modest integration is observed throughout. The G7 excluding Europe maintains a single cointegrating relation in every regime, and the PIIS remains at a single cointegrating relation in all but the second regime. I find that markets are most segmented between November 28th 1997 and February 23rd 2001. This implies that despite the relative instability associated with an Asian and Russian crisis, the introduction of the euro, as well as the crashing of the dot-com bubble, developed equity markets remained relatively segmented from geographical and economic peers during this time. However, the Asia-Pacific group maintains only a single cointegration relation, suggesting that this period can be characterised by the heightened integration of European markets only.

The results for the final regime suggest that the global financial crisis cannot be associated with a deepening of market integration among developed European markets, or indeed the PIIS. In fact, these groupings, alongside the G7, actually move away from integration and toward greater segmentation in the final regime between October 3rd 2008 and December 27th 2013. This analysis shows that there are different patterns of integration among developed markets across different regions of the world. European markets are most integrated when the markets of the Asia-Pacific are not, and vice versa. The above analysis suggests that the global crisis can be associated with a move away from market integration in Europe, but with a strengthening of linkages in the Asia-Pacific.

Table 4.3 Sub-period Cointegration Results for the Developed Market Sample

H_0	Western Europe	Asia-Pacific	PIIS	G7	G7 – No Europe	Asia
Regime 1: 06/01/95 – 21/11/97						
r = 0	348.68***	114.80	72.86***	174.12***	57.26***	5.71
r ≤ 1	249.89***	47.52	4.61	63.64	15.30	1.06
r ≤ 2	158.52	27.75	0.44	30.42	0.41	0.27
r ≤ 3	78.61	11.11	0.01	9.13	0.03	
r ≤ 4	37.14	4.10		0.82		
r ≤ 5	14.13	0.42		0.17		
Regime 2: 28/11/97 – 23/02/01						
r = 0	310.61***	241.31***	31.77	157.65***	54.46***	20.10
r ≤ 1	219.20	61.21	13.40	77.72	11.91	4.93
r ≤ 2	147.24	28.91	1.56	22.19	1.36	0.04
r ≤ 3	84.41	10.15	0.10	8.56	0.16	
r ≤ 4	42.54	5.01		2.58		
r ≤ 5	8.92	0.68		0.50		
Regime 3: 02/03/01 – 26/09/08						
r = 0	2162.22***	176.39***	166.15***	1161.49***	99.89***	19.23
r ≤ 1	1480.14***	75.69	15.86	540.24***	14.29	6.50
r ≤ 2	970.95***	15.17	5.43	213.68***	1.22	0.00
r ≤ 3	573.36***	8.73	0.01	47.97**	0.16	
r ≤ 4	257.42***	3.96		13.72		
r ≤ 5	64.02	0.16		0.90		
Regime 4: 03/10/08 – 27/12/13						
r = 0	448.11***	345.01***	60.70***	249.18***	84.99***	36.95***
r ≤ 1	196.04	202.55***	9.00	108.75***	15.75	0.54
r ≤ 2	120.17	94.07***	0.38	26.79	5.88	0.01
r ≤ 3	55.02	26.84	0.01	8.05	0.01	
r ≤ 4	26.57	4.01		1.18		
r ≤ 5	9.01	0.92		0.06		

Notes. This table contains the test statistics for the sub-period Johansen-Juselius (1990) multivariate cointegration test for each group of developed markets. The markets present in each group are detailed in Table 3.2 of Chapter 3. Sub-periods are determined as outlined in Section 3.8 of Chapter 3. The trace statistic tests the null hypothesis of τ cointegrating relations versus the alternative hypothesis of k cointegrating relations, with k = the number of endogenous variables, for τ = 1, 2,...,k – 1. The maximum eigenvalue statistic tests the null hypothesis of τ cointegrating relations versus the alternative hypothesis of τ + 1 cointegrating relations. The results are based on a single lag specification, determined by the Bayesian Information Criterion (BIC). Results are for vector autoregressive (VAR) specification. ***, **, * denote statistical significance at the 1, 5 and 10% level respectively.

I use the break-dates reported in Table 3.10 of Chapter 3 to establish different regimes within which to analyse cointegration among the emerging market groups. The results are presented in Table 4.4. As with the developed market sample, I observe evidence of time variation in market integration across the sample. At a glance, this sub-period analysis reveals substantially lower levels of integration among the emerging markets, compared to the developed markets. Similarly to the developed markets, the emerging markets are most integrated in regimes three and four. The differences between Europe and Asia persist among emerging markets and are not limited to the developed markets of these regions. In moving from the third to the fourth regime, the emerging Asian-Pacific markets move toward greater integration, while the Emerging European markets move away from integration towards segmentation. Integration has been steadily increasing among the Emerging APEC and EAGLE groups across the four regimes. There is modest evidence of market integration among the BRICS, with a single cointegration relation found in the third and fourth regimes.

As with the developed markets, the global financial crisis can be associated with a move toward greater integration for some regional and economic groupings (EAGLE, APEC, Asia-Pacific) and a move toward market segmentation for others (Middle East and Africa, Emerging Europe), while there is no change for others (BRICS). Overall, market integration among the emerging markets appears to be strengthening over time, but they remain less integrated compared to the developed markets. The levels of market integration present in the third and fourth regimes indicate that there are potential limitations to the benefits of diversifying a portfolio of equities across the studied groups studied between April 9th 2004 and December 27th 2013. This is also observed in the developed market sample.

Table 4.4 Sub-period Cointegration Results for the Emerging Market Sample

H_0	The Americas	Middle East & Africa	Asia-Pacific	Emerging Europe	Emerging APEC	BRICS	EAGLE
			Regime 1: 06/01/95 – 09/01/98				
r = 0	77.77***	25.69	36.66	56.79***	67.77	27.32	57.96
r ≤ 1	8.29	0.64	17.85	12.99	32.92	12.61	23.99
r ≤ 2	3.92	0.12	6.54	1.58	17.92	3.23	11.31
r ≤ 3	0.72		1.95	0.45	9.44	0.41	6.27
r ≤ 4	0.09		1.05		5.60		3.59
r ≤ 5			0.25		2.82		1.20
			Regime 2: 16/01/98 – 26/03/04				
r = 0	83.31***	13.60	143.49	67.26	306.50***	25.87	173.33***
r ≤ 1	26.41	4.90	75.01	26.87	176.38	10.92	94.14
r ≤ 2	7.29	0.96	19.10	5.70	80.58	2.70	46.96
r ≤ 3	1.32		7.76	1.59	48.40	0.37	20.21
r ≤ 4	0.02		1.56	0.38	27.76	0.00	7.71
r ≤ 5			0.68		13.85		1.40
			Regime 3: 09/04/04 – 26/09/08				
r = 0	209.91***	104.10*	230.19***	167.81***	348.43***	102.68***	239.71***
r ≤ 1	80.73***	47.21**	105.93	51.81**	194.70	30.47	122.12*
r ≤ 2	9.55	12.88	52.67	10.49	113.09	5.03	65.09
r ≤ 3	4.23	1.17	18.78	3.93	57.35	1.83	35.50
r ≤ 4	0.10	0.12	6.74	0.05	35.10	0.07	13.52
r ≤ 5			2.06		17.32		5.50
			Regime 4: 03/10/08 – 27/12/13				
r = 0	132.11***	74.24**	263.34***	101.06***	427.52***	97.86***	292.31***
r ≤ 1	50.95**	17.03	193.08***	24.22	268.65***	42.66	135.13***
r ≤ 2	22.66	3.92	67.79	7.48	142.42	2.46	65.27
r ≤ 3	2.09	1.31	28.80	0.41	97.83	0.74	28.42
r ≤ 4	0.12	0.18	16.35	0.10	65.02	0.00	9.19
r ≤ 5			4.01		43.28		2.38

Notes. This table contains the test statistics for the sub-period Johansen-Juselius (1990) multivariate cointegration test for each group of emerging markets. The markets present in each group are detailed in Table 3.2 of Chapter 3. Sub-periods are determined as outlined in Chapter 3.8. The trace statistic tests the null hypothesis of τ cointegrating relations versus the alternative hypothesis of k cointegrating relations, with k = the number of endogenous variables, for $\tau = 1, 2, \ldots, k-1$. The maximum eigenvalue statistic tests the null hypothesis of τ cointegrating relations versus the alternative hypothesis of $\tau + 1$ cointegrating relations. The results are based on a single lag specification, determined by the Bayesian Information Criterion (BIC). Results are for vector autoregressive (VAR) specification. ***, **, * denote statistical significance at the 1, 5 and 10% level respectively.

The preceding sub-period analysis has highlighted the temporal instability of market integration, with some degree of time-variation found in among linkages within the majority of groups. To further examine time-varying market linkages, I pursue a recursive cointegration analysis using the Johansen-Juselius test. This approach allows me to identify temporal patterns in market integration, and to more explicitly track the implications of the onset of the global financial crisis for linkages among the studied groups.

4.2.3 Recursive Analyses

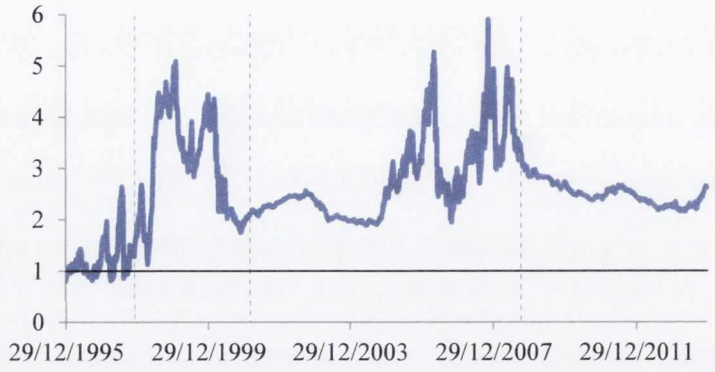
In this recursive analysis, following Hansen and Johansen (1993), the multivariate Johansen-Juselius test is applied to the groups of developed and emerging markets studied in Sections 4.2.1 and 4.2.2, over an initial window of fifty-two weeks. The window is expanded incrementally, by a single week, and the analysis is repeated. I continue in this way until I reach the end-point of the sample on December 27th 2013. The resulting time series of trace statistics, for the null hypothesis of no cointegration, are rescaled to the 90 per cent critical value and plotted. When the value of the rescaled trace statistic exceeds one, there is integration in the system, while markets are relatively segmented when the rescaled trace statistic is below one. The timing of the four regimes has been superimposed onto each graph.

Figure 4.1 shows the dynamics of market integration across the developed market groups. Several key features emerge. The instability of long-run relationships is evident in each case. There is evidence of a long-run relationship throughout most of the sample period in every group. The period encompassing the first regime is marked by low levels of market integration, with significant fluctuation around the threshold level of the rescaled trace statistic. Moving forward, there is evidence of a cointegrating relation between November 28th 1997 and December 27th 2013 for each group. There is some

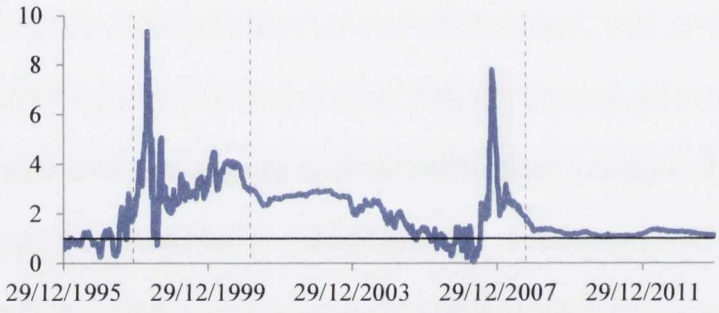
fluctuation for the PIIS, the Asia-Pacific, and the G7 excluding Europe in the third regime, but entering the final regime, that which encompasses the global crisis, there is evidence of market integration for every group. Furthermore, the rescaled trace statistic is relatively stable around the time of the final sub-period compared to sub-periods one through three.

I proceed with an analysis of each regime. For Asia-Pacific and the G7 groups, there is a move away from integration in 1996, which continues until the end of the first regime in November 1997. The second regime begins with a sharp increase in market integration across all groups. There is a particularly steep incline in the PIIS and in the G7 group excluding continental Europe. I observe a modest increase in integration in the Asia-Pacific region by comparison. Overall, there is stronger evidence of market integration across the studied groups compared to the previous regime. This suggests that there is less potential for diversification benefits by the end of the second regime, compared to the first, with an overall trend toward heightened market integration. This is unsurprising, given that this period encompasses an Asian and Russian crisis, the introduction of the Euro, and the dot-com bubble in the US technology sector. This finding has also been documented elsewhere in the literature (De Santis and Gerard, 1997; Kearney and Lucey, 2004; Goetzmann et al., 2005).

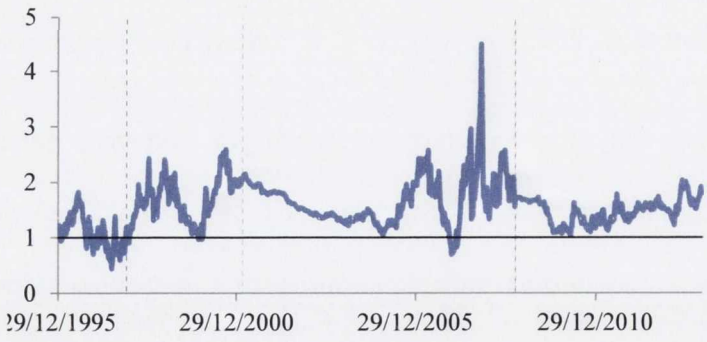
Figure 4.1 Recursive Cointegration Analysis of Developed markets



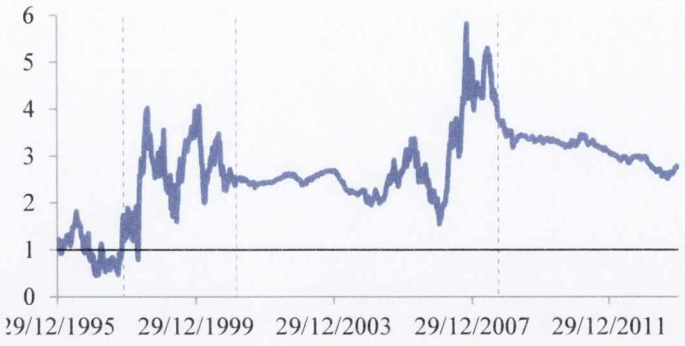
A: PIIS



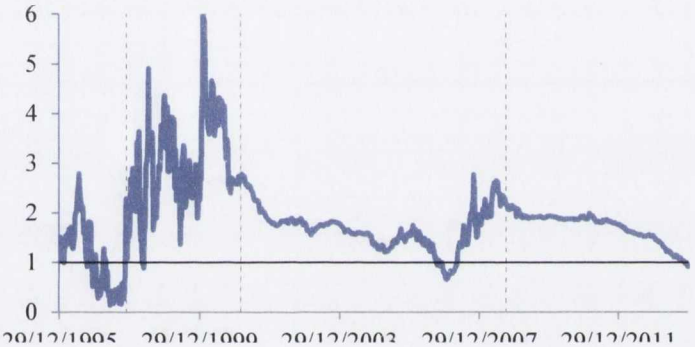
B: Western Europe



C: Developed APEC



D: G7



E: G7 – No Europe

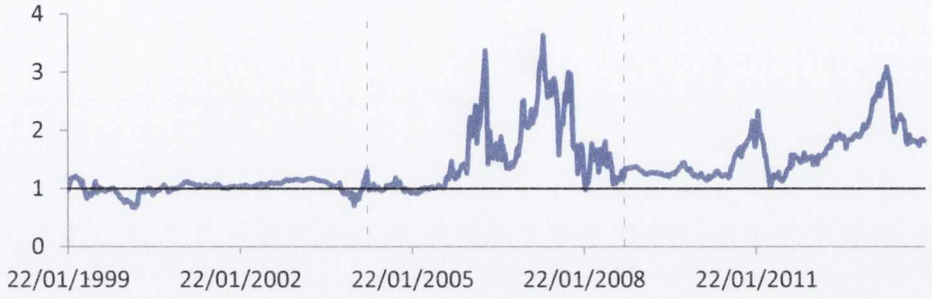
Notes. The figure above shows values of the trace statistic scaled to the 10 per cent critical value for the null hypothesis of no cointegration against the alternative hypothesis of a single cointegration relation, in a recursive framework. Values above 1 indicate the presence of a cointegration relationship, with a rising trend indicating a move toward market integration within the group.

Moving into the third regime, there is relative stability in the dynamics of integration for every group. For the first half of the regime, there is strong evidence of a stable long-run relationship, with a downward trend suggesting a move away from integration advancing into the second half of the regime. Beyond 2004, there is increased volatility in long-run relationships. The regime ends with evidence of market integration for every group, and for the G7 and Western Europe, the regime ends with stronger evidence of integration than it began. Conversely, for the PIIS and Asia-Pacific, there is weaker evidence of integration at the end of the regime, compared to the beginning.

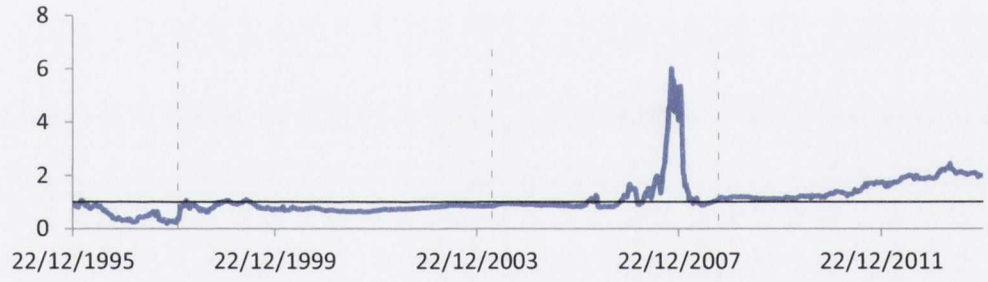
Entering the final regime, there is a return to stability in long-run relationships for all but the Asia-Pacific group. Furthermore, while the Asia-Pacific group appears to be moving toward market integration, there is a noticeable downward trend present in each other group, with the PIIS returning to levels of integration seen at the beginning of the sample. By the end of the sample, there is no long-run relationship found in the group of G7 markets excluding continental Europe. While the complete G7 group experiences a downward trend, there is still strong evidence of integration by the end of the sample, implying that this integration is driven by the markets of Germany, Italy, and France. The end of sample integration in the Asia-Pacific region is comparable to integration levels in this group at the end of the second and third regimes. There is a modest climb in integration at the end of the sample for the complete G7 group, and for Western Europe.

The results of a recursive analysis of the emerging market groups are shown in Figure 4.2. Given the lack of available data in earlier years of the sample for Russia, Egypt, the UAE and Qatar, I conduct additional analyses without these markets for every group that they are present in.

