UNIVERSITY OF SOUTHAMPTON

Faculty of Social Sciences

School of Management

EVALUATION OF THE BENEFITS OF INVESTMENT DIVERSIFICATION TO EMERGING FINANCIAL MARKETS WITH REGRESSION-BASED TESTS OF MEAN-VARIANCE SPANNING: UK INVESTORS' PERSPECTIVE

By

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ABSTRACT

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EVALUATION OF THE BENEFITS OF INVESTMENT DIVERSIFICATION TO EMERGING FINANCIAL MARKETS WITH REGRESSION-BASED TESTS OF MEAN-VARIANCE SPANNING: UK INVESTORS' PERSPECTIVE

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Emerging markets have become the focus of attraction for international investors wishing to reduce portfolio risk. From the standpoint of US investors, several studies document evidence of substantial gains from diversification to emerging markets. Such studies employ one test method in examining the benefits from emerging market investment. In contribution to the literature on diversification to emerging markets this study investigates the benefits to UK investors from diversifying developed market portfolios to emerging financial markets using five tests of mean-variance spanning. The study is based on the equity return indices of five developed markets and fourteen emerging markets grouped first, as a standalone asset and second as four assets; South-east Asia, Latin America, Eastern Europe and Southern Africa.

Preceding the empirical work are preliminary analyses that evaluate the expected returns, risk, correlations among the developed and the emerging markets and among the emerging markets themselves. The conclusions from this are that, compared to the developed markets, emerging markets have higher expected return and higher volatility. Besides, they have low correlation with one another and with the developed markets. By implication, the addition of emerging markets to developed market portfolios can be beneficial. In order to empirically substantiate these observations, four tests: the F-test, the likelihood ratio test, the Wald test, the Lagrangian multiplier test of spanning were employed to examine whether the addition of emerging market significantly shift the efficient frontier for the developed market portfolios.

The conclusion from this is that, irrespective of the method of classifying the emerging markets or the version of the spanning test that is employed, UK investors can benefit from expanding developed market portfolios to emerging markets. However, the benefits are found to be traceable to specific markets within geographical regions, implying that investors would need to be selective in undertaking emerging market investment. As a further investigation, the returns are divided into two sub-period portfolios and an additional test procedure, the Generalised Methods of Moment Wald test, is introduced. The evidence from this analysis confirms that diversification to emerging markets is beneficial but that the benefits are time-varying. In addition, there are variations in the evidence from the different spanning tests.

Finally, following Bekaert and Urias (1999) and Rowland and Tessar (2004) the economic significance of the benefits is examined based on the incremental Sharpe ratios that emanate from adding the emerging markets to the developed market portfolios. The results suggest that examining both the economic and statistical significance of diversification benefits is more informative. Overall, this study concludes that emerging markets provide diversification benefits to UK investors similar to that reported for US investors and that greater benefit derive from Eastern European and Latin American markets. The evidence of benefit seems to depend on the test method employed, the time period of the analysis, the appropriate choice of emerging market and whether or not there are short-sale constraints in the market(s) selected.

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1.0 Introduction

Emerging markets have become the centre of considerable interest from investors in the developed financial markets in the quest for opportunities for improving portfolio performance. The attraction of emerging markets stems from the belief that returns on emerging market assets exhibit characteristics that make the inclusion of emerging markets in developed market portfolios leads to significant reduction in portfolio risk.

Considered a standalone asset, emerging markets provide higher expected return as well as higher return volatility than the developed markets, when measured over the medium to the long term. More importantly, returns on emerging market assets tend to have lower correlations with returns on developed markets and lower correlations among themselves (Bekaert and Urias (1999)), implying that the addition of emerging markets to developed market portfolios should provide diversification benefits.

More so, financial market liberalisation and deregulation (Gilmore and McManus (2002)), technological innovation that allows easy cross-border capital movement (Ayuso and Blanco (2001)), and the growing similarities in industrial structure, have led to increased correlation among developed market returns. This, in addition to the relatively low expected returns on developed market assets (Harvey (1995)), had translated into reduced benefits from portfolio diversification to developed markets; making emerging markets the new opportunities for reducing global portfolio risk[1].

The gains from emerging market investment have been emphasised in most prior studies. For instance, Speidell and Sarpenfield (1992), fascinated by the prospects of emerging market investment, argue that *diversification free lunch awaits* international investors in emerging equity markets and propose the allocation of between 10% and 15% of investment funds to emerging market assets. However, recent researches on emerging market investments are rather less optimistic about the diversification benefits that emerging equity markets are argued to offer to international investors.

[1] See Errunza (1983)

Particularly, and as will be seen in Chapter Two, studies examining diversification benefits in terms of whether emerging market returns are spanned by developed market returns, in the sense of Huberman and Kandel's (1987) test of mean-variance spanning, seem to report mixed evidence. Harvey (1995), using the F-test of mean-variance spanning, reports significant diversification gains while DeRoon, Nijman and Werker (2001), employing the Wald test of mean-variance spanning, do not find similar magnitude of diversification benefits as documented in the earlier studies.

Kan and Zhou (2001) assert that different versions of the spanning test when applied to even the same return data provide varying suggestions as to the existence of diversification gains, suggesting that implementing more than one test can lead to a more meaningful result. On the basis of this, this study seeks to contribute to the knowledge on emerging market investment by using five different versions of the regression-based test of mean-variance spanning to examine the benefits to UK investors from diversifying developed market portfolios to emerging equity markets.

The organisation of this study proceeds as follows: Chapter Two discusses the theories of portfolio analysis and risk diversification and recent applications in analysing international portfolios. Chapter Three discusses the sources of data and the manipulations required to present the data in a format that is suitable, first, for the purpose of examining the basic statistical properties of the returns on each market, and second to prepare the ground for the empirical analyses that come afterwards.

Chapter Four presents for each market the basic statistics measured in terms of expected return, standard deviation, coefficients of skewness and excess kurtosis, Jarque-Bera (JB) test of normality, correlation coefficients and parameter stability test. Chapter Five commences the empirical analysis with four tests of spanning.

Chapter Six extends the analysis in Chapter Five in two different ways. First, based on the results of the test of parameter stability, the analysis is conducted in two sub-periods as a means of verifying whether there is time-variation in the benefits from diversification. Secondly, Chapter Six re-examines all the results in Chapter Five using Generalised Methods of Moment (GMM) Wald Test as an additional test.

Chapter Seven brings the empirical analysis to completion by examining the economic significance (i.e. quantification) of the diversification gains reported in Chapters Five and Six. Chapter Seven is meant to show that the statistical tests in Chapters Five and Six are necessary but could be insufficient as basis for drawing conclusions on diversification benefits hence economic significance of the benefits need be tested. Chapter Eight provides the summary and conclusions from this study.

This study differs from previous studies on portfolio diversification to emerging markets in many respects. First, unlike the existing studies that mostly employ one statistical test at a time, this study implements different versions of the test of mean – variance spanning and thus provides more comprehensive insights about the benefits to developed market investors from expanding equity portfolios to emerging markets.

Secondly, this study takes a different direction with respect to the perspective from which the benefits from diversification are being investigated. The existing studies have basically concentrated on examining the benefits of portfolio diversification to emerging markets from the standpoint of US investors. This study takes the viewpoint of UK investors and tests whether, similar to their US counterparts, benefits