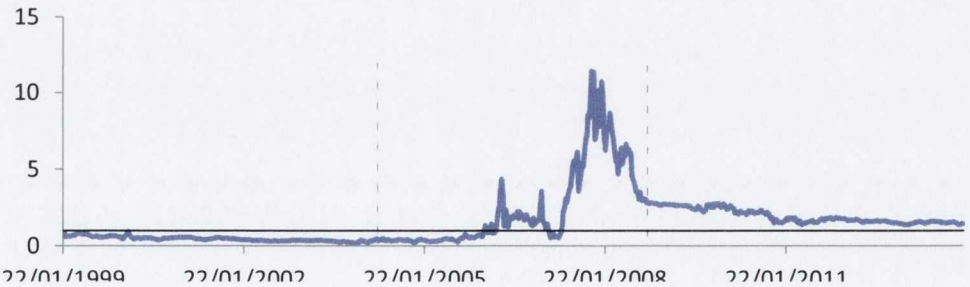
Figure 4.2 Recursive Cointegration Analysis of Emerging Markets



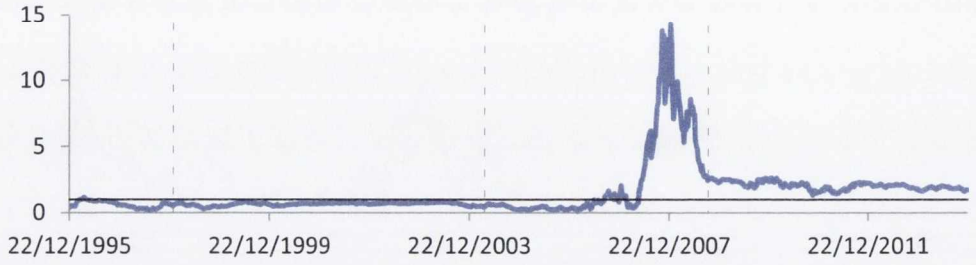
A: Emerging APEC



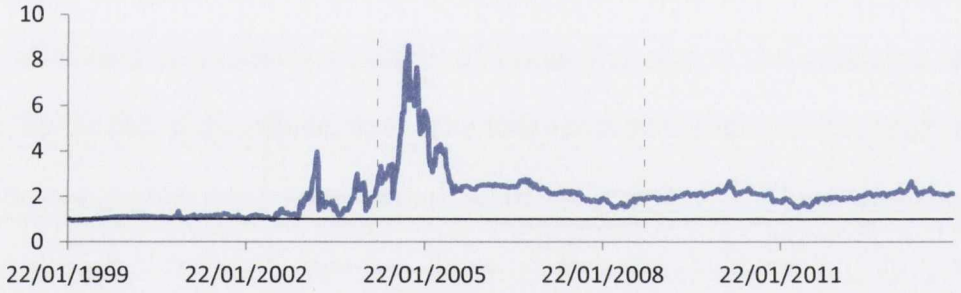
B: Asia-Pacific



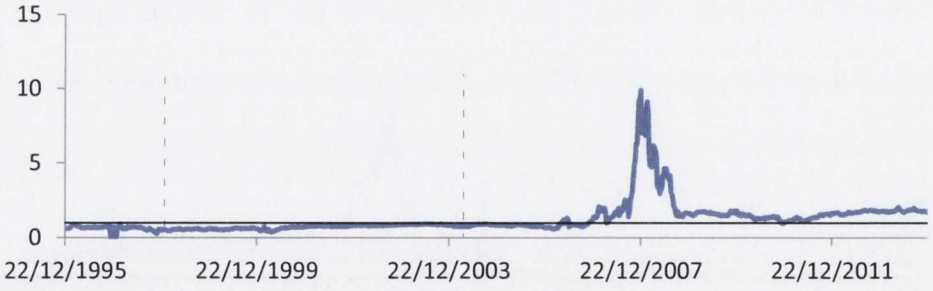
C: BRICS



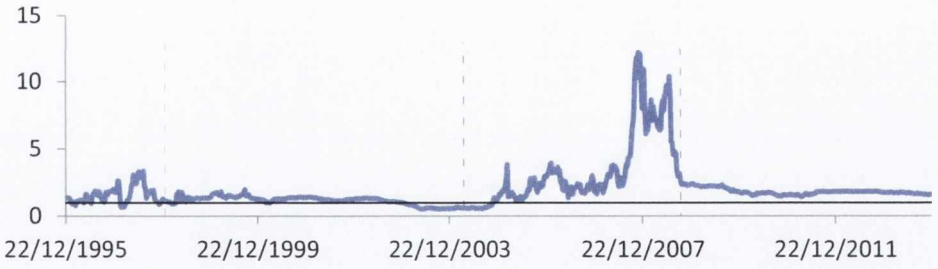
D: BRICS excluding Russia



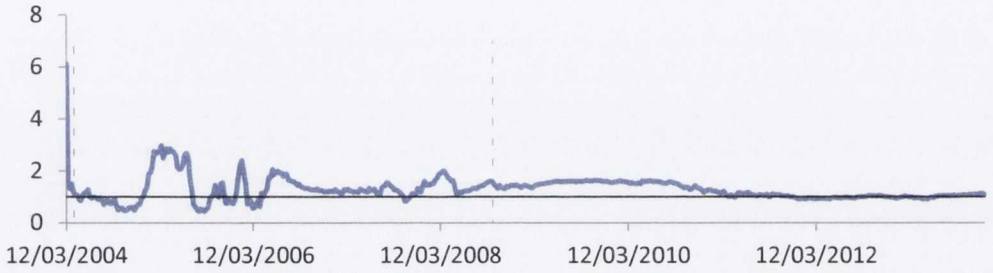
E: EAGLEs



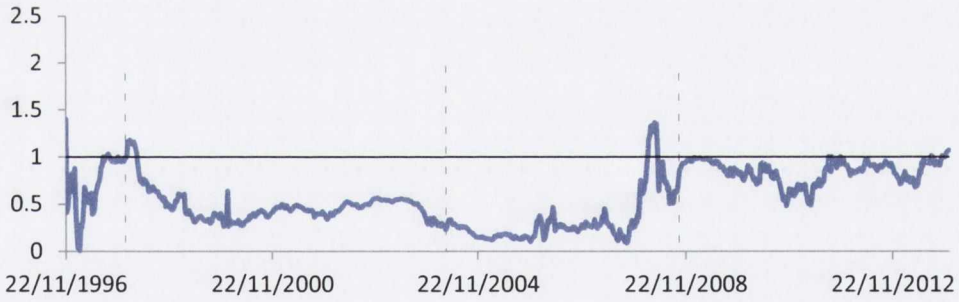
F: EAGLEs excluding Russia



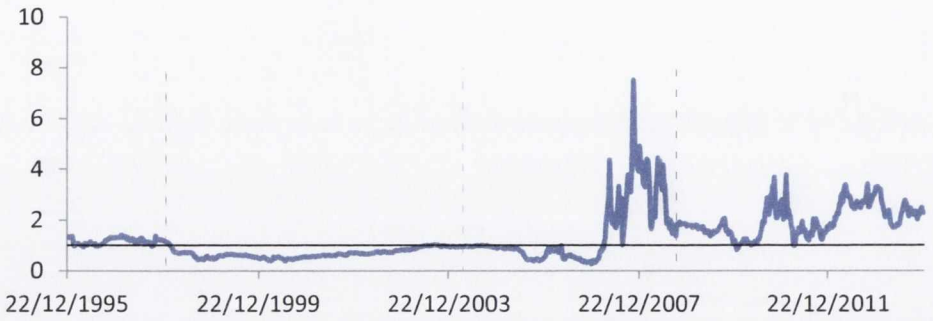
G: Emerging Europe



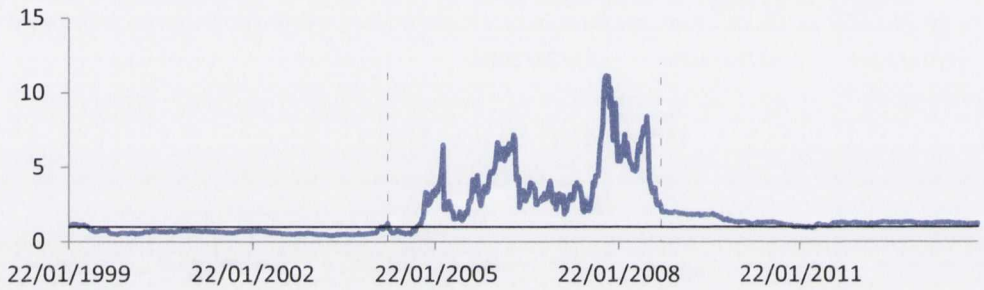
H: Middle-East and Africa



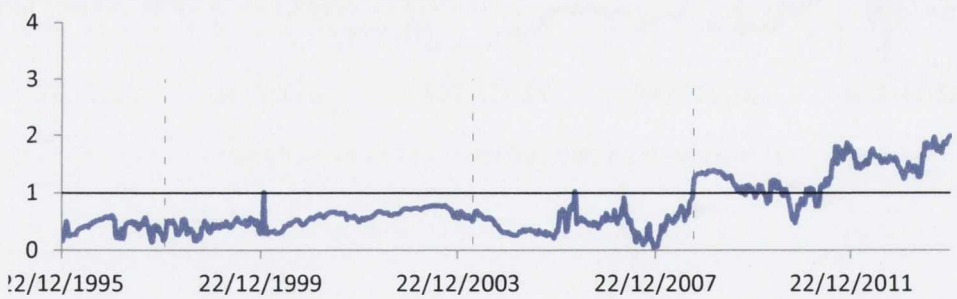
I: Middle-East and Africa without UAE/Qatar



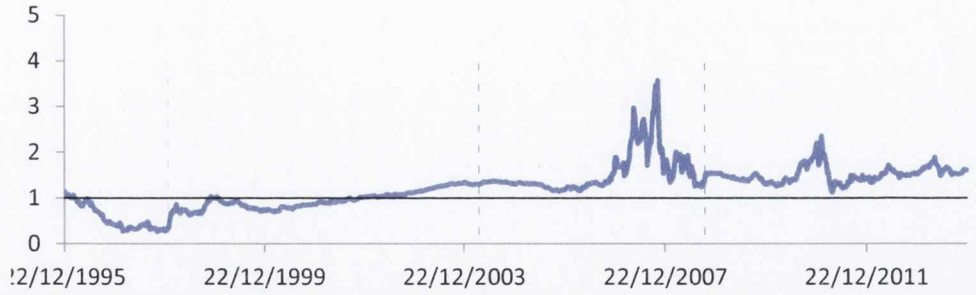
J: The Americas



K: Emerging Europe excluding Russia



L: Middle East and Africa excluding Egypt



M: Emerging APEC excluding Russia

Notes. The figure above shows values of the trace statistic scaled to the 10 per cent critical value for the null hypothesis of no cointegration against the alternative hypothesis of a single cointegration relation, in a recursive framework. Values above 1 indicate the presence of a cointegration relationship, with a rising trend indicating a move toward market integration within the group.

Overall the results immediately indicate the instability of long-run relationships among the emerging market groups. This mirrors the results of the developed market analysis. I further note the existence of a long-run relationship across all of the studied groups, beginning in sub-period three, and continuing until the end of the sample. There is strong evidence of market integration in the Emerging APEC group in sub-periods three and four, with and without the inclusion of the Russian market, with both graphs clearly indicating a trend toward heightened levels of integration over the sample period. I observe similar results for the BRICS group, with and without the Russian market, and also across the EAGLEs group, with and without the Russian market. Furthermore, the analysis of Emerging Europe also shows strong evidence of market integration beginning in the third sub-period, and continuing throughout the rest of the sample, again, with and without the Russian market. In fact, I observe this trend across each of the studied groups. Both Asia-Pacific and the Americas also show evidence of market integration beginning in the third sub-period. The results for the Middle-East and Africa are similar,

with the scaled trace statistic levelling off in the final sub-period. Towards the end of the sample, there is significant evidence of market integration among the emerging market groups.

Despite convincing levels of market integration in the latter half of the sample, the emerging market groups experience a much later surge in levels of integration, when compared to the developed markets. While the study of the developed markets showed substantial evidence of a trend toward heightened market interdependence as early as the mid-90s, the emerging markets do not catch-up until the early- to mid-00s. The implication is that an international investor could reap potentially greater benefits from a portfolio diversified over a group of emerging markets than a group of developed markets throughout the decade between the mid-90s and the mid-00s. However, with emerging markets converging to similar levels of integration by the end of the sample, such diversification benefits are unlikely to materialise in more recent times.

Many previous studies examine the integration of emerging equity markets with developed markets, typically using the Eurozone or the US as a proxy for the developed market group. Despite some conflicting results (see Ewing et al. (1999) versus Aggarwal and Kyaw (2005) on the effect of NAFTA on the integration of emerging Latin America with the US), a large body of work identifies the increasing integration of emerging markets with developed markets (Barari, 2004; Lagoarde-Segot and Lucey, 2005; Diamandis, 2009; Lucey and Muckley, 2011). This chapter finds evidence that integration levels among several groups of emerging markets are rising, with emerging market linkages undergoing a process of convergence towards the integration levels typically seen among developed market samples.

4.3. Gregory-Hansen Cointegration Analysis

The Johansen-Juselius cointegration test relies on the assumption of stability in the cointegration vector. However, given that my sample covers a nineteen year period, it is reasonable to suggest that there may have been a shift in the long-run relationship between the markets in the studied groups at some point. In the presence of this shift, it is possible that the results of the Johansen-Juselius cointegration analysis may have incorrectly indicated the absence of a long-run relationship (Gregory and Hansen, 1996). This is particularly problematic in a sample of this size, which encompasses many significant shocks to global equity markets. Among the major events of the period, are the Asian and Russian financial crises in 1997 and 1998, the dot-com bubble and September 11th terrorist attack in the US in 2000 and 2001, the adoption of the single currency in Europe at the turn of the century, and more recently, the global financial crisis. As such, it is necessary to consider that there may have been a change in the parameters of the cointegration vector at some point in the sample. Indeed, as the preceding recursive analysis shows, there is significant time-variation and instability in the value of the rescaled trace statistic for the null hypothesis of no cointegration.

I use the Gregory-Hansen test, which allows for a long-run relationship in the presence of a single structural break of unknown timing. The Gregory-Hansen test relaxes the assumption of stability in the cointegration vector, allowing for a structural break of unknown timing, which is estimated endogenously. Gregory and Hansen (1996) provide critical values for up to four independent variables, and so I conduct a bivariate analysis. I focus my analysis of developed markets on the G7 group, while my analysis of emerging markets centres on the BRICS. The analysis that follows involves the estimation of equations 3.13 to 3.15, as detailed in Section 3.5.2 of Chapter 3.

4.3.1. G7

I begin with a bivariate analysis of the G7 group. In the first specification, I test for a break in the cointegrating relation between the US and each other market in the G7 group[8]. The results are presented in Table 4.5. I fail to reject the null hypothesis of no cointegration in every pairing. I expand this bivariate analysis by examining all other pairs of G7 markets. The results are presented in Table 4.6. I fail to reject the null hypothesis in all but two of these pairings. I find evidence of cointegration between the UK and Germany, with breaks reported in the cointegration relation between April 27th 2007 and October 5th 2007. This covers a period of heightened volatility in the UK stock market and the beginning of the credit-crunch. This period saw the first run on a bank in over a century, as the British bank Northern Rock sought emergency funding from the Bank of England on September 13th 2007. There is also weak evidence of cointegration between the UK and Italy with a break-date of October 15th 2010. This bivariate analysis reveals little evidence of cointegration among the members of the G7.

To allow for the possibility that a single market is being influenced by others, I expand this bivariate Gregory-Hansen analysis to a multivariate framework. In particular, I focus on the European G7 markets (France, Germany, Italy and the UK) plus the US. The results are presented in Table 4.7. With the US as the dependent variable in the first specification, I find no evidence of cointegration. There is cointegration in the presence of a structural break in each of the four remaining specifications. Break dates vary widely across each specification.

[8] Given the sensitivity of the Gregory-Hansen procedure to the direction of causality, I examine an alternative specification in each case, with the US acting in turn as the dependent and independent variable.

Table 4.5. Bivariate Gregory-Hansen test between the US and each other G7 market

Market	Model	ADF	Break	PP Z_t	Break	PP Z_a	Break
Canada	**C**	-1.96	13-May-05	-1.72	06-May-05	-7.88	06-May-05
	C/T	-2.01	01-Mar-02	-1.80	06-May-05	-7.94	06-May-05
	C/S	-2.27	18-Aug-00	-2.15	25-Aug-00	-13.50	25-Aug-00
France	**C**	-2.41	14-Jan-11	-2.29	18-Feb-11	-11.40	18-Feb-11
	C/T	-2.91	14-Jan-11	-2.59	14-Jan-11	-13.77	14-Jan-11
	C/S	-2.56	18-Feb-11	-2.43	18-Feb-11	-12.34	18-Feb-11
Germany	**C**	-2.38	14-Jan-11	-2.17	05-Dec-97	-10.38	05-Dec-97
	C/T	-3.55	11-Nov-05	-3.29	10-Feb-06	-22.92	10-Feb-06
	C/S	-2.93	21-Nov-08	-2.67	10-Mar-00	-14.45	10-Mar-00
Italy	**C**	-3.30	14-Jan-11	-3.08	14-Jan-11	-20.15	14-Jan-11
	C/T	-3.09	14-Jan-11	-2.81	14-Jan-11	-17.67	14-Jan-11
	C/S	-3.04	18-Feb-11	-2.76	14-Jan-11	-17.74	14-Jan-11
Japan	**C**	-2.73	18-Feb-11	-2.50	02-Jan-98	-14.21	02-Jan-98
	C/T	-2.65	30-Apr-04	-2.49	09-Jan-98	-16.84	09-Jan-98
	C/S	-3.31	26-Nov-99	-2.98	17-Sep-99	-21.85	17-Sep-99
UK	**C**	-2.41	18-Feb-11	-1.95	18-Feb-11	-11.24	18-Feb-11
	C/T	-2.99	13-Aug-04	-2.68	20-Aug-04	-20.36	20-Aug-04
	C/S	-3.17	26-Jun-09	-2.78	26-Jun-09	-18.24	26-Jun-09

Notes. This table contains the results for the Gregory-Hansen cointegration analysis in the bivariate setting, with the US acting as the dependent variable in each case. The test statistics for the Augmented Dickey-Fuller (*ADF*) and Phillips-Perron (*PP* Z_t, *PP* Z_a) are presented. The null hypothesis is no cointegration, while the alternative is cointegration in the presence of a single break. C, C/T, and C/S denote a level shift, a level shift with trend, and a regime shift respectively. Dates refer to estimated break-dates, which are determined endogenously. ***, **, * denote statistical significance at the 1, 5 and 10% level respectively.

Table 4.6. Bivariate Gregory-Hansen test between the G7 excluding the US

Market	Model	ADF	Break	PP Z_t	Break	PP Z_a	Break
			Canada				
France	**C**	-3.38	25-Jul-08	-3.58	07-Aug-09	-23.45	07-Aug-09
	C/T	-3.94	05-Jun-98	-3.93	10-Apr-98	-32.77	10-Apr-98
	C/S	-3.97	03-Jul-09	-3.98	26-Jun-09	-30.52	26-Jun-09
Germany	**C**	-3.15	31-Dec-04	-3.10	26-Nov-04	-19.24	26-Nov-04
	C/T	-3.47	31-Dec-04	-3.32	03-Dec-04	-25.30	03-Dec-04
	C/S	-3.14	31-Dec-04	-3.06	03-Dec-04	-18.92	03-Dec-04
Italy	**C**	-3.30	12-Aug-05	-3.45	15-Jan-10	-21.41	15-Jan-10
	C/T	-3.97	17-Apr-98	-3.97	17-Apr-98	-31.39	17-Apr-98
	C/S	-3.88	13-Mar-09	-3.79	13-Mar-09	-29.06	13-Mar-09
Japan	**C**	-3.51	12-Aug-05	-3.53	30-Sep-05	-22.90	30-Sep-05
	C/T	-3.70	12-Aug-05	-3.33	07-Oct-05	-24.47	07-Oct-05
	C/S	-3.51	30-Sep-05	-3.52	30-Sep-05	-23.16	30-Sep-05
UK	**C**	-3.24	12-Aug-05	-3.21	30-Sep-05	-20.17	30-Sep-05
	C/T	-3.73	12-Aug-05	-3.66	30-Sep-05	-26.69	30-Sep-05
	C/S	-3.25	12-Aug-05	-3.23	30-Sep-05	-20.49	30-Sep-05
US	**C**	-3.53	12-Aug-05	-3.47	06-May-05	-24.66	06-May-05
	C/T	-3.54	12-Aug-05	-3.48	06-May-05	-24.92	06-May-05
	C/S	-3.33	12-Aug-05	-3.28	07-Oct-05	-22.29	07-Oct-05
			France				
Canada	**C**	-3.29	25-Jul-08	-3.44	05-Dec-08	-22.45	05-Dec-08
	C/T	-3.65	05-Jun-98	-3.69	05-Jun-98	-28.46	05-Jun-98
	C/S	-3.92	23-May-08	-4.12	11-Jul-08	-32.62	11-Jul-08
Germany	**C**	-1.90	11-Sep-98	-1.76	07-Jan-11	-8.28	07-Jan-11
	C/T	-3.68	07-Jul-00	-3.34	07-Jul-00	-26.84	07-Jul-00
	C/S	-2.39	08-Aug-08	-2.14	16-May-08	-10.12	16-May-08
Italy	**C**	-3.19	09-Oct-09	-3.09	09-Jan-09	-20.86	09-Jan-09
	C/T	-3.61	14-Sep-01	-3.29	21-Dec-01	-24.77	21-Dec-01
	C/S	-3.47	20-Mar-09	-3.36	20-Mar-09	-25.58	20-Mar-09
Japan	**C**	-3.11	09-Jan-98	-2.89	09-Jan-98	-17.84	09-Jan-98
	C/T	-3.78	12-Sep-08	-3.57	05-Dec-08	-25.15	05-Dec-08
	C/S	-4.29	24-Mar-00	-4.18	24-Mar-00	-32.12	24-Mar-00
UK	**C**	-3.37	24-Dec-99	-3.29	10-Mar-00	-20.80	10-Mar-00
	C/T	-3.98	12-Nov-10	-3.96	14-Jan-11	-29.20	14-Jan-11
	C/S	-3.90	24-Dec-99	-3.73	31-Dec-99	-28.42	31-Dec-99
US	**C**	-2.20	16-Jul-04	-2.12	16-Jul-04	-10.05	16-Jul-04
	C/T	-3.01	07-Jan-11	-3.00	14-Jan-11	-17.04	14-Jan-11
	C/S	-2.70	13-Feb-09	-2.46	20-Feb-09	-12.63	20-Feb-09
			Germany				
Canada	**C**	-2.70	21-Sep-01	-2.66	28-Sep-01	-15.69	28-Sep-01
	C/T	-2.64	21-Sep-01	-2.54	28-Sep-01	-15.94	28-Sep-01
	C/S	-3.06	14-Jul-00	-2.97	26-May-00	-19.99	26-May-00
France	**C**	-1.98	07jan2011	-1.93	07-Jan-11	-9.88	07-Jan-11
	C/T	-3.86	07-Jul-00	-3.59	07-Jul-00	-30.27	07-Jul-00
	C/S	-2.47	12-Oct-07	-2.17	27-Apr-07	-12.59	27-Apr-07
Italy	**C**	-2.51	06-Aug-10	-2.42	13-Aug-10	-13.93	13-Aug-10
	C/T	-3.20	01-Dec-00	-3.02	01-Dec-00	-21.88	01-Dec-00
	C/S	-2.59	11-Feb-11	-2.49	07-Jan-11	-13.91	13-Aug-10
Japan	**C**	-3.24	01-Sep-06	-3.01	12-May-06	-17.61	12-May-06
	C/T	-3.13	05-May-06	-2.90	29-Sep-06	-17.19	29-Sep-06
	C/S	-4.35	23-Feb-07	-4.08	16-Feb-07	-30.95	16-Feb-07
UK	**C**	-4.47*	27-Apr-07	-4.35*	27-Apr-07	-39.48*	27-Apr-07
	C/T	-5.27**	05-Oct-07	-5.23**	17-Aug-07	-56.37**	17-Aug-07
	C/S	-4.68	27-Apr-07	-4.58	27-Apr-07	-43.01*	27-Apr-07
US	**C**	-3.05	06-Jan-06	-2.90	02-Jun-02	-17.09	02-Jun-02
	C/T	-4.03	06-Jan-06	-3.78	10-Feb-06	-29.30	10-Feb-06
	C/S	-2.96	06-Jan-06	-2.83	02-Jun-06	-16.41	02-Jun-06
			Italy				
Canada	**C**	-3.17	13-Mar-09	-3.45	20-Mar-09	-21.00	20-Mar-09
	C/T	-3.61	17-Apr-98	-3.70	17-Apr-98	-25.87	17-Apr-98
	C/S	-4.18	23-May-08	-4.36	11-Jul-08	-35.25	11-Jul-08
France	**C**	-3.21	09-Oct-09	-3.13	20-Mar-09	-21.49	20-Mar-09
	C/T	-3.41	08-Feb-02	-3.17	21-Dec-01	-22.19	21-Dec-01
	C/S	-3.98	22-Aug-08	-3.96	29-Aug-08	-31.25	29-Aug-08

Germany	**C**	-2.41	23-Jul-10	-2.32	13-Aug-10	-12.44	13-Aug-10
	C/T	-2.65	01-Dec-00	-2.69	24-Oct-08	-15.26	24-Oct-08
	C/S	-3.57	18-Jul-08	-3.56	01-Aug-08	-24.30	01-Aug-08
Japan	**C**	-2.95	14-Nov-97	-2.66	14-Nov-97	-15.69	14-Nov-97
	C/T	-3.28	24-Oct-08	-3.31	31-Oct-08	-20.85	31-Oct-08
	C/S	-3.78	26-Nov-99	-3.69	17-Dec-99	-27.26	17-Dec-99
UK	**C**	-4.27	15-Oct-10	-4.16	14-Jan-11	-34.68	14-Jan-11
	C/T	-4.54	15-Oct-10	-4.45	11-Jun-10	-39.65	11-Jun-10
	C/S	-4.60	22-Aug-08	-4.48	22-Aug-08	-38.69	22-Aug-08
US	**C**	-2.96	14-Jan-11	-2.92	14-Jan-11	-17.97	14-Jan-11
	C/T	-3.15	14-Jan-11	-3.16	14-Jan-11	-20.20	14-Jan-11
	C/S	-3.71	22-Aug-08	-3.49	15-Aug-08	-23.88	15-Aug-08
				Japan			
Canada	**C**	-2.70	13-Apr-01	-2.54	13-Apr-01	-13.83	13-Apr-01
	C/T	-2.58	20-Apr-01	-2.42	20-Apr-01	-15.20	20-Apr-01
	C/S	-2.69	13-Apr-01	-2.53	13-Apr-01	-13.75	13-Apr-01
Germany	**C**	-2.89	16-Feb-07	-2.70	09-Jan-98	-14.58	09-Jan-98
	C/T	-2.94	16-Jan-98	-2.76	09-Jan-98	-17.39	09-Jan-98
	C/S	-3.04	22-Jan-99	-2.84	15-Jan-99	-18.38	15-Jan-99
Italy	**C**	-2.84	16-Jan-98	-2.72	14-Nov-97	-17.11	14-Nov-97
	C/T	-2.98	23-Jan-98	-2.86	14-Nov-97	-18.61	14-Nov-97
	C/S	-3.46	15-Jan-99	-3.18	08-Jan-99	-22.70	08-Jan-99
France	**C**	-3.12	23-Jan-98	-2.99	09-Jan-98	-19.28	09-Jan-98
	C/T	-3.27	14-Nov-97	-3.19	09-Jan-98	-22.70	09-Jan-98
	C/S	-3.15	22-Jan-99	-2.95	15-Jan-99	-19.92	15-Jan-99
UK	**C**	-3.07	14-Nov-97	-2.89	14-Nov-97	-18.27	14-Nov-97
	C/T	-3.12	14-Nov-97	-2.88	14-Nov-97	-18.96	14-Nov-97
	C/S	-3.57	30-Apr-99	-3.33	30-Apr-99	-25.48	30-Apr-99
US	**C**	-2.76	09-Jan-98	-2.64	09-Jan-98	-16.35	09-Jan-98
	C/T	-3.08	23-Apr-04	-2.89	13-May-05	-18.64	13-May-05
	C/S	-2.86	30-Apr-99	-2.64	30-Apr-99	-17.89	30-Apr-99
				UK			
Canada	**C**	-2.86	23-Nov-07	-2.80	16-Nov-07	-16.11	16-Nov-07
	C/T	-2.94	09-Nov-07	-2.89	28-Nov-97	-17.99	28-Nov-97
	C/S	-2.89	24-Mar-00	-2.84	25-Feb-00	-16.47	25-Feb-00
France	**C**	-3.35	17-Mar-00	-3.19	10-Mar-00	-19.80	10-Mar-00
	C/T	-3.91	12-Nov-10	-3.86	14-Jan-11	-27.39	14-Jan-11
	C/S	-3.91	19-Nov-99	-3.77	31-Dec-99	-29.32	31-Dec-99
Germany	**C**	-4.41*	27-Apr-07	-4.28	04-May-07	-36.81*	04-May-07
	C/T	-5.39**	05-Oct-07	-5.30**	28-Sep-07	-57.21**	28-Sep-07
	C/S	-4.62	13-Jul-07	-4.49	06-Jul-07	-40.11	06-Jul-07
Italy	**C**	-4.42*	15-Oct-10	-4.23	14-Jan-11	-36.09	14-Jan-11
	C/T	-4.51	15-Oct-10	-4.30	08-Oct-10	-37.57	08-Oct-10
	C/S	-4.39	20-Aug-10	-4.15	18-Jun-10	-37.32	18-Jun-10
Japan	**C**	-3.16	09-Jan-98	-2.78	14-Nov-97	-17.61	14-Nov-97
	C/T	-3.31	08-Aug-08	-3.00	14-Nov-97	-18.77	14-Nov-97
	C/S	-4.29	14-Jan-00	-4.02	10-Dec-99	-33.11	10-Dec-99
US	**C**	-2.25	18-Feb-11	-1.78	11-Feb-11	-10.00	11-Feb-11
	C/T	-3.31	13-Aug-04	-2.98	20-Aug-04	-23.22	20-Aug-04
	C/S	-2.58	26-Jun-09	-2.08	26-Jun-09	-12.37	26-Jun-09

Notes. This table contains the results for the Gregory-Hansen cointegration analysis in the bivariate setting with each of the G7 markets, excluding the US, acting as the dependent variable in each case. The test statistics for the Augmented Dickey-Fuller (*ADF*) and Phillips-Perron (*PP* Z_t, *PP* Z_a) are presented. The null hypothesis is no cointegration, while the alternative is cointegration in the presence of a single break. C, C/T, and C/S denote a level shift, a level shift with trend, and a regime shift respectively. Dates refer to estimated break-dates, which are determined endogenously. ***, **, * denote statistical significance at the 1, 5 and 10% level respectively.

Table 4.7. Multivariate Gregory-Hansen test of European G7 Markets plus the US

Market	Model	ADF	Break	PP Z_t	Break	PP Z_a	Break
			US				
France,	**C**	-4.32	23-Jul-99	-3.98	23-Jul-99	-41.53	23-Jul-99
Germany, Italy,	**C/T**	-5.52	10-Apr-98	-4.99	13-Feb-98	-58.66	13-Feb-98
UK	**C/S**	-5.53	16-Jan-04	-5.36	09-Jan-04	-72.14	09-Jan-04
			France				
Germany Italy, UK, US	**C**	-5.55*	11-Feb-00	-4.98	17-Sep-99	-54.61*	17-Sep-99
	C/T	-6.17**	14-Nov-97	-5.57	07-Nov-97	-66.28**	07-Nov-97
	C/S	-6.52**	09-Jan-04	-6.39*	09-Jan-04	-92.17***	09-Jan-04
			Germany				
France, Italy, UK, US	**C**	-5.16	11-Jun-99	-4.59	17-Sep-99	-46.14	17-Sep-99
	C/T	-6.42***	16-Nov-07	-5.98**	16-Nov-07	-75.99**	16-Nov-07
	C/S	-5.86	28-Nov-03	-5.63	24-Oct-03	-74.91*	24-Oct-03
			Italy				
France,	**C**	-5.24	14-May-10	-5.08	11-Jun-10	-50.51	11-Jun-10
Germany, UK,	**C/T**	-6.96***	14-Nov-97	-6.42***	21-Nov-97	-84.89***	21-Nov-97
US	**C/S**	-5.98	19-Sep-08	-5.81	29-Aug-08	-64.68	29-Aug-08
			UK				
France,	**C**	-5.03	11-Jun-10	-4.34	23-Jul-99	-43.89	23-Jul-99
Germany, Italy,	**C/T**	-5.84**	10-Apr-98	-5.22	13-Feb-98	-59.69	13-Feb-98
US	**C/S**	-6.12	05-Jan-01	-5.96	05-Jan-01	-85.00**	05-Jan-01

Notes. This table contains the results for the Gregory-Hansen cointegration analysis in the multivariate setting, with each of the European G7 markets, plus the US, as the dependent variable in each case. The test statistics for the Augmented Dickey-Fuller (*ADF*) and Phillips-Perron (*PP* Z_t, *PP* Z_a) are presented. The null hypothesis is no cointegration, while the alternative is cointegration in the presence of a single break. C, C/T, and C/S denote a level shift, a level shift with trend, and a regime shift respectively. Dates refer to estimated break-dates, which are determined endogenously. ***, **, * denote statistical significance at the 1, 5 and 10% level respectively.

There is a break in the cointegrating relation for Germany on November 14th and 21st 1997. There is also evidence of cointegration with a break on January 9th 2004 for France. There is weak evidence of cointegration for the UK with a break on April 10th 1998 and January 5th 2001. The diversity of breaks reflects the time span of the study. The Asian and Russian financial crises in 1997 and 1998, the dot-com bubble and September 11th attacks in 2001, and the global financial crisis in 2007/2008 are all possible explanations for the reported break-dates.

I conduct further multivariate analysis, excluding the US and focusing exclusively on the set of European G7 markets (France, Germany, Italy and the UK). The results are presented in Table 4.8. There is strong evidence of cointegration for Germany, with the same reported break-date found previously, November 16th 2007. There is weak evidence of cointegration for France with a break on July 7th 2000. Italy is cointegrated with a break-date on August 22nd 2008, while there is further evidence of cointegration for the UK, with reported break-dates on September 28th and October 19th 2007. Again, there is evidence of a break in the cointegrating relations among the European G7 group. Excluding the US, break-dates converge to the period surrounding the global financial crisis, and there is evidence that the crisis has caused a shift in the cointegration vector among the European G7 group, to a new long-run relationship.

Finally, I examine cointegration in the presence of a break among the continental European markets. I exclude the UK and replicate the previous analysis. These results are also presented in Table 4.8. In the absence of the UK and the US, the estimated break dates converge to the period surrounding the introduction of the single currency in Europe. In fact, all reported break dates take place in the year 2000. There is evidence of cointegration with a break in all three specifications, with breaks on January 14th, February 11th, March 10th, October 27th and November 24th, all in the year 2000.The

global crisis does not feature as a structural break in the cointegrating relation between France, Germany, and Italy, across any of the three specifications.

Table 4.8. Multivariate Gregory-Hansen test of European G7 Markets

Market	Model	ADF	Break	PP Z_t	Break	PP Z_a	Break
			Germany				
France, Italy, UK	**C**	-5.13*	07-Jul-00	-4.46	07-Jul-00	-45.45	07-Jul-00
	C/T	-6.44**	16-Nov-07	-6.00**	16-Nov-07	-76.37***	16-Nov-07
	C/S	-5.92*	27-Oct-00	-5.24	27-Oct-00	-60.41	27-Oct-00
			France				
Germany Italy, UK	**C**	-5.14*	07-Jul-00	-4.56	07-Jul-00	-45.83	07-Jul-00
	C/T	-5.05	11-Feb-00	-4.41	16-Nov-07	-45.00	16-Nov-07
	C/S	-5.73	07-Jul-00	-5.15	11-Feb-00	-56.73	11-Feb-00
			Italy				
France, Germany, UK	**C**	-5.05*	14-May-10	-4.94	18-Jun-10	-48.12	18-Jun-10
	C/T	-5.06	06-Aug-10	-4.77	07-May-10	-46.19	07-May-10
	C/S	-6.01**	22-Aug-08	-5.70	22-Aug-08	-64.33*	22-Aug-08
			UK				
France, Germany, Italy	**C**	-4.87	15-Oct-10	-4.67	08-Oct-10	-42.48	08-Oct-10
	C/T	-6.00**	19-Oct-07	-5.77**	28-Sep-07	-67.60**	28-Sep-07
	C/S	-5.77*	21-Aug-09	-5.42	04-Dec-09	-58.14	04-Dec-09
			Germany				
France, Italy	**C**	-4.96**	07-Jul-00	-4.34	07-Jul-00	-42.97*	07-Jul-00
	C/T	-4.91	07-Jul-00	-4.40	07-Jul-00	-43.69	07-Jul-00
	C/S	-6.05***	27-Oct-00	-5.37*	24-Nov-00	-62.22**	24-Nov-00
			France				
Germany, Italy	**C**	-5.23**	14-Jan-00	-4.65	07-Jul-00	-46.48*	07-Jul-00
	C/T	-5.09*	11-Feb-00	-4.44	11-Feb-00	-43.94	11-Feb-00
	C/S	-5.90*	14-Jan-00	-5.16	11-Feb-00	-56.84*	11-Feb-00
			Italy				
France, Germany	**C**	-4.74*	07-Jul-00	-4.32	07-Jul-00	-39.06	07-Jul-2000
	C/T	-4.79	14-Nov-97	-4.23	07-Nov-97	-40.15	07-Nov-97
	C/S	-5.98***	10-Mar-00	-5.59*	11-Feb-00	-62.38**	11-Feb-00

Notes. This table contains the results for the Gregory-Hansen cointegration analysis in the multivariate setting, with each of the European G7 markets as the dependent variable in each case. The final three specifications exclude the UK. The test statistics for the Augmented Dickey-Fuller (*ADF*) and Phillips-Perron (*PP* Z_t, *PP* Z_a) are presented. The null hypothesis is no cointegration, while the alternative is cointegration in the presence of a single break. C, C/T, and C/S denote a level shift, a level shift with trend, and a regime shift respectively. Dates refer to estimated break-dates, which are determined endogenously. ***, **, * denote statistical significance at the 1, 5 and 10% respectively.

In the final stage of the Gregory-Hansen analysis of the G7 group, I examine cointegration in the presence of a break across the G7 excluding the European continent - exclusively examining the US, the UK, Canada and Japan. The results are presented in Table 4.9. For the US, Canada and the UK, the null hypothesis of no cointegration cannot be rejected. There is evidence of cointegration only in the case of Japan, with a break on May 19th and June 2nd 2000. This implies that, while there is significant integration among the European members of the G7, there is little evidence of cointegration among the remaining members. The absence of a common stochastic drift, a requisite for cointegration, implies that there are potential benefits to diversifying across these markets.

Despite finding little evidence of cointegration among the members of the G7 in a bivariate framework, the subsequent multivariate analysis reveals the presence of a cointegration relation among the European members of the G7, with and without the US and the UK. When the US and the UK are analysed alongside the core European markets, there is evidence of cointegration with breaks in 2007 and 2008, as the effects of the global crisis are felt, causing a shift to a new long-run relationship. Focusing exclusively on the core European markets, break-dates converge to the period surrounding the introduction of the Euro in 2000, with no evidence that the global crisis has caused a shift to a new long-run relationship among the studied markets. This implies that the crisis has mattered for the integration of the US and the UK with the rest of the G7 markets, but it has not materially altered the nature of the relationship among the core European markets of Germany, France, and Italy. More generally, the results reveal the importance of allowing for instability in the cointegration vector when examining equity market interdependencies over a long and volatile period.

Table 4.9. Multivariate Gregory-Hansen test of G7 Markets Excluding Europe

Market	Model	ADF	Break	PP Z_t	Break	PP Z_a	Break
			US				
Canada,	**C**	-2.59	07-Jan-11	-2.26	19-Sep-08	-14.39	19-Sep-08
UK,	**C/T**	-4.39	27-Feb-04	-4.11	16-Jan-04	-42.95	16-Jan-04
Japan	**C/S**	-3.70	12-Sep-08	-3.37	12-Sep-08	-27.46	12-Sep-08
			Canada				
US, UK,	**C**	-3.53	12-Aug-05	-3.56	07-Oct-05	-24.1	07-Oct-05
Japan	**C/T**	-4.68	15-Jan-10	-4.61	08-Jan-10	-48.61	08-Jan-10
	C/S	-4.50	03-Dec-04	-4.37	03-Dec-04	-38.7	03-Dec-04
			UK				
US,	**C**	-3.89	19-Sep-08	-3.4	19-Sep-08	-25.98	19-Sep-08
Canada,	**C/T**	-4.61	15-Jan-10	-4.39	08-Jan-10	-45.56	08-Jan-10
Japan	**C/S**	-4.77	12-May-06	-4.33	12-May-06	-47.35	12-May-06
			Japan				
US, UK,	**C**	-3.25	14-Nov-97	-3.04	14-Nov-97	-20.57	14-Nov-97
Canada	**C/T**	-3.53	30-Apr-04	-3.27	23-Jan-04	-27.58	23-Jan-04
	C/S	-6.05**	02-Jun-00	-5.79*	19-May-00	-80.95***	19-May-00

Notes. This table contains the results for the Gregory-Hansen cointegration analysis in the multivariate setting, across the G7 group excluding Europe. The final three specifications exclude the UK. The test statistics for the Augmented Dickey-Fuller (*ADF*) and Phillips-Perron (*PP* Z_t, *PP* Z_a) are presented. The null hypothesis is no cointegration, while the alternative is cointegration in the presence of a single break. C, C/T, and C/S denote a level shift, a level shift with trend, and a regime shift respectively. Dates refer to estimated break-dates, which are determined endogenously. ***, **, * denote statistical significance at the 1, 5 and 10% level respectively.

4.3.2. BRICS

As with my analysis of the G7 group, my analysis of the BRICS is two-fold. I first conduct a bivariate analysis for every pairing of the US and each of the BRICS. The results are presented in Table 4.10. I fail to reject the null hypothesis of no cointegration in every case. This result mirrors the results of the bivariate analysis of the US and the rest of the G7. The implication is that, in a bivariate setting, it is not possible to infer a long-term relationship between the US market and each of the members of the G7 and the BRICS, that is, the largest, wealthiest and most influential of the developed and emerging market samples.

I follow this with a bivariate analysis between each pair of BRICS. The results are presented in Table 4.11. There is evidence of several bivariate long-run relationships. Focusing first on Brazil, there is a cointegration relation between Brazil and Russia with a break on May 7th 2004, and strong evidence of cointegration between Brazil and India, with breaks on November 9th 2007 and December 28th 2007. I find weak evidence of cointegration with a break with China on March 28th 2002 and July 12th 2002. For the Russian market, there is cointegration with India and China, with breaks on the 6th and 23rd of May 2005, and various dates between May 2004 and September 2005, respectively. There is very weak evidence of cointegration between the Russian market, and Brazil and South Africa, with implied break dates on August 19th and September 23rd 2005, and May 5th and December 8th 2006, respectively. Much of these reported breaks are difficult to reconcile with events in financial markets at the time. While breaks in late 2007 may be attributable to the effects of the global crisis, it is surprising that the Russian market enters into a new long-run relationship with India and China in 2004 and 2005.

Table 4.10. Bivariate Gregory-Hansen test of BRICS plus the US

Market	Model	ADF	Break	PP Z_t	Break	PP Z_a	Break
Brazil	C	-2.05	11-Feb-11	-1.90	05-Dec-97	-7.22	05-Dec-97
	C/T	-2.74	10-Aug-01	-2.60	21-Sep-01	-13.69	21-Sep-01
	C/S	-2.92	21-Aug-09	-2.71	04-Sep-09	-12.95	04-Sep-09
Russia	C	-2.18	27-Jun-08	-1.99	27-Jun-08	-10.48	27-Jun-08
	C/T	-2.72	27-Jun-08	-2.51	27-Jun-08	-15.64	27-Jun-08
	C/S	-2.74	20-Jun-08	-2.56	20-Jun-08	-15.66	20-Jun-08
India	C	-2.12	11-Feb-11	-2.01	05-Dec-97	-7.98	05-Dec-97
	C/T	-2.48	10-Aug-01	-2.37	21-Sep-01	-11.43	21-Sep-01
	C/S	-2.78	21-Aug-09	-2.64	21-Aug-09	-12.62	21-Aug-09
China	C	-2.11	11-Feb-11	-2.03	05-Dec-97	-8.48	05-Dec-97
	C/T	-2.74	14-Sep-01	-2.65	21-Sep-01	-14.12	21-Sep-01
	C/S	-2.50	19-Dec-03	-2.39	02-Jan-04	-12.79	02-Jan-04
South Africa	C	-1.96	11-Feb-11	-1.89	05-Dec-97	-9.19	05-Dec-97
	C/T	-2.44	21-Sep-01	-2.32	21-Sep-01	-10.95	21-Sep-01
	C/S	-2.67	14-Sep-01	-2.59	21-Sep-01	-13.64	21-Sep-01

Notes. This table contains the results for the Gregory-Hansen cointegration analysis in the bivariate setting, with the US acting as the dependent variable in each case. The emerging BRICS form the independent variables. The null hypothesis is no cointegration, while the alternative is cointegration in the presence of a single break. C, C/T, and C/S denote a level shift, a level shift with trend, and a regime shift respectively. Dates refer to estimated break-dates, which are determined endogenously. ***, **, * denote statistical significance at the 1, 5 and 10% respectively.

Table 4.11. Bivariate Gregory-Hansen test for all pairs of BRICS Markets

Market	Model	ADF	Break	PP Z_t	Break	PP Z_a	Break
			Brazil				
Russia	**C**	-4.34	07-May-04	-3.84	14-May-04	-33.78	14-May-04
	C/T	-5.15**	07-May-04	-4.86*	25-Jun-04	-49.02**	25-Jun-04
	C/S	-4.93*	07-May-04	-4.46	14-May-04	-44.27*	14-May-04
India	**C**	-6.13***	09-Nov-07	-4.65**	28-Dec-07	-47.97**	28-Dec-07
	C/T	-7.08***	09-Nov-07	-5.93***	14-Mar-08	-70.58***	14-Mar-08
	C/S	-6.19***	09-Nov-07	-5.04**	28-Dec-07	-54.50**	28-Dec-07
China	**C**	-4.55*	17-May-02	-4.54*	10-May-02	-48.06**	10-May-02
	C/T	-4.89*	28-Mar-02	-4.52	12-Jul-02	-47.62*	12-Jul-02
	C/S	-4.54	17-May-02	-4.53	10-May-02	-48.47**	10-May-02
South Africa	**C**	-2.98	21-Sep-07	-2.65	13-Apr-07	-17.61	13-Apr-07
	C/T	-3.62	08-Jun-07	-3.34	13-Apr-07	-25.83	13-Apr-07
	C/S	-2.99	21-Sep-07	-2.64	13-Apr-07	-17.64	13-Apr-07
US	**C**	-3.32	24-Feb-06	-3.29	05-May-06	-22.49	05-May-06
	C/T	-3.28	24-Feb-06	-3.26	05-May-06	-22.07	05-May-06
	C/S	-3.45	15-Aug-08	-3.20	05-May-06	-21.60	05-May-06
			Russia				
Brazil	**C**	-3.18	02-Jul-04	-3.03	25-Jun-04	-22.45	25-Jun-04
	C/T	-4.99*	19-Aug-05	-4.77*	23-Sep-05	-44.12*	23-Sep-05
	C/S	-4.29	21-May-04	-3.92	07-May-04	-32.25	07-May-04
India	**C**	-3.76	09-Jul-04	-3.72	09-Jul-04	-27.67	09-Jul-04
	C/T	-5.47***	06-May-05	-5.23**	23-May-05	-52.17**	23-May-05
	C/S	-4.87*	11-Mar-05	-4.25	30-Apr-04	-34.29	30-Apr-04
China	**C**	-4.95**	21-May-04	-4.85**	02-Jul-04	-45.71**	02-Jul-04
	C/T	-5.12**	08-Jul-05	-4.92*	23-Sep-05	-47.86*	23-Sep-05
	C/S	-4.84*	04-Jun-04	-4.79*	02-Jul-04	-43.75*	02-Jul-04
South Africa	**C**	-4.49*	05-May-06	-4.31	08-Dec-06	-36.81*	08-Dec-06
	C/T	-4.39	08-Dec-06	-4.26	08-Dec-06	-36.38	08-Dec-06
	C/S	-4.31	04-Mar-05	-4.09	19-Aug-05	-33.56	19-Aug-05
US	**C**	-2.53	18-Apr-03	-2.70	06-Sep-02	-14.11	06-Sep-02
	C/T	-2.76	07-Oct-05	-2.62	23-Sep-05	-14.54	23-Sep-05
	C/S	-2.48	18-Apr-03	-2.57	06-Sep-02	-13.55	06-Sep-02
			India				
Russia	**C**	-4.54*	31-Dec-04	-4.29	30-Apr-04	-34.70	30-Apr-04
	C/T	-4.87*	29-Apr-05	-4.71	23-Sep-05	-42.82	23-Sep-05
	C/S	-4.25	30-Apr-04	-4.35	30-Apr-04	-36.44	30-Apr-04
Brazil	**C**	-5.19***	14-Mar-03	-4.76**	05-Sep-03	-45.65**	05-Sep-03
	C/T	-7.00***	09-Nov-07	-6.01***	14-Mar-08	-70.26***	14-Mar-08
	C/S	-5.89***	09-Nov-07	-5.11**	14-Mar-08	-52.25**	14-Mar-08
China	**C**	-5.55***	11-Apr-08	-5.62***	11-Apr-08	-60.84***	11-Apr-08
	C/T	-5.85***	03-Apr-08	-5.99***	30-Jan-98	-67.99***	30-Jan-98
	C/S	-5.67***	11-Apr-08	-5.67***	11-Apr-08	-63.06***	11-Apr-08
South Africa	**C**	-4.61*	21-Jan-11	-4.14	14-Jan-11	-36.69*	14-Jan-11
	C/T	-4.60	14-Jan-11	-4.10	14-Jan-11	-36.30	14-Jan-11
	C/S	-4.69*	03-Dec-10	-4.29	14-Jan-11	-37.50	14-Jan-11
US	**C**	-3.82	12-May-06	-4.15	12-May-06	-23.35	12-May-06
	C/T	-3.81	12-May-06	-4.15	12-May-06	-24.69	12-May-06
	C/S	-3.80	12-May-06	-4.12	12-May-06	-25.15	12-May-06
			China				
Russia	**C**	-5.62***	09-Jul-04	-5.62***	23-Apr-04	-59.00***	23-Apr-04
	C/T	-5.57***	21-May-04	-5.55***	23-Apr-04	-59.00***	23-Apr-04
	C/S	-5.59***	09-Jul-04	-5.59***	23-Apr-04	-59.06***	23-Apr-04
Brazil	**C**	-5.16***	20-Dec-02	-4.70**	12-Jul-02	-50.63***	12-Jul-02
	C/T	-5.40**	12-Jul-02	-4.90**	12-Jul-02	-52.25**	12-Jul-02
	C/S	-4.84**	23-Nov-07	-4.59	10-May-02	-49.23**	10-May-02

India	**C**	-5.83***	05-Jan-07	-5.96***	05-Jan-07	-66.77***	05-Jan-07
	C/T	-6.22***	13-Mar-98	-6.32***	30-Jan-98	-75.78***	30-Jan-98
	C/S	-5.86***	05-Jan-07	-5.97***	05-Jan-07	-67.26***	05-Jan-07
South Africa	**C**	-4.66**	05-Jan-07	-4.36*	12-Jan-07	-38.79*	12-Jan-07
	C/T	-4.65	05-Jan-07	-4.35	12-Jan-07	-38.73	12-Jan-07
	C/S	-4.68	05-Jan-07	-4.45	12-Jan-07	-39.79	12-Jan-07
US	**C**	-3.91	24-Feb-06	-4.09	19-May-06	-30.76	19-May-06
	C/T	-3.99	13-Oct-06	-4.21	19-May-06	-32.14	19-May-06
	C/S	-3.87	24-Feb-06	-3.95	12-May-06	-30.07	12-May-06
South Africa							
Russia	**C**	-4.71**	05-May-06	-4.54*	08-Dec-06	-40.75**	08-Dec-06
	C/T	-4.78*	27-Apr-07	-4.54	08-Dec-06	-41.19	08-Dec-06
	C/S	-4.86*	25-Aug-06	-4.73*	18-Aug-06	-43.78*	18-Aug-06
Brazil	**C**	-3.10	31-Dec-04	-2.89	31-Dec-04	-18.46	31-Dec-04
	C/T	-3.42	17-Aug-07	-3.11	24-Aug-07	-21.80	24-Aug-07
	C/S	-3.10	31-Dec-04	-2.87	31-Dec-04	-18.39	31-Dec-04
India	**C**	-4.79**	21-Jan-11	-4.19	14-Jan-11	-39.45*	14-Jan-11
	C/T	-4.74*	21-Jan-11	-4.07	14-Jan-11	-38.04	14-Jan-11
	C/S	-4.69*	21-May-10	-4.16	06-Aug-10	-39.11	06-Aug-10
China	**C**	-3.52	07-Jan-11	-3.21	07-Jan-11	-25.38	07-Jan-11
	C/T	-3.59	06-Jul-07	-3.15	06-Jul-07	-25.18	06-Jul-07
	C/S	-3.62	26-Oct-07	-3.15	07-Jan-11	-24.64	07-Jan-11
US	**C**	-3.75	23-Sep-05	-3.72	23-Sep-05	-26.76	23-Sep-05
	C/T	-3.76	23-Sep-05	-3.70	23-Sep-05	-26.46	23-Sep-05
	C/S	-3.71	05-Aug-05	-3.65	05-Aug-05	-27.91	05-Aug-05

Notes. This table contains the results for the Gregory-Hansen cointegration analysis in the bivariate setting, with each of the BRICS markets as the dependent variable in each case. The test statistics for the Augmented Dickey-Fuller (*ADF*) and Phillips-Perron (*PP* Z_t, *PP* Z_a) are presented. The null hypothesis is no cointegration, while the alternative is cointegration in the presence of a single break. C, C/T, and C/S denote a level shift, a level shift with trend, and a regime shift respectively. Dates refer to estimated break-dates, which are determined endogenously. ***, **, * denote statistical significance at the 1, 5 and 10% level respectively.

For India, there is strong evidence of cointegration with Brazil and China. Reported breaks in the cointegration relation with Brazil are on November 9th 2007 and March 14th 2008, with some evidence of a level shift only on March 14th and September 5th 2003. For China, most of the reported breaks in the cointegration relation are dated on April 11th 2008, with some evidence of a break on April 3rd 2008 and January 30th 1998. Again, I find only very weak evidence of cointegration with South Africa. These dates correspond strongly to the etiology of the global crisis, while there is also some evidence of a break as a result of the Asian crisis in early 1998.

Examining China, there is strong evidence of cointegration with Russia, Brazil, and India, making the Chinese market the most integrated among the BRICS. Breaks with Russia are largely in 2004; on April 23rd, July 9th and May 21st. There is evidence of breaks with Brazil on July 12th, December 20th and May 10th 2002. Breaks with India are dated January 5th 2007, and March 13th and January 30th 1998. Again there is only weak evidence of cointegration with South Africa, with reported breaks on January 5th and 13th 2007. Finally, the results for South Africa reflect the previous analyses, with very little evidence of a bivariate cointegration relation with each of the remaining BRICS and the US. There is only weak evidence of cointegration with Russia and India, with breaks reported in 2006 and 2011 respectively.

I find greater evidence of integration among the members of the BRICS than the G7. Break-dates reported for the BRICS also differ substantially to those reported for the G7. For the G7 group, reported breaks are widespread around the timing of the global crisis in 2007 and 2008, as well as around the introduction of the euro and the dot-com bubble between 1999 and 2001.

However, long-term relationships between the BRICS appear to be largely unaffected by these events. I proceed with a multivariate analysis that examines long-run relationships

between each of the individual BRICS and the remaining four BRICS. The results are presented in Table 4.12. I fail to reject the null hypothesis of no cointegration with Russia and South Africa as dependent variables. This implies that there is no evidence of a long-run relationship between Russia or South Africa and the rest of the BRICS group. There is evidence of a long-run relationship for Brazil, India and China. Breaks for Brazil are reported on November 26th and December 3rd 2004, and on February 11th 2005. February 11th 2005 is also a reported break-point for India. For China, there are several break-points ranging from October 24th 2003 to October 22nd 2004. As with the preceding bivariate analysis, there is no evidence that the global crisis has materially altered the long-run relationship between any of the individual BRICS and the rest of the BRICS group.

I continue this multivariate analysis by excluding the Russian market, and replicating the previous analysis. This approach facilitates a robustness analysis of the preceding results, given the fact that data for the Russian market is unavailable prior to 1998. The results are in Table 4.13. I observe a loss in significance from removing the Russian market, particularly when the Brazilian market is the dependent variable. Breaks are found on November 9th 2007 with some weak evidence of a break on March 21st 2008 also. I also find changes in the break-dates reported for the Indian market, without Russia. Break-dates are now reported on June 12th 1998, October 12th 2007 and March 14th 2008, with evidence of a break on January 14th 2011 also. In the absence of the Russian market, China remains cointegrated with the rest of the BRICS, with reported break-dates on November 28th 1998, January 5th 2007, and November 26th 2006. In the absence of the Russian market, break-dates converge towards the Asian and global crises.

Table 4.12. Multivariate Gregory-Hansen analysis of the BRICS markets

Market	Model	ADF	Break	PP Z_t	Break	PP Z_a	Break
				Brazil			
Russia, India,	**C**	-5.21	08-Oct-04	-4.48	11-Feb-05	-45.73	11-Feb-05
China &	**C/T**	-6.56***	03-Dec-04	-6.36**	26-Nov-04	-84.32***	26-Nov-04
South Africa	**C/S**	-6.79**	11-Feb-05	-6.35*	11-Feb-05	-82.85**	11-Feb-05
				Russia			
Brazil, India,	**C**	-5.06	14-Oct-05	-5.00	16-Sep-05	-47.65	16-Sep-05
China &	**C/T**	-5.25	19-Aug-05	-5.28	23-Sep-05	-53.48	23-Sep-05
South Africa	**C/S**	-5.51	03-Dec-04	-5.19	19-Aug-05	-52.91	19-Aug-05
				India			
Brazil, Russia,	**C**	-6.16***	11-Feb-05	-6.21***	11-Feb-05	-72.73***	11-Feb-05
China & South	**C/T**	-6.17**	11-Feb-05	-6.22**	11-Feb-05	-73.08**	11-Feb-05
Africa	**C/S**	-7.16***	18-Feb-05	-7.14***	11-Feb-05	-95.88***	11-Feb-05
				China			
Brazil, Russia,	**C**	-5.99**	21-May-04	-5.86**	16-Apr-04	-66.55**	16-Apr-04
India & South	**C/T**	-6.36**	12-Nov-04	-6.31**	22-Oct-04	-76.23**	22-Oct-04
Africa	**C/S**	-6.61**	24-Oct-03	-6.47**	24-Oct-03	-82.10**	24-Oct-03
				South Africa			
Brazil, Russia, India & China	**C**	-5.04	06-Jul-07	-4.46	14-Dec-07	-43.12	14-Dec-07
	C/T	-5.29	12-Oct-07	-4.78	06-Jul-07	-46.16	06-Jul-07
	C/S	-5.64	31-Mar-06	-5.18	10-Mar-06	-54.93	10-Mar-06

Notes. This table contains the results for the Gregory-Hansen cointegration analysis in the multivariate setting, between the BRICS. The null hypothesis is no cointegration, while the alternative is cointegration in the presence of a single break. C, C/T, and C/S denote a level shift, a level shift with trend, and a regime shift respectively. Dates refer to estimated break-dates, which are determined endogenously. ***, **, * denote statistical significance at the 1, 5 and 10% level respectively.

Table 4.13. Multivariate Gregory-Hansen analysis of the BRICS markets excluding Russia

Market	Mode	ADF	Break	PP Z_t	Break	PP Z_a	Break
				Brazil			
India, China & South Africa	**C**	-4.61	14-Mar-03	-4.45	05-Jul-02	-44.79	05-Jul-02
	C/T	-5.95**	09-Nov-07	-5.23	21-Mar-08	-57.52*	21-Mar-08
	C/S	-4.91	04-Jan-08	-4.47	28-Dec-07	-45.76	28-Dec-07
				India			
Brazil, China & South Africa	**C**	-5.92***	14-Jan-11	-5.95***	14-Mar-08	-67.96***	14-Mar-08
	C/T	-6.52***	12-Jun-98	-6.52***	12-Jun-98	-81.62***	12-Jun-98
	C/S	-6.46**	12-Oct-07	-6.46**	12-Oct-07	-78.69**	12-Oct-07
				China			
Brazil, India & South Africa	**C**	-5.73**	05-Jan-07	-5.59**	05-Jan-07	-62.48**	05-Jan-07
	C/T	-6.35***	28-Nov-98	-6.31***	28-Nov-98	-77.27***	28-Nov-98
	C/S	-5.85*	24-Nov-06	-5.74	24-Nov-06	-65.83*	24-Nov-06
				South Africa			
Brazil, India & China	**C**	-4.13	14-Jan-11	-3.88	14-Jan-11	-35.07	14-Jan-11
	C/T	-4.55	10-Jul-98	-3.96	17-Jul-98	-35.17	17-Jul-98
	C/S	-4.06	14-Jan-11	-3.78	14-Jan-11	-34.16	14-Jan-11

Notes. This table contains the results for the Gregory-Hansen cointegration analysis in the multivariate setting, between the BRICS excluding Russia. The null hypothesis is no cointegration, while the alternative is cointegration in the presence of a single break. C, C/T, and C/S denote a level shift, a level shift with trend, and a regime shift respectively. Dates refer to estimated break-dates, which are determined endogenously. ***, **, * denote statistical significance at the 1, 5 and 10% level respectively.

Overall, I find the markets of Brazil, India, and China, to be the most integrated with the rest of the BRICS group, and there is greater evidence of market integration among the emerging BRICS in general, compared to the G7 group. Break-dates for the BRICS differ largely to those reported for the G7 markets. There is evidence of a shift to a new long-run relationship among the G7 surrounding the global crisis, and evidence of a shift to a new long-run relationship surrounding the introduction of the single currency once the UK and the US are removed from analysis. Break-dates reported for the BRICS are more erratic and less consistent. However, excluding the Russian market, there is evidence of a shift to a new long-run relationship at the time of the Asian and global crises.

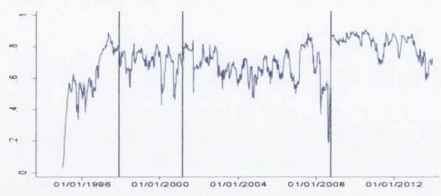
4.4 Short-Term Linkages: A DCC Analysis

The DCC GARCH analysis that follows is based on the approach by Engle (2002) as described in Section 3.5.3 of Chapter 3. I examine short-term linkages between the US and each of the G7 and BRICS markets to identify changes in the co-movement between markets surrounding the global crisis. Figure 4.3 presents the estimated dynamic conditional correlations. Conditional correlations are time-varying and volatile; however, correlations appear to be rising over time, particularly for the BRICS markets. To examine the implications of the global crisis for these dynamic conditional correlations, I use the Bai-Perron break-point test. I examine breaks in the mean of each of the estimated DCC series. The results of this analysis are presented and discussed in Table 3.10 of Chapter 3.

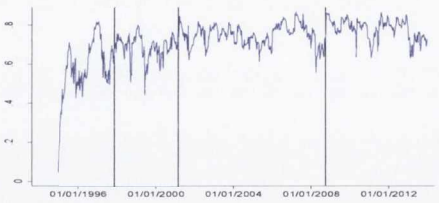
I use these break-dates, alongside the preceding Gregory-Hansen analysis, to establish four separate regimes for the G7 and the BRICS. For the G7 markets, the first begins at the start of the sample on January 6th 1995 and continues until November 21st 1997. The second begins on November 28th 1997 and ends on February 23rd 2001. The third regime

begins on March 2nd 2001 and ends on September 26th 2008. The final regime begins on October 8th 2008 and continues until the end of the sample on December 27th 2013.

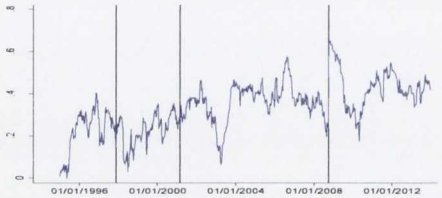
Figure 4.3. DCC between the US and the members of the G7 and BRICS



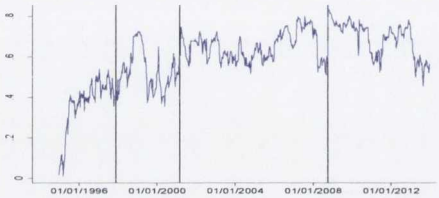
US - Canada



US - France



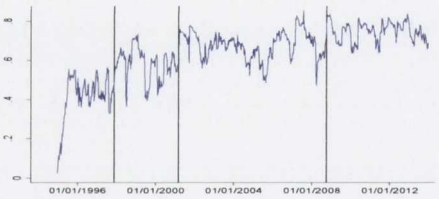
US - Japan



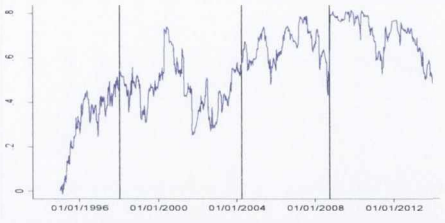
US - Italy



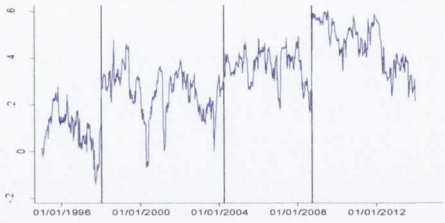
US - Germany



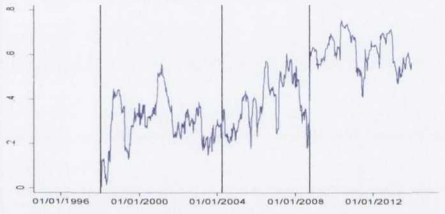
US - UK



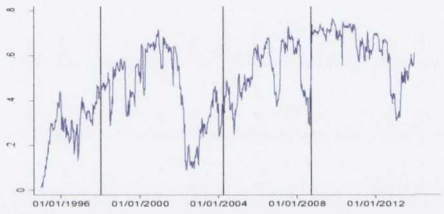
US - Brazil



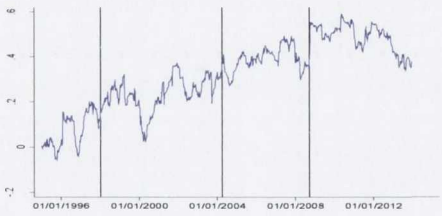
US - China



US - Russia



US – South Africa



US - India

Notes. The figure above presents the dynamic conditional correlation series between the US and each of the G7 and BRICS markets. Breakdates estimated using the Bai-Perron procedure outlined in Section 3.8 of Chapter 3, have been superimposed onto each graph.

The BRICS are divided into the following regimes. The first ranges from the beginning of the sample on January 6th 1995 to January 9th 1998. The second regime begins on January 16th 1998 and ends on March 26th 2004. The third regime begins on April 2nd 2004 and ends on September 26th 2008, while the final regime begins on October 3rd 2008 and ends at the end of the sample on December 27th 2013. Figure 4.2 presents the each of the DCC series with the relevant break-dates superimposed.

I conclude this analysis of dynamic conditional correlations by examining changes in the mean of each DCC series in moving from one regime to the next. The results are presented in Table 4.14. Statistically significant increases in conditional correlations are recorded in all cases, except Japan - when moving from the first to the second regime, there is a statistically significant decrease in correlation for Japan. This shows that conditional correlations between the US and the rest of the G7 group have been rising consistently throughout the sample, and reach a sample peak in the final regime, which encompasses the global financial crisis. In the final regime, conditional correlations are highest between the US and Canada, and lowest between the US and Japan, and this is maintained across each regime. Among European markets, conditional correlations are highest with France in the first regime, but are highest with Germany in the final regime, while they are lowest with Italy in the first and final regimes. I find similar results for the BRICS, with conditional correlations between the US and each of the BRICS rising from each regime to the next. Correlations are noticeably lower between the US and the BRICS, compared to the US and the G7, with the exception of Japan. However, as shown in the graph of each of the DCC series, correlations between the BRICS and the US are rising more rapidly over time, compared to the G7 markets. Correlations are highest in the final regime, and are strongest with Brazil, and weakest with China. Increases in the conditional correlation each period are all statistically significant.

Table 4.14. Two-tailed t-test for differences in the mean of DCC coefficients across each regime

Start	**06/01/95**	**28/11/97**	**02/03/01**	**03/10/08**
End	**21/11/97**	**23/02/01**	**26/09/08**	**27/12/13**
Japan	0.22	0.20**	0.39***	0.46***
UK	0.49	0.65***	0.74***	0.81***
Italy	0.38	0.53***	0.67***	0.72***
Canada	0.64	0.73***	0.69***	0.82***
France	0.48	0.61***	0.74***	0.79***
Germany	0.45	0.61***	0.75***	0.80***
Start	**06/01/95**	**16/01/98**	**02/04/04**	**03/10/08**
End	**09/01/98**	**26/03/04**	**26/09/08**	**27/12/13**
Brazil	0.32	0.47***	0.65***	0.71***
Russia		0.30	0.38***	0.61***
India	0.07	0.24***	0.39***	0.49***
China	0.09	0.26***	0.37***	0.46***
South Africa	0.29	0.45***	0.52***	0.63***

Notes. This table contains the results for a series of two-tailed t-tests of the significance of changes in the mean of the DCC coefficient between the US and each other G7 and BRICS market, moving from one sub-period to the next. The figures above represent the mean of the DCC coefficient for each pair in each sub-period. Sub-periods are determined in line with break-dates identified in a Bai-Perron analysis, the results of which are presented in Table 3.10 in Chapter 3.***, **, * denote statistical significance at the 1, 5 and 10% level respectively.

This analysis demonstrates that the degree of co-movement between the US and the largest and most prominent developed and emerging equity markets has been rising consistently from January 6th 1995 to December 26th 2013, the nineteen-year period under study. The rise in correlation from each regime to the next is highly statistically significant in each case, and implies that the benefits to diversifying internationally across these markets are significantly diminishing over time.

4.5 Conclusion

4.5.1. Economic implications

The evidence in favour of market integration varies considerably over time. This implies that static tests for linkages between equity markets are inappropriate, and insufficient for understanding the diversification potential of a set of markets. The investor must be cognisant that the extent to which markets may provide diversification benefits is temporally inconsistent. This persists in every studied group of both the developed and the emerging market samples, and across the sampled time period.

The developed market groups are integrated throughout the sample period. This alone is not a novel finding; the idea that the developed markets of Europe are integrated is not new and has been proposed and studied extensively, particularly since the introduction of the single currency. Similarly, the developed markets of the Asia-Pacific are integrated to a large extent, as expected.

Also evident, is a persistent rise in the level of market integration within the studied groups over time, as indicated by the growing size of the rolling trace statistic. This holds especially for the emerging market groups. Although they display minimal evidence of integration early in the sample, there is strong and rising integration later. This finding

sheds new light on conventional wisdom regarding the treatment of emerging market equities as a fundamentally different asset class.

I also note the convergence of emerging market integration towards levels of integration typically associated with developed markets. The implication is that emerging markets may no longer hold to the same extent, diversification potential for the international investor. As the emerging markets continue to liberalise and develop, it seems reasonable to assume that this pattern is likely to continue into the future.

The impact of the crisis is felt in almost every studied group with a substantial spike in the value of the trace statistic entering into the crisis period in 2007. While this suggests a rise in market integration across the studied groups attributable to the global crisis, this effect is short-lived, and the increased integration does not persist for the remainder of the sample period. While the crisis had some limiting effect on the benefits to diversifying across the markets of the studied groups, this is not a long-term effect and the nature of the underlying relationships does not alter fundamentally in the long-run.

4.5.2 Concluding remarks

In this chapter, I use a series of cointegration measures to model long-term relationships among developed and emerging equity markets. A DCC analysis is also used to examine short-term linkages. I confirm that the integration of developed and emerging markets is time-varying and volatile. This feature of the long-term relationships between equity markets has been established elsewhere in the literature (Bekaert and Harvey, 1997; Aggarwal et al., 2004; Lucey and Voronkova, 2008). This time-variation holds when studying integration across developed and emerging market samples, and implies that market interdependencies must be studied and understood in a dynamic framework.

I contribute to the literature in a number of ways. I separately analyse samples of twenty-three developed and twenty-two emerging markets to determine the extent to which

integration levels differ between developed and emerging markets. I examine the nineteen-year period from January 1995 to December 2013. To my knowledge, no previous studies exist that compare patterns of integration among developed and emerging markets on this scale. I also contribute a study that assess and compares integration levels across a multitude of market groupings, as opposed to a study of a single region only. Furthermore, until now, little has been done to characterise linkages among equity markets surrounding the global financial crisis. I use a sub-period and recursive analysis to disentangle the crisis period from the wider sample, and to examine if the crisis can be associated with material changes in integration levels.

I find large instability in market integration levels across several market groupings. A recursive analysis reveals a period of relative stability in the first half of the 2000s, and beyond 2008, with volatility in market linkages throughout the rest of the sample period. I find convincing evidence that developed equity markets are integrated for most of the sample period in every studied group. Despite the time-varying and volatile nature of market linkages, I observe consistent equity market interdependence in every group. In answering the question of how, if at all, the global crisis has impacted on market linkages, I find that the sub-period characterising the crisis and its aftermath, is marked by strong and stable market linkages among European markets. While linkages between Asian-Pacific markets during this time are noticeably more volatile, they are strong and rising. This has important implications for international investors. The linkages between the developed markets of Europe, and those of the Asia-Pacific, imply that there are few gains to diversifying across the developed markets of these regions. I find that emerging markets become more integrated much later than developed markets. While there is a strong trend toward heightened integration among developed markets in the 1990s, this growth in integration is not observed among the emerging markets until a decade later, during the 2000s. While a sub-period analysis highlights a fall in the number of

cointegrating relations beyond the global crisis for the markets of Western Europe, the Asia-Pacific region experiences the opposite effect. Regardless, a recursive analysis informs that integration is present and strong across both regions throughout the crisis.

Chapter 5 The Relative Importance of Industry and Country Effects

5.1 Introduction

International diversification has long been the focal point of risk reduction analysis. A sufficiently low return correlation between international equity markets rewards a higher return per unit of risk for fund managers who diversify internationally (Markowitz, 1952; Tobin, 1956; Levy and Sarnat, 1970; Lessard, 1975; Eun and Resnick, 1985; Driessen and Laeven, 2007). There was a shift in the literature, however, at the turn of the last century towards recognising the growing importance of industrial diversification for fund managers and the significance of industry effects against a backdrop of heightened levels of market correlation (Baca et al., 2000; Serra, 2000). In the context of an increasingly globalised world (Coelho et al., 2007; Quinn and Voth, 2008) the respective roles of country and industry effects in portfolio diversification remains a contentious issue. While modern portfolio theory suggests that higher equity market correlations will detract from the benefits of international diversification, the empirical evidence is varied (Flavin, 2004; Bekaert et al., 2009). The debate continues on whether portfolio managers should focus their investment decisions on industry-based diversification strategies, as opposed to a more traditional country-based approach. Furthermore, the emergence of the relatively more segmented less-developed equity markets presents a new opportunity for the international investor when faced with the interdependence of developed equity markets.

In this chapter, I compare the relative importance of industry and country factors in developed and emerging equity market returns, using a factor analysis. I follow previous studies in employing a variant of the factor model proposed by Heston and Rouwenhorst (1994) that disentangles industry and country effects, before comparing their relative size. Specifically, I adapt the panel-data framework of Flavin (2004) to a recursive

setting and track the evolution of the industry-to-country effect ratio throughout the period under study. A recursive study of this nature is absent from the surrounding literature, and is a novel contribution of this chapter. I also conduct whole and sub-period analyses. Furthermore, studying the inter-temporal stability of the relative importance of industry and country factors, allows me to identify the implications of the global financial crisis for this on-going debate – this has not been analysed elsewhere in the literature. For a more detailed discussion of the methods used in this chapter, see Section 3.6 of Chapter 3. Sub-periods are determined using the Bai-Perron procedure. This procedure and the results of this structural break analysis can be found in Section 3.8 of Chapter 3. I explore the relative importance of industry and country effects using the following hypotheses.

$H1_0$. Industry effects are larger in market returns, across the period from January 1995 to December 2013.

$H1_A$. Country effects are larger in market returns, across the period from January 1995 to December 2013.

I examine these hypotheses across separate developed and emerging market samples. I study forty-six markets. This list of markets and the classification of each market can be found in Table 3.1 of Chapter 3. For the developed markets, in the context of a whole period analysis, I find that industry effects are marginally more important than country effects. However, country effects dominate industries among emerging markets across the whole period.

Analysing individual sub-periods, I find that industry effects dominate country effects across developed markets from November 28th 1997 to February 23rd 2001, and from March 2nd 2001 to September 26th 2008. However, industry effects are larger between January 6th 1995 and November 21st 1998, and between October 3rd 2008 and the end of

the sample on December 27th 2013. For the emerging markets, country factors dominate industry factors in every sub-period.

Finally, a recursive analysis reveals that the relative importance of industry and country effects is time-varying and volatile. In developed markets, industry factors are relatively more important than country factors across the period under study. However, country factors dominate in emerging markets throughout. However, in both developed and emerging markets, the global crisis is associated with the dominance of country effects despite the overwhelming dominance of industry effects in the sub-period immediately preceding the crisis for developed markets.

This study makes several important contributions to the literature. It is the first study to assess the relative importance of industry and country effects in this dynamic, recursive framework. This approach is particularly appealing, as it allows for statistical as well as economic significance among the estimated industry and country effects by using a panel data version of the traditional Heston and Rouwenhorst (1994) factor model. This chapter also contributes to the literature by analysing the implications of the global financial crisis for the debate on industry versus country effects in equity market returns. Finally, by examining separate samples of developed and emerging markets, this chapter identifies differences in the relative importance of industries and countries between these classifications. To my knowledge, a study of this scale, that assess differences in industry and country effects between developed and emerging equity markets, is absent from the relevant literature.

The remainder of this chapter is structured as follows. In section 5.2 I present the results of the full period analysis. In Section 5.3 I discuss the results of the sub-period analyses, while Section 5.4 presents the results of my recursive analyses. Finally, in Section 5.4 I offer some concluding remarks.

5.2 Industry and Country Effects

In the following analysis of industry and country effects, I estimate equation 3.23 of Section 3.6 in Chapter 3 for both developed and emerging market samples, across the full sample period from January 1995 to December 2013. As described in greater detail in Section 3.6 of Chapter 3, this equation is estimated as a random effects model by generalised least squares (GLS).

In Table 5.1 I present the estimated industry and country effects across the samples of developed and emerging markets. Focusing on the developed market sample, I find evidence of statistical significance at conventional significance levels, across many of the estimated country and industry effects. Individual estimates indicate how overinvestment in a particular stock impacts on a portfolio, relative to a value-weighted benchmark, maintaining geographical or industrial composition. For example, the positive coefficient for Canada, Sweden, and the US, indicates that an overinvestment in these stocks, relative to a value weighted benchmark of stocks, leads to an improvement in performance. In contrast, an overinvestment in all remaining country stocks worsens performance relative to the value-weighted benchmark. The interpretation is similar for the estimated industry effects. Overinvestment in all but telecommunications stocks, leads to an improvement in performance relative to the value-weighted benchmark. These results are reflected in the summary statistics for the developed market index returns, and the corresponding industry returns, presented in Table 3.5 and Table 3.8 respectively, of Section 3.4 in Chapter 3. Canada, Sweden and the US are among the best performing markets while the telecommunications industry is the only industry with a negative mean return.

Table 5.1 Industry and Country Effects: January 6th 1995 to December 27th 2013

Country	**β**	**Country**	**β**
Austria	-0.0012***	Brazil	0.0013**
Australia	-0.0003	Chile	0.0013**
Belgium	-0.0013***	Colombia	0.0014**
Denmark	-0.0004	Czech Republic	0.0007
Canada	0.0003	China	0.0023***
Finland	-0.0007*	Egypt	0.0002
France	-0.0008***	Qatar	0.0009
Germany	-0.0009***	UAE	0.0005
Hong Kong	-0.0003	Hungary	-0.0012*
Ireland	-0.0018***	India	0.0015***
Israel	-0.0001	Indonesia	0.0011
Italy	-0.0017***	Korea	0.0014***
Japan	-0.0018***	Malaysia	0.0007
Netherlands	-0.0020***	Mexico	0.0011**
Norway	-0.0004	Peru	0.0015**
New Zealand	-0.0005	Poland	0.0018***
Sweden	0.0002	Philippines	0.0010*
Singapore	-0.0007**	Russia	0.0012*
Switzerland	-0.0005**	South Africa	0.0013**
Spain	-0.0015***	Taiwan	0.0008
Portugal	-0.0027***	Turkey	0.0012**
UK	-0.0007***	Thailand	0.0007
US	0.0013***	Greece	-0.0617***
Industry	**γ**	**Industry**	**γ**
Oil and Gas	0.0005	Oil and Gas	0.0008
Basic Materials	0.0001	Basic Materials	0.0005
Industrials	0.0005*	Industrials	0.0008*
Consumer Goods	0.0006*	Consumer Goods	0.0012**
Healthcare	0.0007**	Healthcare	0.0016**
Consumer Services	0.0003	Consumer services	0.0010**
Utilities	0.0002	Utilities	0.0001
Financials	0.0002	Financials	0.0004
Technology	0.0003	Technology	0.0011*
Telecommunications	-0.0062	Telecommunications	-0.0070
Ratio	**1.02**		**0.38**

Notes. The table above shows the estimated industry and country effects for the full period between January 6th 1995 and December 27th 2013 for the developed market sample. *, **, and *** denote statistical significance at the 10, 5, and 1 per cent levels respectively. *Ratio* refers to the ratio of the absolute average of the country and industry effects, and shows the relative importance of countries and industries in stock return determination. A ratio above 1 indicates the superiority of industry effects, while a ratio below ones indicates the superiority of country effects.

To identify the relative importance of these competing factors, I analyse the industry-to-country effect ratio. I divide the absolute average of the industry effects by the absolute average of the country effects to establish a ratio for the period equal to 1.02. This indicates that industry factors were marginally more important than country factors in developed markets between January 6th 1995 and December 27th 2013.

This suggests that diversification across industries is advisable when investing in developed markets. This result is substantially different from the earliest studies, that utilise data from periods pre-dating the monetary integration and globalisation that characterises the 1990s and 2000s (Griffin and Karolyi, 1998; Roll, 1992; Heston and Rouwenhorst, 1994, 1998). However, it reflects several other studies that examine samples from the late 1990s and the 2000s which find a greater role for industries, and larger overall industry effects (Baca et al., 2000; Cavaglia et al., 2000; Kerneis and Williams, 2000; Brooks and Catáo, 2000; Isakov and Sonney, 2002; Flavin, 2004).

I proceed by examining the estimated industry and country effects across the emerging market sample. The results are also presented in Table 5.1. Again I establish the statistical significance of many of the estimated effects at conventional significance levels. The results indicate that overinvestment in all but Greece and Hungary would improve on a value-weighted benchmark. Furthermore, overinvestment in all but the telecommunications industry would improve on a value-weighted benchmark. This result for the telecommunications industry is also observed among the developed market industries. I find an industry-to-country effect ratio for the emerging markets equal to 0.38. This is markedly different to the ratio of 1.02 that was established for the developed market sample. This suggests that across the period from January 6th 1995 to December 31st 2013, industry factors were marginally more important in developed markets, while country factors dominated in emerging markets. This implies that investors should pursue country motivated diversification strategies when investing in emerging markets.

This discrepancy between developed and emerging market samples is striking, and highlights the need for a separate analysis across these two classifications. However, while these full-period results are interesting, it is necessary to consider temporal instability in the relative importance of industry and country factors. For example, Graff (2011) finds that industry effects dominate among developed markets between 1999 and 2001, and again in 2007 and 2008, while country effects remain dominant among emerging markets in every period. To examine time variation among industry and country effects, I proceed with a sub-period and recursive analysis.

5.3 Industry and Country Effects: Sub-period Analysis

I conduct a sub-period analysis of the relative importance of the estimated industry and country effects across both the developed and emerging market samples. Sub-periods are chosen in line with the selection procedure outlined in Section 3.8 of Chapter 3, the results of which are presented in Table 3.10. Based on the results of this breakpoint analysis, I analyse the developed markets across the following sub-periods: January 6th 1995 to November 11th 1997, November 28th 1997 to February 23rd 2001, March 2nd 2001 to September 26th 2008, and October 3rd 2008 to December 27th 2013. While for the emerging markets, sub-periods are determined as follows: January 6th 1995 to January 9th 1998, January 16th 1998 to March 26th 2004, April 2nd 2004 to September 26th 2008, and October 3rd 2008 to December 27th 2013.

The results of the developed market analysis are presented in Table 5.2. β_1 through β_4 shows the estimated country effects for sub-periods one through four, while γ_1 through γ_4 shows the estimated industry effects for sub-periods one through four. There is evidence of statistical significance in each sub-period, particularly in sub-period four.

Table 5.2 Industry & Country Effects, Developed Markets: Sub-periods

Country	β_1	β_2	β_3	β_4
Austria	-0.0042***	-0.0013	0.0006	-0.0022***
Australia	-0.0021**	-0.0014**	0.0012***	-0.0011***
Belgium	-0.0015	-0.0025***	0.0002	-0.0022***
Denmark	-0.0011	-0.0012	0.0012**	-0.0017***
Canada	0.0000	-0.0005	0.0014***	-0.0006**
Finland	-0.0005	-0.0026**	0.0007	-0.0014**
France	-0.0032***	0.0010*	0.0001	-0.0018***
Germany	-0.0031***	-0.0018***	0.0000	-0.0009***
Hong Kong	-0.0034***	-0.0019**	-0.0002	0.0009**
Ireland	-0.0007	-0.0028*	-0.0008	-0.0028***
Israel	-0.0037**	0.0016	0.0002	0.0002
Italy	-0.0041***	0.0017**	-0.0008**	-0.0030***
Japan	-0.0084***	-0.0005	-0.0009***	-0.0011***
Netherlands	-0.0019*	-0.0026***	-0.0007*	-0.0031***
Norway	0.0015	-0.0021*	0.0001	-0.0007
New Zealand	-0.0021	-0.0027**	0.0008	-0.0007
Sweden	0.0001	-0.0013	0.0008*	0.0003
Singapore	-0.0081***	-0.0017*	0.0005	-0.0001
Switzerland	-0.0019**	0.0004	0.0003	-0.0012***
Spain	-0.0008	-0.0014*	0.0004	-0.0038***
Portugal	-0.0023	-0.0024**	-0.0007	-0.0049***
UK	-0.0018***	-0.0001	-0.0003	-0.0009***
USA	0.0075***	0.0006**	0.0001	0.0016***
Industry	γ_2	γ_2	γ_3	γ_4
Oil and Gas	0.0014	-0.0014	0.0020***	-0.0008
Basic Materials	-0.0008	-0.0023**	0.0022***	-0.0011**
Industrials	0.0007	-0.0015	0.0015***	0.0002
Consumer Goods	0.0006	-0.0016*	0.0016***	0.0003
Healthcare	0.0012	-0.0004	0.0013**	0.0003
Consumer Services	0.0006	-0.0009	0.0008	0.0000
Utilities	0.0002	-0.0016	0.0021***	-0.0013**
Financials	0.0008	-0.0011	0.0011**	-0.0007
Technology	0.0023	-0.0006	0.0000	0.0004
Telecommunications	-0.0129	0.0096	-0.0210**	0.0048
Ratio	**0.77**	**1.35**	**5.91**	**0.62**

Notes. The table above shows the industry and country effects estimated for the developed market sample for the four sub-periods: January 6th 1995 to November 11th 1997, November 28th 1997 to February 23rd 2001, March 2nd 2001 to September 26th 2008, and October 3rd 2008 to December 27th 2013. β_1 through β_4 shows the estimated country effects for sub-periods one to four, while γ_1 through γ_4 shows the estimated industry effects for sub-periods one through four. *, **, and *** denote statistical significance at the 10, 5, and 1 per cent levels respectively. *Ratio* refers to the ratio of the absolute average of the country and industry effects, and shows the relative importance of countries and industries in stock return determination. A ratio above 1 indicates the superiority of industry effects, while a ratio below ones indicates the superiority of country effects. Regimes are chosen in line with the Bai-Perron breakpoint procedure discussed in Section 3.8 of Chapter 3.

An analysis of the industry-to-country effect ratio for each of the sub-periods reveals the dominance of country effects over industry effects in sub-periods one and four, from January 6th 1995 to November 11th 1997 and from and October 3rd 2008 to December 27th 2013. However, industry effects are overwhelmingly dominant in sub-periods two and three, from November 28th 1997 to February 23rd 2001, and from March 2nd 2001 to September 26th 2008.While industry effects did grow in relative importance, and substantially, during the 2000s, country effects return to a position of dominance in the most recent sub-period encompassing the global financial crisis. These results suggest that despite a temporary growth in the relative importance of industry effects, particularly in the period following the introduction of the single currency in Europe, country effects eventually return to a position of dominance in more recent times It appears the global crisis is associated with the dominance of country effects over industry effects, much like the period prior to the introduction of the euro in sub-period one. In fact, the final sub-period ratio of 0.62 is not substantially different to the ratio of 0.77 recorded in sub-period one. The idea that the rise of industry effects was a temporary phenomenon is also captured by Bekaert et al. (2009). However, in characterising the final sub-period as one of heightened volatility, this result is counter to the findings of Marcelo and Quiros (2013), who find that country effects are no longer dominant, and industries offer better protection to investors in more volatile times.

My study of the whole sample period in Section 5.2 identified substantially different results for the developed and emerging market samples. I proceed by conducting a sub-period analysis of the emerging market sample. The results are presented in Table 5.3. β_1 through β_4 shows the estimated country effects for sub-periods one to four, while γ_1 through γ_4 shows the estimated industry effects for sub-periods one through four. As with the sub-period developed market analysis, there is statistical significance among the estimates in every sub-period, particularly in the final sub-period.

Table 5.3 Industry & Country Effects, Emerging Markets: Sub-periods

Country	β_1	β_2	β_3	β_4
Brazil	0.0029	-0.0032**	0.0030***	-0.0031***
Chile	0.0027	-0.0028**	0.0013	-0.0019**
Colombia	0.0035	-0.0050***	0.0025**	-0.0019*
Czech Republic	-0.0382	0.0000	0.0018	-0.0055***
China	-0.0042	0.0009	0.0013	-0.0019**
Egypt	0.0114*	-0.0080***	0.0049***	-0.0051***
Qatar		0.0197***	0.0000	-0.0033***
UAE		0.0005	0.0008	-0.0043***
Hungary	0.0111*	-0.0053***	0.0022*	-0.0079***
India	-0.0005	-0.0010	0.0024**	-0.0026***
Indonesia	0.0029	-0.0038	0.0003	-0.0023**
Korea	-0.0029	0.0003	0.0016*	-0.0023***
Malaysia	-0.0058	-0.0008	0.0003	-0.0011
Mexico	0.0047	-0.0043***	0.0018*	-0.0021**
Peru	0.0024	-0.0040***	0.0037***	-0.0023**
Poland	0.0048	-0.0024	0.0033***	-0.0032*
Philippines	-0.0044	-0.0045***	0.0024**	0.0006
Russia		0.0017	-0.0011	-0.0029***
South Africa	0.0024	-0.0020*	0.0011	-0.0021**
Taiwan	0.0044	-0.0039***	-0.0007	-0.0016*
Turkey	0.0100*	-0.0040***	0.0006	-0.0032***
Thailand	-0.0098*	0.0837**	-0.0520	0.0820***
Greece	0.0062	-0.0022*	0.0007	-0.0071***
Industry	γ_2	γ_2	γ_3	γ_4
Oil and Gas	-0.0013	0.0007	0.0012	0.0006
Basic Materials	-0.0033	0.0011	0.0019**	0.0003
Industrials	-0.0026	0.0011	0.0011	0.0012*
Consumer Goods	-0.0003	0.0006	0.0003	0.0029***
Healthcare	0.0003	0.0022	-0.0002	0.0030***
Consumer services	-0.0010	0.0004	0.0013	0.0015**
Utilities	-0.0012	-0.0001	0.0002	0.0001
Financials	-0.0016	0.0008	0.0009	0.0005
Technology	0.0068	0.0014	-0.0007	0.0013
Telecommunications	0.0134	-0.0049	-0.0083	-0.0127
Ratio	**0.47**	**0.19**	**0.41**	**0.83**

Notes. The table above shows the estimated industry and country effects for the four sub-periods: January 6th 1995 to January 9th 1998, January 16th 1998 to March 26th 2004, April 2nd 2004 to September 26th 2008, and October 3rd 2008 to December 27th 2013. β_1 through β_4 shows the estimated country effects for sub-periods one to four, while γ_1 through γ_4 shows the estimated industry effects for sub-periods one through four. *, **, and *** denote statistical significance at the 10, 5, and 1 per cent levels respectively. *Ratio* refers to the ratio of the absolute average of the country and industry effects, and shows the relative importance of countries and industries in stock return determination. A ratio above 1 indicates the superiority of industry effects, while a ratio below ones indicates the superiority of country effects. Estimates for Qatar, UAE, and Russia are provided for all sub-periods for which there is available data.

Unlike the developed market sample, the industry-to-country effect ratio reveals that country effects dominate in every sub-period. Industry factors are highest in the final sub-period that encompasses the global crisis, from October 3rd 2008 to December 27th 2013, and lowest in the second sub-period, that characterises a period of strengthening market linkages among developed markets, from January 16th 1998 to March 26th 2004.

While there is some evidence of the dominance of industry effects throughout the sample period among developed markets, this does not hold for the emerging market sample. This sub-period analysis reveals greater potential for industry based diversification among developed markets than emerging markets, particularly during the 2000s, but shows the dominance of country effects in more recent times across both samples. This sub-period analysis highlights significant time variation in the relative importance of industry and country factors in stock returns. To examine the evolution of the relative importance of these competing effects, I proceed with a recursive analysis that allows me to more explicitly track the dynamics of the industry-to-country effect ratio across the studied period.

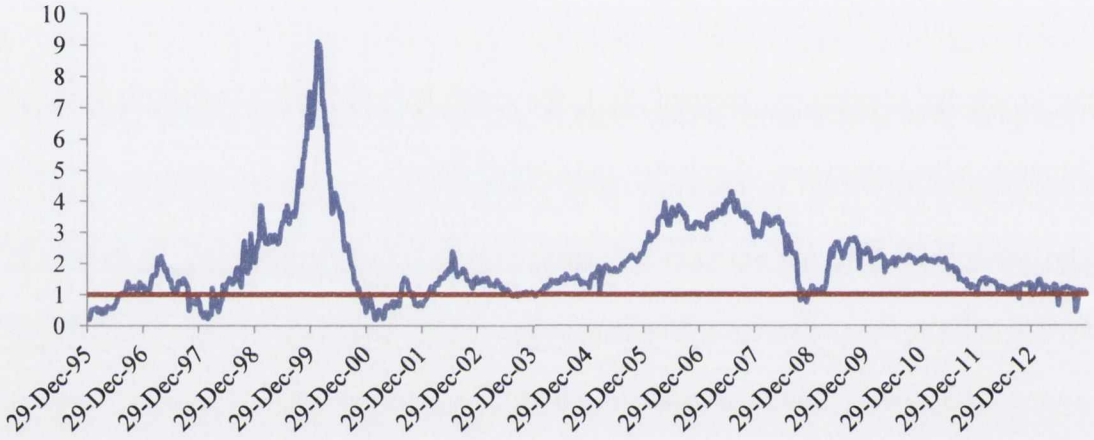
5.4 Industry and Country Effects: Recursive Analysis

In this recursive analysis, I begin with a window size of fifty-two weeks, and expand incrementally by a single week until the end of the sample is reached. I estimate equation 3.23 of Section 3.6 in Chapter 3, across 940 regressions for both the developed and emerging markets samples. For each regression I calculate the industry-to-country effect ratio of the resulting industry and country estimates.

The time-series of these 940 ratios for the developed market sample is presented in Figure 5.1. The ratio is lowest at 0.17 in the first year, between January 1995 and December 1995. Industry effects dominate between 1998 and 2000. This mirrors the

results of similar studies using data from this period (Baca et al., 2000; Cavaglia et al., 2000; Kerneis and Williams, 2000; Brooks and Catáo, 2000; Hopkins and Miller, 2001; Isakov and Sonney, 2002; Flavin, 2004). This sudden spike in the relative importance of industry effects, although pronounced (with the ratio reaching a sample peak at 9.12 between January 1995 and February 2000), is short-lived. There is another brief and modest spike in industry effects in 2002. Furthermore, between August 2005 and July 2008, and between January 2009 and April 2011, industry effects exceed country effects. Industry effects are larger for the bulk of the crisis period, with the exception of early 2009. From 2009 to the end of the sample in 2013, it appears that country effects are rising in relative importance. Beyond 2011, the curve levels off with indistinguishable differences in the importance of industry and country factors.

Figure 5.1 Recursive Analysis of Industry and Country Effects in Developed Markets

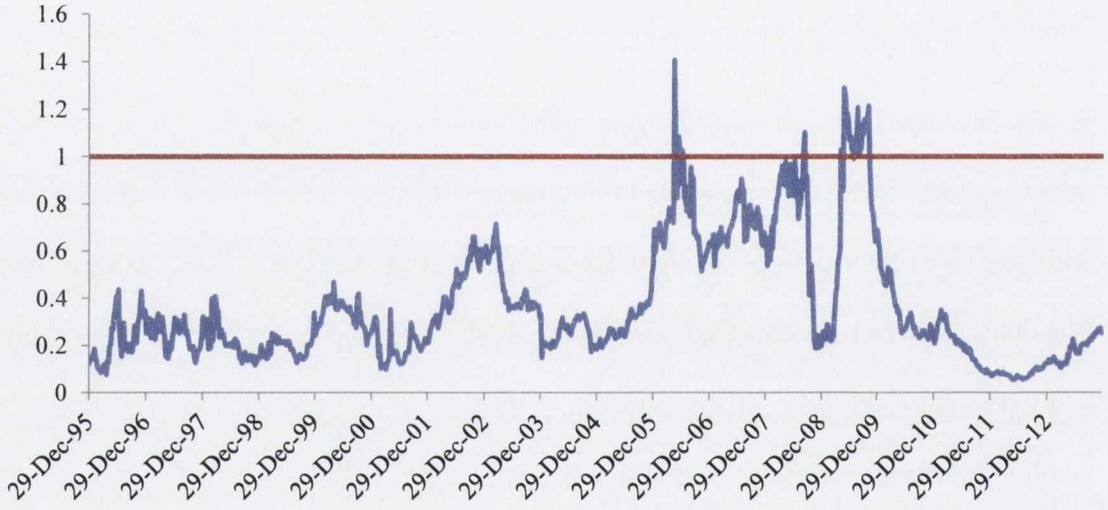


Notes. The figure above plots the time-series of the panel-data estimated industry-to-country effect ratio for the developed market sample. This graph is the result of 940 regressions generated in a recursive framework with an initial window size of 52 weeks. When the graph is above the horizontal line, the ratio exceeds 1 and industry effects are larger, and when the graph is below the horizontal line, the ratio is below 1 and country effects are larger.

The results of the recursive analysis for the emerging market sample are presented in Figure 5.2. As shown, country effects dominate in the vast majority of sub-samples. There is also significant volatility in the ratio of industry to country effects. Industry effects rise in importance in 2006, 2008 and 2009, however this is a very temporary spike. The evidence is clear; country effects are dominant over industry effects in emerging markets throughout the sample period, including the period surrounding the global financial crisis. Similarly to the developed market sample, country effects rise in relative importance from 2009 until the end of the sample period. This rise is more pronounced for the emerging markets, but industry effects do recover somewhat from mid-2011.

In the developed market case there is some evidence to support the greater relative importance of industry effects at the turn of the century. The idea that this trend lessened the benefits to international diversification across affected markets is not a novel one. The dominance of industry effects over country effects is widely reported in the literature using data from this time, as discussed in Section 2.3 of Chapter 2. However, the same result is not observed for the sample of emerging markets. The evidence suggests that for developed markets, there is greater scope for industries in the portfolio diversification decision of an investor, relative to emerging markets. However, based on this recursive analysis, country effects appear to be on a downward trend from 2009 towards the end of the sample, in the case of both developed and emerging markets. This end-of-sample rise in the importance of country factors is also captured by the preceding sub-period analysis of developed markets. It appears, irrespective of their relative importance prior to the global crisis, the crisis period can be associated with a rise in the relative importance of country factors in the case of developed markets, and this persists until the end of the sample in December 2013.

Figure 5.2 Recursive Analysis of Industry and Country Effects in Emerging Markets



Notes. The figure above plots the time-series of the panel-data estimated industry-to-country effect ratio for the emerging market sample. This graph is the result of 940 regressions generated in a recursive framework with an initial window size of 52 weeks. When the graph is above the horizontal line, the ratio exceeds 1 and industry effects are larger, and when the graph is below the horizontal line, the ratio is below 1 and country effects are larger.

5.5 Conclusion

5.5.1 Economic Implications

Country factors dominate in the full sample analysis, and this holds for both developed and emerging markets. This immediately suggests that the diversification decision of an investor should focus on an international strategy. However, as demonstrated in the preceding chapter, the extent to which global equity markets are linked varies considerably over time, in terms of both the cointegration of market prices, and the correlation of their returns. With this in mind, it is important to consider the industry versus country debate in a dynamic, time-varying setting.

An initial sub-period analysis shows that the relative importance of these competing factors is non-constant. For example, industries offer greater potential for diversification relative to countries in periods spanning the introduction of the single currency in Europe, and in periods that encompass the Asian and Russian crises. However, countries should be the focus of the investor in the final sub-period, which spans the global crisis.

The recursive analysis is telling, and offers two particularly interesting results. Firstly, it illustrates the substantial volatility of the industry to country effect ratio. That is, the relative importance of countries and industries in the diversification decision of the investor varies considerably over time. This mirrors the substantial volatility of market linkages, recorded in the previous chapter.

Secondly, it highlights the extent to which developed and emerging markets differ, in terms of the relative importance of industry and country factors. For emerging markets, there is convincing evidence that countries offer greater diversification potential than industries throughout the sample period. However, for developed markets, there is much greater potential for industries. In fact, for the majority of the sample period, industry factors exceed country factors, implying that investors in developed markets should

pursue industry focused diversification strategies. However, country factors decline in relative importance towards the end of the sample period.

5.5.2 Concluding remarks

This chapter analyses the relative importance of country and industry effects in developed and emerging market equity returns. Using a factor decomposition model, I estimate separate industry and country effects and compare their relative importance across a sample of twenty-three developed and twenty-three emerging equity markets, from January 1995 to December 2013. This analysis is multi-faceted. In Section 5.1 I introduce the chapter. In Section 5.2 I present the results of my whole period analyses, while in Sections 5.2 and 5.3 I present the results of my sub-period, and recursive analyses of industry and country effects. This allows me to explicitly examine the temporal stability of the relative importance of industry and country factors, and to track their evolution over time. In particular, the recursive approach used in this chapter has not been done elsewhere in the literature, and represents a novel contribution of this study.

The initial full period analysis confirms the dominance of countries over industries from January 1995 to December 2013. I conduct a recursive analysis and find that, while there is some importance for industries in the diversification decision of an international investor in the case of developed markets, particularly at the turn of the century, the same is not true of the emerging market sample. For the developed markets, this recursive analysis shows that industry factors are larger throughout most of the period from January 1995 to December 2013. Industry factors are particularly strong in the time between 1999 and 2000. However, this result is likely driven by pre-2000 data, and has been reported elsewhere in the literature that draws on samples from this time (Kerneis and Williams, 2000; Brooks and Catáo, 2000; Hopkins and Miller, 2001; Isakov and

Sonney, 2002; Serra, 2000). This chapter builds upon these earlier findings, with the benefit of an extended sample.

A sub-period analysis reveals that industry effects dominate in sub-periods that span monetary integration in Europe and that encompass the timing of the Asian and Russian crises between 1997 and 1998. This sub-period analysis also reveals that countries dominate in the final sub-period that spans the global financial crisis. There is a notable downward trend in the relative importance of country effects from 2009 onwards across both samples, but in the case of emerging markets, there is some recovery for industry effects beyond 2011. However, for emerging markets, country effects remain dominant over industry effects for the vast majority of the sample period, including before, during, and after the global financial crisis. The message is clear, investors in emerging markets should pursue country based diversification strategies over an industry-focused approach, and the global financial crisis has not substantially changed this. For developed markets, while there is ample evidence of the advantages of pursuing an industry-focused diversification strategy throughout the 2000s, the rise in the relative importance of country factors surrounding the global financial crisis suggests that these benefits do not persist for the duration of the crisis.

Chapter 6 Mean-Variance Spanning Analysis of Industry and Country Motivated Diversification

6.1 Introduction

In this Chapter, I examine the mean-variance efficiency of industry- and country-focused portfolios relative to a portfolio containing both countries and industries. I use multiple tests of spanning, and a Sharpe ratio analysis. Three samples are examined; a global sample containing forty-four markets, a developed market sample containing twenty-three markets, and an emerging market sample containing twenty-one markets. I conduct a whole and sub-period analysis to examine if the relative benefits of industry- and country-motivated diversification have changed over the sample period, from February 6th 1998 to December 27th 2013. In particular, I examine if the recent crisis period has materially altered the mean-variance efficiency of pursuing an industry- or country-focused portfolio relative to a portfolio mixing both industries and countries.

In Chapter 5, I employ the traditional factor model of Heston and Rouwenhorst (1994) to identify the relative importance of industry and country factors in the decomposition of a stock's return. The more important of the two competing effects is a topic of considerable debate in the surrounding literature, and informs the investor of whether diversification strategy should focus on industries as a more potent contributor to stock return variability, or countries. Beyond this factor model, more recent studies examine the merits of industry and country motivated strategies in mean-variance space, consider Gerard et al. (2002), Ehling and Ramos (2003), Driessen and Laeven (2007), and Eiling et al. (2005; 2012). Unlike previous studies, in this chapter I employ a multitude of spanning tests across a highly global and longitudinal sample - in this way, I hope to make a novel contribution to the on-going debate on the relative merits of pursuing industry and country focused diversification strategies. Furthermore, I use a novel

approach to testing for significance differences in maximum Sharpe ratios that has yet to be applied to studies of the relative merits of industry and country based portfolio diversification. My analysis of the implications of the global crisis for the relative benefits of diversification over industries and countries is another valuable contribution to the surrounding literature.

I examine the propensity for countries or industries to improve upon the mean variance efficiency of an industry- or country-based portfolio. I conduct tests of spanning using both OLS and GMM specifications. I also employ three different test statistics to examine the null hypothesis that the benchmark assets span the extended set; the Wald, likelihood ratio, and Lagrange multiplier test statistics are all used and compared. In addition to the joint test of spanning, I conduct a step-down Wald test analysis following Kan and Zhou (2012). In addition to this, I apply Bekerart-Urias spanning tests, with and without the errors-in-variables adjustments, and the De Santis spanning test. Finally, I test for statistically significant differences in the maximum Sharpe ratio of the benchmark and the extended set using the Sharpe ratio test of Ledoit and Wolf (2008). I consider both the case when short-sales constraints are imposed, and when these constraints are relaxed.

I find little evidence that the benchmark industries or countries span the extended set of both industries and countries. This holds across all spanning tests. The implication is that investors should pursue a mixed strategy over a country or industry motivated approach. A step-down Wald test reveals that investors pursuing the tangency portfolio can invest exclusively in industries across a global and developed market sample. These results are also observed in a sub-period analysis across three separate sub-periods. However, a mixed strategy is preferred to a country-specific strategy across the full period in all three samples. I also find that there is stronger evidence of the economic benefits to pursuing a mixed strategy across both industries and countries, once short-selling is allowed. There

is no evidence that the global crisis has materially altered the mean-variance efficiency of pursuing an industry- or country-focused portfolio, relative to a portfolio mixing both industries and countries.

I examine the propensity for countries or industries to improve upon the mean-variance efficiency of a benchmark industry or country based portfolio using the following hypotheses.

H1$_0$. Benchmark countries span the extended set of countries plus industries.

H1$_A$. Benchmark countries do not span the extended set of countries plus industries.

H2$_0$. Benchmark industries span the extended set of industries plus countries.

H2$_A$. Benchmark industries do not span the extended set of industries plus countries.

In the event that the null hypothesis of spanning is rejected, investors can expect real gains from an investment strategy that diversifies across both countries and industries, as opposed to a country-only or industry-only approach. In contrast, failure to reject spanning implies that the benchmark is sufficient to reap all diversification gains. The issue of whether the chosen benchmark spans the extended set is further explored in the context of a sub-period analysis. This allows an inter-temporal examination of mean-variance efficiency and facilitates an investigation into the implications of the global crisis for the benefits of expanding the benchmark to the extended set of assets. Each of the above hypotheses is tested on a global sample, and also on developed and emerging market sub-samples.

The traditional spanning test involves the OLS regression of N test assets on K benchmark assets as follows:

$$\begin{bmatrix} r_1 \\ \vdots \\ r_N \end{bmatrix} = \begin{bmatrix} a_1 \\ \vdots \\ a_N \end{bmatrix} + \begin{bmatrix} b_{1,1} & \dots & b_{1,K} \\ \vdots & \vdots & \vdots \\ b_{n,1} & \dots & b_{N,K} \end{bmatrix} \begin{bmatrix} R_1 \\ \vdots \\ R_K \end{bmatrix} + \begin{bmatrix} e_1 \\ \vdots \\ e_N \end{bmatrix} \qquad (6.1)$$

The spanning hypothesis is examined initially using a Wald test analysis, wherein I test the following joint hypothesis:

$$H_0: \begin{pmatrix} \sum_{i=1}^{K} \beta_{j,1} - 1 & \dots & \sum_{i=1}^{K} \beta_{j,N} - 1 \\ a_1 & \dots & a_N \end{pmatrix} = 0_{2xN} \qquad (6.2)$$

I further conduct a step-down Wald test analysis. I follow this analysis with an examination of the likelihood ratio and Lagrange multiplier tests to analyse the robustness of my results. I then relax the assumptions of normality and homoscedasticity, and conduct an analysis using the stochastic discount factor (SDF) GMM Wald tests of Bekaert and Urias (1996) and De Santis (1993), as discussed in Kan and Zhou (2012).

The traditional interpretation of tests of mean-variance spanning refers to the benefits from an expansion or an extension of the investment opportunity set, in terms of mean variance efficiency. However, given the nature of my data, the benchmark and the test assets have overlapping components; for example, firms in the technology industry in the US are present in both the US index, and in the global technology portfolio. Therefore, I refer to a statistically significant test result as requiring a change in the weighting of countries in the global industry portfolios.

Economic significance is assessed using the Sharpe ratio analysis of Ledoit and Wolf (2008). I test for statistically significant differences between the maximum Sharpe ratio of the benchmark and the extended set in each case. A statistically significant difference in maximum Sharpe ratios implies that investors can realise gains from expanding to the extended set, while a lack of statistical significance means that these gains are not certain to occur. Intuitively, an expansion of assets can only lead to a positive or zero change in the maximum Sharpe ratio. For each case when a change in the Sharpe ratio is observed,

I test the statistical significance of this change and thus determine if there are real gains for investors from investing across the extended set of assets.

The remainder of this chapter is structured as follows. In Section 6.2 I describe the spanning tests in greater detail. Section 6.3 contains the results for the full sample period, while Section 6.4 presents the results of my sub-period analysis. Finally, Section 6.5 concludes.

6.2 Full period analysis: Global sample

6.2.1 Spanning test results

I first examine the global sample of developed and emerging markets. The results of each specification, with countries and industries as benchmark assets in turn, are presented in Table 6.1. There is overwhelming evidence in favour of a rejection of the null hypothesis of spanning, across both specifications. The results of the Wald, likelihood ratio, and Lagrange multiplier tests all indicate that neither industries nor countries span the extended set of both industries and countries. Spanning is rejected at the 1 per cent level for both specifications as indicated by the results of the joint Wald test. For a combined sample of developed and emerging markets, the addition of industries or countries, to a country or industry only portfolio, can shift the mean variance efficient frontier. This implies that neither industries nor countries are individually sufficient to achieve full diversification benefits, relative to a portfolio combining both industries and countries. Investors should pursue a strategy that combines both industries and countries.

This result is robust across the range of alternative spanning tests employed. Spanning is further rejected by the joint F-test, and by each of the GMM Wald tests, under the general distribution assumption and under the assumption that returns follow a

multivariate elliptical distribution; W_e and W_a. The spanning hypothesis is further rejected by both Bekerart-Urias spanning tests, with and without the errors-in-variables (EIV) assumption; J_1 and J_2, and also by the De Santis spanning test; J_3. Furthermore, each result is significant at the 1 per cent level. To identify the source of this rejection, a step-down Wald test is used. In the case of the benchmark industries, the rejection of the joint test is due to statistically significant differences in the global minimum variance portfolios at the 1 per cent level, with statistically indistinguishable tangency portfolios. This spanning of the tangency portfolios implies that relatively less risk-averse investors can pursue an industry-only strategy. For the benchmark countries, both the tangency and global minimum variance portfolios are statistically different at the 1 per cent level, and so all investor types should pursue a mixed strategy of both countries and industries.

The results of this full period global analysis imply that investors preferring the tangency portfolio can pursue an industry-only strategy, relative to a combined strategy, while a country-only portfolio is insufficient for all investor types. The relatively more risk-averse investor should always pursue a strategy that mixes both countries and industries.

6.2.2 Sharpe ratio test results

The results of this analysis are presented in Table 6.1. It is not possible to reject the null hypothesis of no difference in maximum Sharpe ratios between the benchmark and the extended set for either specification. This implies that there are no economic gains to investing in the extended set of both industries and countries, relative to an industry- or country-focused strategy.

Table 6.1 Mean-variance spanning results for the global sample

Benchmark Assets:	Industries	Countries
LM	432.54	248.22
	(0.00)	(0.00)
LR	565.10	283.87
	(0.00)	(0.00)
Wald	764.91	327.46
	(0.00)	(0.00)
F-Test	7.15	14.47
	(0.00)	(0.00)
$\alpha = 0$	1.12	3.156
	(0.28)	(0.00)
$\beta = 1$	15.15	27.41
	(0.00)	(0.00)
Joint P	0.00	0.00
SR Test	1.58	0.17
	(0.19)	(0.87)
SR Test Short Sales	1.17	8.20
	(0.24)	(0.00)
W	764.91	327.46
	(0.00)	(0.00)
W_e	245.46	109.37
	(0.00)	(0.00)
W_a	1157.39	149.93
	(0.00)	(0.00)
J_1	332.08	108.39
	(0.00)	(0.00)
J_2	337.04	112.57
	(0.00)	(0.00)
J_3	551.62	285.24
	(0.00)	(0.00)

Notes. The Table above contains the test statistics of the Wald (W), likelihood ratio (LR) and Lagrange multiplier (LM) tests of the spanning hypothesis based on OLS specification. It also contains the results of the spanning test with GMM specification for the general (W_a) and elliptical (W_e) distribution. Also presented are the results of the Bekerart Urias spanning tests with and without the errors-in-variables adjustments (J_1 and J_2, respectively), and the results of the De Santis spanning test (J_3). P-values are in parantheses. Also shown are the results of the Ledoit and Wolf (2008) Sharpe ratio test that tests if the difference in the maximum Sharpe ratio between the benchmark and the extended set is 0, with short-sales constraints (SR Test) and without short-sales constraints (SR Test Short Sales).

To test the robustness of these results, I relax the short-sales constraint. I find that the Sharpe ratio for the benchmark countries is significantly different to the Sharpe ratio of the extended set, implying that there are economic benefits from expanding beyond the benchmark countries and investing in the extended set of assets. This discrepancy in the results with and without short-sales constraints is striking.

6.3 Full period analysis: Developed and Emerging market samples

6.3.1 Spanning test results

I proceed with a separate analysis of developed and emerging markets. Table 6.2 presents the results of the various spanning tests using the developed market sample. The results are largely similar to those from the analysis of the global sample; this is unsurprising given the relative dominance of the developed markets over the emerging markets in the value-weighted global industry returns. See Table 3.8 of Chapter 3 for summary statistics on these industry returns. Spanning is rejected at the 1 per cent level across both specifications, as indicated by the Wald, likelihood ratio, and Lagrange multiplier tests. Neither industries nor countries are individually sufficient to achieve full diversification benefits relative to a portfolio combining both industries and countries. As with the global sample of both developed and emerging markets, the null hypothesis of spanning is further rejected by the joint F-test, and by each of the GMM Wald tests, the Bekerart-Urias spanning tests, and the De Santis spanning test, all at the 1 per cent level.

Table 6.2 Mean-variance spanning results for developed (DM) and emerging (EM)

Benchmark:	DM: Industries	DM: Countries	EM: Industries	Countries
LM	270.52	291.34	447.79	264.26
	(0.00)	(0.00)	(0.00)	(0.00)
LR	315.86	349.23	599.44	302.75
	(0.00)	(0.00)	(0.00)	(0.00)
Wald	372.94	424.63	835.94	350.11
	(0.00)	(0.00)	(0.00)	(0.00)
F-Test	7.26	18.66	16.55	15.99
	(0.00)	(0.00)	(0.00)	(0.00)
$\alpha = 0$	1.17	2.06	2.16	4.60
	(0.26)	(0.03)	(0.00)	(0.00)
$\beta = 1$	14.41	38.68	36.13	28.94
	(0.00)	(0.00)	(0.00)	(0.00)
Joint P	0.00	0.00	0.00	0.00
SR Test	0.99	0.05	0.02	3.43
	(0.38)	(0.97)	(0.99)	(0.01)
SR Test Short Sales	4.97	3.02	4.47	8.86
	(0.00)	(0.00)	(0.00)	(0.00)
W	372.94	424.63	835.94	350.11
	(0.00)	(0.00)	(0.00)	(0.00)
W_e	117.63	125.51	271.94	130.38
	(0.00)	(0.00)	(0.00)	(0.00)
W_a	479.65	182.54	761.57	345.06
	(0.00)	(0.00)	(0.00)	(0.00)
J_1	232.5	110.11	291.16	199.57
	(0.00)	(0.00)	(0.00)	(0.00)
J_2	233.56	112.1	295.64	203.02
	(0.00)	(0.00)	(0.00)	(0.00)
J_3	249.4	321.77	613.05	202.55
	(0.00)	(0.00)	(0.00)	(0.00)

Notes. The Table above contains the test statistics of the Wald (W), likelihood ratio (LR) and Lagrange multiplier (LM) tests of the spanning hypothesis based on OLS specification. It also contains the results of the spanning test with GMM specification for the general (W_a) and elliptical (W_e) distribution. Also presented are the results of the Bekerart Urias spanning tests with and without the errors-in-variables adjustments (J_1 and J_2, respectively), and the results of the DeSantis spanning test (J_3). P-values are in parantheses. Also shown is the results of the Ledoit and Wolf (2008) Sharpe ratio test that the difference in the Sharpe ratio between the benchmark and the extended set is 0, with short-sales constraints (SR Test) and without short-sales constraints (SR Test Short Sales)

I proceed with the step-down Wald test to examine the source of this rejection. As before, I find statistically indistinguishable tangency portfolios but statistically different global minimum variance portfolios at the 1 per cent level for the specification in which industries form the benchmark asserts. Examining the specification in which countries form the benchmark assets, the tangency portfolios are statistically different at the 5 per cent level, meaning that there is a loss in significance for this test relative to the global sample. The global minimum variance portfolios are again found to be statistically different also.

The results of this full period analysis across the developed market sample are the same as those for the sample combining both developed and emerging markets. Investors preferring the tangency portfolio can pursue an industry-only strategy, while relatively more risk-averse investors should pursue a strategy that mixes both countries and industries, while a country-only portfolio is insufficient for all investor types. However, with the removal of emerging markets from the sample, there is somewhat weaker evidence that the tangency portfolio of the benchmark countries is statistically different from the tangency portfolio of the extended set of both countries and industries.

In the final stage of this full period analysis, I examine the spanning hypothesis across the sample of emerging markets. Table 6.2 presents the results. As with the preceding analyses, the spanning hypothesis is rejected at the 1 per cent level, across both specifications, using the Wald, likelihood ratio and Lagrange multiplier tests. Again, the results suggest that a portfolio combining both industries and countries is preferable. As with the preceding analyses, the null hypothesis of spanning is also rejected by the joint F-test, the GMM Wald tests, and the Bekerart-Urias and De Santis spanning tests, all at the 1 per cent level.

The step-down Wald test reveals statistically different tangency and global minimum variance portfolios across both specifications at the 1 per cent level. Unlike the global and developed market samples, the tangency portfolio of the benchmark industries does not span the tangency portfolio of the extended set of industries and countries across the emerging markets. This implies that all investors should pursue a mixed strategy, even those who are relatively more risk-averse with a preference for the tangency portfolio. The results suggest that diversification across emerging markets should include investment across both countries and industries, as neither are individually sufficient to capture full diversification benefits. This is an important finding, with wider implications for the literature on investment in emerging markets.

This full period analysis reveals that the benchmark assets do not span the extended set of assets across any specification, using the global, developed or emerging market samples. Investors with a preference for the tangency portfolio can pursue an industry focused strategy across a global sample of developed and emerging markets, and likewise for a sample of exclusively developed markets, while all others should pursue a mixed strategy. Focusing on emerging markets only, all investors should include holdings of both countries and industries to achieve full diversification benefits.

6.3.2 Sharpe ratio test results

The results for this Sharpe ratio analysis are also presented in Table 6.2. Using a Sharpe ratio analysis, when short-sales constraints are imposed, it is not possible to infer any economic benefits to investing in the extended set over an industry or country motivated approach. However, this result is not robust to the relaxation of short-sales constraints, with significantly different Sharpe ratios once these constraints are no longer imposed. Once short-selling is allowed, there is greater evidence of benefits to investing in the extended set for both the developed and emerging market samples. This result is also

observed across the global sample. This analysis further highlights the need to examine differences in Sharpe ratios with and without the imposition of short-sales constraints.

6.4 Sub-period analysis

I carry out a sub-period spanning analysis for several reasons. A separation of the sample into multiple periods characterised by different regimes allows me to check the robustness of the spanning results identified in the preceding section, across different market states. By allowing for time variation in the relative benefits of industry and country motivated diversification strategies, this approach allows me to distinguish between temporary and long-term influences. Finally, this sub-period approach facilitates an explicit analysis of industry versus country based diversification strategies surrounding the global financial crisis. It further allows for a comparison of the relative merits of industry and country motivated strategies between the crisis period and historical time periods. Break-points are chosen using the Bai-Perron procedure as outlined in Section 3.8 of Chapter 3. The global, developed, and emerging samples are divided into the following regimes: February 6th 1998 to September 21st 2001, September 28th 2001 to October 17th 2008, and October 24th 2008 to December 27th 2013.

Table 6.3 presents the results of the sub-period analysis of the global sample of developed and emerging markets. The null hypothesis of spanning is rejected across both specifications in every sub-period according to the Wald, likelihood ratio, and Lagrange multiplier tests, at the 1 per cent level. This result persists across the F-test, and the GMM, Bekerart-Urias and De Santis spanning tests.

Table 6.3 Sub-period Analysis of the Global Sample

Benchmar	Industrie	Countries	Industrie	Countries	Industries	Countries
	06/02/1998 - 21/09/2001		28/09/2001 – 17/10/2008		24/10/2008 –	27/12/201
LM	150.38	98.04	287.52	119.20	247.04	166.39
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
LR	218.42	120.63	423.96	133.85	368.62	202.55
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Wald	344.89	152.01	683.22	151.38	607.46	251.13
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
F-Test	2.40	5.08	5.56	6.26	4.80	9.83
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$\alpha = 0$	0.88	1.80	1.30	2.65	1.73	6.42
	(0.69)	(0.07)	(0.11)	(0.00)	(0.01)	(0.00)
$\beta = 1$	4.54	9.13	11.99	10.30	9.34	13.72
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Joint P	0.00	0.00	0.00	0.00	0.00	0.00
SR Test	0.07	No	2.38	No difference	0.24	0.31
	(0.95)	difference	(0.06)		(0.81)	(0.77)
SR Test Short Sales	No difference	No difference	No difference	No difference	No difference	No difference
W	344.9	152.01	683.22	151.38	607.46	251.13
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
W_e	201.15	87.9	162.96	40.61	318.08	152.08
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
W_a	828.63	182.25	1385.86	171.61	1081.83	251.82
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
J_1	254.14	84.88	277.19	113.24	291.73	151.53
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
J_2	281.74	90.72	294.8	119.41	337.12	169.64
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
J_3	582.3	145.91	563.39	129.86	924.17	285.28
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

Notes. The Table above contains the test statistics of the Wald (W), likelihood ratio (LR) and Lagrange multiplier (LM) tests of the spanning hypothesis based on OLS specification. It also contains the results of the spanning test with GMM specification for the general (W_a) and elliptical (W_e) distribution. Also presented are the results of the Bekerart Urias spanning tests with and without the errors-in-variables adjustments (J_1 and J_2, respectively), and the results of the De Santis spanning test (J_3). P-values are in parentheses. Also show is the results of the Ledoit and Wolf (2008) Sharpe ratio test (SR) that the difference in the Sharpe ratio between the benchmark and the extended set is 0. *No difference* refers to the fact that there was no change in the maximum Sharpe ratio in moving from the benchmark to the extended set.

I proceed with a step-down Wald test. There is evidence of spanning of the tangency portfolios for the benchmark industries in sub-periods one and two, with a rejection of the spanning hypothesis only possible at the 5 per cent level in sub-period three. In the first and second sub-periods, there is substantial evidence that an industry motivated strategy is sufficient for the investor interested in the tangency portfolio, with weaker evidence of this in sub-period three.

A country-only portfolio is similarly appealing to this investor in sub-period one, while a mixed strategy is desirable in sub-periods two and three. For the benchmark countries, the spanning hypothesis can only be rejected at the 10 per cent level in sub-period one, but can be rejected at the 1 per cent level in sub-periods two and three. The evidence in favour of spanning weakens over time, as indicated by the decreasing value of the test statistic, and in the final sub-period surrounding the global financial crisis, there is the strongest evidence that a mixed strategy is preferable to a country or industry-only strategy for all investor types. The global minimum variance portfolios are statistically different across both specifications in every sub-period, and at the 1 per cent level. An examination of maximum Sharpe ratios reveals little room for economic benefits in expanding to the extended set of assets. For each case where there are differences in the maximum Sharpe ratio, it is not possible to establish the statistical significance of these differences.

In Table 6.4 I present the results of a sub-period analysis of the developed market sample. As with the full period analysis, these results largely mirror the results of the preceding analysis of the global sample. The null hypothesis of spanning is rejected across the Wald, likelihood ratio, and Lagrange multiplier tests. However, while this result holds for the F-test, and the Bekerart-Urias and De Santis spanning tests, there is evidence of spanning under the GMM specification for the general distribution, W_e. This

is seen in all three sub-periods for the benchmark industries, and in sub-periods two and three for the benchmark countries.

Table 6.4 Sub-period Analysis of Developed Market Sample

Benchmark Assets:	Industries	Countries	Industries	Countries	Industries	Countries
	06/02/1998 - 21/09/2001		28/09/2001 – 17/10/2008		24/10/2008 – 27/12/2013	
LM	73.87	100.07	181.32	95.13	158.51	169.30
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
LR	87.75	136.14	226.24	104.59	198.10	212.59
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Wald	105.82	193.10	289.73	115.52	254.57	274.67
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
F-Test	1.77	6.76	5.24	5.12	4.57	11.43
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$\alpha = 0$	0.49	0.58	1.40	2.13	1.90	5.45
	(0.98)	(0.83)	(0.11)	(0.02)	(0.01)	(0.00)
$\beta = 1$	3.30	15.40	10.03	8.38	7.85	18.71
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Joint P	0.00	0.00	0.00	0.00	0.00	0.00
SR Test	0.39	0.33	0.76	0.20	0.11	1.38
	(0.70)	(0.75)	(0.49)	(0.85)	(0.91)	(0.17)
SR Test Short Sales	0.87	0.44	1.09	0.02	4.21	4.83
	(0.41)	(0.67)	(0.31)	(0.99)	(0.00)	(0.00)
W	105.82	193.1	289.73	115.52	254.57	274.67
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
W_e	66.25	113.77	63.44	29.09	148.7	165.23
	(0.03)	(0.00)	(0.05)	(0.09)	(0.05)	(0.09)
W_a	183.81	185.65	402.62	132.17	398.74	241.1
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
J_1	91.06	73.9	155.66	93.721	175.31	143.97
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
J_2	92.77	73.81	161.11	96.873	197.23	162.13
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
J_3	137.62	183.61	151.41	112.911	277.77	276.7
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

Notes. The Table above contains the test statistics of the Wald (W), likelihood ratio (LR) and Lagrange multiplier (LM) tests of the spanning hypothesis based on OLS specification. It also contains the results of the spanning test with GMM specification for the general (W_a) and elliptical (W_e) distribution. Also presented are the results of the Bekerart Urias spanning tests with and without the errors-in-variables adjustments (J_1 and J_2, respectively), and the results of the DeSantis spanning test (J_3). P-values are in parantheses. Also show is the results of the Ledoit and Wolf (2008) Sharpe ratio test (SR) that the difference in the Sharpe ratio between the benchmark and the extended set is 0.

With this in mind, I proceed with a step-down Wald test, to identify the source of the rejection of the joint Wald test. As with the global sample, there is strong evidence of spanning of the tangency portfolios for both specifications in the first sub-period, with the evidence in favour of spanning weakening over time. The evidence in favour of pursuing a mixed strategy is strongest in the third sub-period. Investors interested in the tangency portfolio can pursue an industry-focused strategy in sub-periods one and two, and a country-focused strategy in the first sub-period. There is weaker evidence that an industry-focused strategy is advantageous in the final sub-period, while the evidence in favour of a country-focused strategy is weaker in sub-period two and entirely absent in the final sub-period. The global minimum variance portfolios are statistically different across both specifications in every sub-period, and at the 1 per cent level. The Sharpe ratio analysis reveals that it is not possible to infer any economic benefits in sub-periods one and two from expanding to the extended set of assets, with short-sales constraints. However, once short-sales constraints are relaxed, the final sub-period shows evidence of economic benefits to investing beyond benchmark industries or countries, to the extended set of both industries and countries.

Table 6.5 presents the results of a sub-period analysis of the emerging market sample. There is no evidence of spanning reported by the Wald, likelihood ratio, or Lagrange multiplier tests, and this result holds for the F-test, and the Bekerart-Urias and De Santis spanning tests. However, as with the developed market sample, there is evidence of spanning under the GMM specification for the general distribution, W_e, in all three sub-periods for the benchmark industries, and in sub-periods two and three for the benchmark countries. I proceed with a step-down Wald test, to identify the source of the rejection of the preceding joint Wald test.

Table 6.5 Sub-period Analysis of Emerging Market Sample

Benchmark Assets:	Industries	Countries	Industries	Countries	Industries	Countries
	06/02/1998 - 21/09/2001		28/09/2001 – 17/10/2008		24/10/2008 – 27/12/2013	
LM	140.91	77.06	206.63	120.05	180.00	123.24
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
LR	194.80	87.86	276.83	139.38	259.98	145.70
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Wald	286.53	101.06	387.13	163.58	402.82	174.88
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
F-Test	5.07	4.14	7.33	7.03	7.03	7.40
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$\alpha = 0$	1.72	2.78	1.15	1.35	1.23	3.53
	(0.03)	(0.00)	(0.30)	(0.20)	(0.23)	(0.00)
$\beta = 1$	9.69	5.63	15.76	13.65	15.57	11.87
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Joint P	0.00	0.00	0.00	0.00	0.00	0.00
SR Test	No	0.46	1.37	0.34	0.35	0.59
	difference	(0.67)	(0.22)	(0.72)	(0.74)	(0.57)
SR Test	0.10	1.62	3.20	2.14	0.86	3.94
Short Sales	(0.93)	(0.13)	(0.00)	(0.03)	(0.39)	(0.00)
W	286.53	101.06	387.13	163.58	402.82	174.89
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
W_e	157.86	66.61	106.15	48.52	162.08	84.48
	(0.03)	(0.00)	(0.05)	(0.09)	(0.05)	(0.09)
W_a	443.69	106.1	454.7	194.04	615.08	161.24
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
J_1	130.81	57.18	183.81	110.22	154.24	85.25
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
J_2	140.17	65.48	187.68	112.08	160.01	89.36
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
J_3	322.99	90.51	413.93	144.23	403.6	158.32
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

Notes. The Table above contains the test statistics of the Wald (W), likelihood ratio (LR) and Lagrange multiplier (LM) tests of the spanning hypothesis based on OLS specification. It also contains the results of the spanning test with GMM specification for the general (W_a) and elliptical (W_e) distribution. Also presented are the results of the Bekerart Urias spanning tests with and without the errors-in-variables adjustments (J_1 and J_2, respectively), and the results of the DeSantis spanning test (J_3). P-values are in parantheses. Also show is the results of the Ledoit and Wolf (2008) Sharpe ratio test (SR) that the difference in the Sharpe ratio between the benchmark and the extended set is 0. *No difference* refers to the fact that there was no change in the maximum Sharpe ratio in moving from the benchmark to the extended set.

The results of this step-down analysis are markedly different to the results for the global and developed market samples. The strongest evidence of spanning is found in sub-period two, with substantial evidence of the spanning of the tangency portfolios across both specifications. There is substantial evidence that the industry-only tangency portfolio spans the tangency portfolio of the extended set in every sub-period, while the tangency portfolio consisting of only countries, does not span the tangency portfolio of the extended set in sub-periods one and three. The global minimum variance portfolios are statistically different across both specifications in every sub-period, and at the 1 per cent level. A mixed strategy is recommended over a country-specific portfolio for investors in pursuit of either the tangency or global minimum variance portfolio in the final sub-period, while an industry-specific portfolio is sufficient for investors in pursuit of the tangency portfolio in this final sub-period. In terms of economic significance, as with the previous analyses of global and developed market samples, there are substantial differences in the results once short-sales constraints are relaxed. With short-sales constraints, no economic benefits are realised when expanding beyond the benchmark to the extended set of assets. This holds for every sub-period. However, in relaxing short-sales constraints, there are benefits to adopting the extended set of assets relative to the benchmark industries, and to a lesser extent the benchmark countries, in sub-periods two and three.

6.5 Conclusion

6.5.1 Economic Implications

Initial testing of the developed and global samples reveals that it is always preferable to pursue a mixed strategy, as neither industries nor countries are individually sufficient to capture all diversification benefits. This holds across the full sample, and in each of three

studied sub-periods, including that which corresponds to the global crisis. The results of the step-down procedure are less clear-cut, and highlight the importance of considering the investor's risk preferences when considering the relative appeal of industry or country focused strategies.

Focusing on the global sample, the relatively more risk averse investor should always mix countries and industries, as neither is individually sufficient given that spanning of the global minimum variance portfolios is always rejected. For the relatively less risk averse investor, industries are sufficient in sub-periods 1 and 2, from 1998 to 2008. There is some evidence that countries are sufficient in sub-period 1 also. The developed market sample gives similar results.

A sub-period analysis suggests that for global and developed market samples, the evidence in favour of mixing both countries and industries, rather than investing exclusively in either countries or industries, is strengthening over time. Focusing on the global crisis, it is preferable for both investor types to pursue a mixed strategy.

In the case of emerging markets, the relatively less risk-averse investor can invest exclusively in industries in sub-period 2 and 3 (with minimal evidence also in sub-period 1), between 2001 and 2013, and in countries in sub-period 2, between 2001 and 2008. The more risk-averse investor should always mix industries and countries, in every sub-period. Focusing specifically on the crisis, this means that the less risk-averse investor can invest exclusively in industries while the more risk-averse investor should pursue a mixed strategy.

6.5.2 Concluding Remarks

In this Chapter, I examine the mean-variance efficiency of industry- and country-specific portfolios relative to a portfolio containing both countries and industries, using various tests of spanning alongside a Sharpe ratio analysis. I examine three samples; a global

sample containing forty-four markets, a developed market sample containing twenty-three markets, and an emerging market sample containing twenty-one markets. I conduct a full period as well as a sub-period analysis, to examine if the relative benefits of industry- and country-motivated diversification strategies have changed over the sample period, from February 6th 1998 to December 27th 2013.

The results of the Wald, likelihood ratio, and Lagrange multiplier tests suggest that the benchmark assets never span the extended set of assets across any specification using any of the three samples, and this holds across the full period as well as across the three sub-periods. This implies that investors should pursue a mixed strategy over an industry- or country-only strategy. Further testing is done to examine the inter-temporal stability of this finding. A sub-period analysis suggest that for global and developed market samples, the evidence in favour of mixing both countries and industries, rather than investing exclusively in either countries or industries, is strengthening over time. However, using the GMM spanning test, there is some evidence of spanning of the extended set by both benchmark industries and countries, across the developed and emerging market samples. There is no evidence of spanning of the global minimum variance portfolios in any specification, across any sample or sub-period. Spanning is only detected among the tangency portfolios, which shows the importance of conducting a step-down Wald test analysis when employing tests of mean-variance spanning. Finally, I find that there is stronger evidence of the economic benefits to pursuing a mixed strategy once short-selling is allowed, with substantial differences in the results between the case when short-selling is constrained, and when these constraints are relaxed.

This chapter offers a valuable contribution to the literature on the relative benefits of industry versus country based diversification strategies. I use a wider array of spanning tests than used in previous studies of the relative importance of industry versus country

factors. I further compare the results for separate developed and emerging market samples, and examine the implications of the global financial crisis for this debate - no previous studies have examined the mean-variance efficiency of industry- and country-motivated diversification across these domains to-date. Finally, I employ a test of the statistical significance of differences in maximum Sharpe ratio that has not been previously employed in the surrounding literature.

Chapter 7 Conclusion

7.1 Introduction

The global integration of equity markets remains a topic of considerable debate among scholars of international finance. Following from this, the extent to which investors benefit from the international diversification of a portfolio is continuously being reassessed in the literature. Diversification benefits depend upon minimal or negative linkages between the underlying assets. However, the trend toward globalisation, financial market liberalisation, and monetary and fiscal consolidation that characterises the 1990s and 2000s, poses a direct challenge to the idea that national equity markets are sufficiently dissimilar to justify their use, by international investors, as a means of risk reduction. The extent to which the 2008 financial crisis was propagated globally gives further credence to the importance of identifying and characterising the linkages that exist between equity markets. Furthermore, the differences that exist between developed and emerging market classifications, from capitalisation and liquidity, to the extent of integration with the world market, warrants a separate and comparative analysis of linkages across these groups.

This thesis contributes to the literature on market linkages and international portfolio diversification. I conduct a thorough and rigorous analysis that characterises the linkages that exist among developed and emerging markets in a dynamic framework. I further contribute a robust analysis of the implications of the global financial crisis for these market linkages. The convergence of integration levels among emerging markets, to those integration levels seen among developed markets is an important result, and one that inspires and motivates further analysis of the relative benefits of diversifying across separate developed and emerging market samples.

In addition, the relative importance of industries and countries in the diversification decision of an investor is explored. The country versus industry debate is tackled using two popular methods in the surrounding literature. I adapt the frequently employed factor model to a recursive framework that allows me to track the dynamics of the relative importance of industries and countries in stock return determination cross a large and global sample. In mean-variance space, I further examine this debate. I use a wealth of alternative spanning tests and a previously unused Sharpe ratio analysis, to contribute a rigorous study and offer a reliable and robust perspective on this on-going debate.

This chapter presents some concluding remarks for the thesis. The remainder of the chapter is structured as follows. Section 7.2 summarises the main results and findings of each chapter. Section 7.3 addresses the limitations of this thesis and suggests areas worthy of further research. Section 7.4 concludes this chapter and the thesis.

7.2 Main Findings and Contributions

In Chapter 2 I offer a synthesis of the vast literature in the area of equity market integration and international portfolio diversification. Across three sub-headings, I discuss the literature that is of key importance to this thesis. I examine the various techniques used in analysing market linkages, and the regional focus of different studies. I note the trend in the literature towards the recognition that market integration is growing. I further detail the literature on the country versus industry debate in international portfolio diversification. I present the findings of earlier papers that identify a growth in the relative importance of industry factors at the turn of the century, and I identify a gap in this literature regarding the implications of the global crisis for this debate. I also note the substantial ambiguity that exists regarding the findings of these papers, and the conclusions drawn regarding the relative importance of industry and country factors. Finally, in this chapter I present previous studies that have examined the

implications of crisis periods, or of excessive volatility, for market linkages and the benefits of international portfolio diversification. I discuss the prevalence of studies that examine the Asian and Russian crises, and note that the global crisis remains relatively understudied across these two domains.

Chapter 3 discusses the data and methods used in examining each of my central research questions. I begin by presenting my research paradigm, which discusses the role that positivism and empiricism play in my analysis. I present summary statistics and some preliminary analysis of my data. I justify my chosen methods, examine their origin, and describe their application to my data in the context of my central research questions.

In Chapter 4 I present the results of a global and longitudinal analysis of equity market linkages. I use country-level price indices, and in the context of a recursive cointegration and dynamic conditional correlation analysis, I track the evolution of global equity market integration over the past nineteen years, between January 1995 and December 2013. I further examine if the global financial crisis, or any previous crises captured by my sample, have materially altered the nature of market linkages. I find that market integration is time-varying and volatile across both developed and emerging markets. Emerging markets integrate later than developed markets, but do appear to converge. Developed markets are generally more integrated. Market linkages are time-varying and volatile. The first half of the 2000s can be associated with stable levels of integration, with significant volatility throughout the rest of the sample. The sub-period characterising the crisis and its aftermath, is marked by strong and stable market linkages among European markets. While linkages between Asian-Pacific markets during this time are noticeably more volatile, they are strong and rising.

In Chapter 5 I present my analysis of the relative importance of industry and country effects in stock return determination. I use a recursive panel data approach, as an alternative to the cross-sectional analysis of Heston and Rouwenhorst (1994), to track the evolution of the industry-to-country effect ratio for the period between January 1995 and December 2013. I find that industry effects are marginally bigger for developed markets across the full-period, while country effects dominate in emerging markets during this time. The relative importance of industry and country effects is time-varying. Among developed markets, country factors are more important between January 1995 and November 1997, and between October 2008 and December 2013. Industry effects dominate significantly in the time between these two sub-periods. For emerging markets, country effects remain dominant over industry effects in all sub-periods.

In Chapter 6 I present the results of my spanning analysis. I use a variety of spanning tests, not commonly used together in the surrounding literature, to ensure a robust and thorough analysis of the mean-variance efficiency of industry- and country-focused diversification strategies. I find that an expanded set of assets that includes both industries and countries is generally preferable to a set that focuses exclusively on industries or countries. Furthermore, a sub-period analysis suggests that for global and developed market samples, the evidence in favour of mixing both countries and industries, rather than investing exclusively in either countries or industries, is strengthening over time. Using a Sharpe ratio analysis, that is previously unapplied in studies of industry versus country factors, I find that there is stronger evidence of the economic benefits to pursuing a mixed strategy once short-selling is allowed. However, with short-sales constraints, it there is no evidence of economic benefits from expanding to the extended set of assets, beyond investment in either countries or industries alone.

7.3 Limitations and Future Work

The factor model conceived by Heston and Rouwenhorst (1994) is an integral part of my analysis in Chapter 4, and still receives widespread application in the surrounding literature. I use a panel data analysis, which improves on this model, allowing for statistical significance among the estimated industry and country effects. However, this factor model is limited in other ways. The extent to which a firm can be classified as belonging to an individual country or industry is debatable. Future studies can further expand upon the traditional four-factor model, and allow for a more complex taxonomy of firms.

In Chapter 4 I identify a convergence of integration levels among emerging markets to the level of integration among developed markets. While developed markets become more integrated relatively early, emerging market integration appears to happen later, but at a greater pace. This is worthy of further analysis that would determine the underlying causes of this. Subsequent analysis on the determinants of integration among emerging versus among developed markets would also be informative.

I assess differences between emerging and developed market samples throughout. However, my analysis does not include the frontier equity markets. This is due to data limitations relative to developed and emerging markets, and also due to their relative inaccessibility from the investor perspective. However, future studies might consider alternative market classification systems, such as that proposed by FTSE that separates emerging markets into advanced and secondary emerging market categories.

Furthermore, a finer examination of the ways in which markets are classified, perhaps combining multiple country classification systems such as both FTSE and MSCI for countries. A deeper analysis and separation of markets by the criteria used in identifying them as developed, emerging, or frontier by these classification systems, would enable

me to identify the elements of this classification by which differences in integration levels, and the importance of country and industry factors, vary. A deeper analysis at the industry level would also benefit this study. I use Datastream level 3 indices, which classified industries across ten broad groupings. A finer specification of industry would allow for a more in-depth analysis of industry factors.

Relatively few studies test for statistical significance in differences between maximum Sharpe ratios. The procedure used in this thesis, as proposed by Ledoit and Wolf (2008), could be used in future studies that conduct a Sharpe ratio analysis. In general, future studies that utilise a Sharpe ratio analysis should examine the statistical significance of their results.

This thesis considers a macro approach in examining the benefits to international portfolio diversification. This macro analysis establishes that diversifying across both industries and countries is beneficial in terms of mean-variance spanning. Future studies could build on these results, by contributing a micro analysis. That is, focus on the firm level and consider the relative benefits of investing in firms that are more geographically diversified versus firms that are more industrially diversified.

I make a novel contribution in explicitly examining the implications of the global financial crisis for market linkages, and for the debate on country versus industry factors in portfolio diversification. However, my analysis of periods surrounding the global financial crisis would benefit from an extended post-crisis sample. Studying and understanding the crisis in the context of a larger time span would allow us to distinguish between temporary fluctuations and longer-term trends or patterns.

Finally, this thesis considers the US perspective, with analysis of data denominated in US dollars. This is a standard approach in studies of international finance. However, a replication of parts of this analysis using local currencies would ensure that these results

are robust to currency type, and would also offer the perspective of a European or Japanese investor, for example.

7.4 Conclusion

This chapter synthesises the primary conclusions from the thesis. It identifies the limitations of my research and outlines the possibilities for future work. This thesis was structured into multiple sections as outlined in Chapter 1. I began by introducing the research topic and presenting my central research questions (Chapter 1). I then presented a thorough review of the surrounding literature (Chapter 2). I followed this with a discussion of the data and methods used in my analysis throughout the thesis (Chapter 3). I then presented the results of three empirical chapters. These included: a characterisation of global equity market linkages using developed and emerging markets, while drawing upon evidence from the recent global crisis (Chapter 4), an investigation into the evolution of the relative importance of industry and country effects in stock return determination (Chapter 5), and an examination of the mean-variance efficiency of industry- and country-motivated diversification strategies using a multitude of alternative spanning tests (Chapter 6).

My analysis confirms that equity markets are integrated. I find greater integration among groups of developed equity markets, compared to emerging markets. I also confirm that market linkages are time-varying and volatile, and so must be understood in a dynamic framework. For developed markets, there is substantial integration in the post-1997 period, and this is maintained throughout the sample. Emerging markets integrate later than developed markets, generally in the post-2005 period, but they integrate at a rapid pace. I also observe different patterns of integration around the world. For example, Asian markets are most integrated when European markets are not, and vice versa. This result lends to the importance of comparing linkages between different regional or

economic groupings. It further lends to the importance of examining linkages in a dynamic setting.

As a natural follow on from the findings of Chapter 4, I find that industry factors are marginally more important than country factors across a developed market sample. Meanwhile, country factors dominate in emerging markets. It is expected that country factors would have a reduced role in a more integrated world, and this is reflected in the results for Chapters 4 and 5. A recursive analysis reveals that industry factors are more important in developed markets for much of the studied period, from January 1995 to December 2013. Conversely, country factors consistently dominate in emerging markets throughout this sample period. In terms of mean-variance efficiency, a mixed strategy is always preferable to a strategy that prioritises industries or countries. This result is robust across a multitude of alternative spanning tests, and holds across every sub-period studied. I find substantial differences in the results of a Sharpe ratio analysis with and without short-sales constraints. I find no evidence of economic benefits from investing across both industries and countries, relative to investing in industries or countries, once short-selling is restricted. However, in relaxing short-sales constraints, it is apparent that these benefits exist.

I have outlined my contribution to the literature extensively throughout this chapter; however, my results also have implications beyond the spheres of academia. Investors seeking the benefits of diversification from investing across developed or emerging equity markets must consider several key points. It is important to recognise the substantial linkages outlined in Chapter 4 of this thesis, and to identify that market integration is time-varying, and varies by market classification, and geography. Portfolio managers should further consider differences in the relative importance of industry and country factors between those markets classified as developed and those classified as

emerging. A sub-period and recursive analysis finds that this result persists across the time-period that encompasses the global crisis. In mean-variance space, an investment strategy that prioritises either countries or industries is insufficient to achieve full diversification benefits, and a mixed strategy should be pursued.

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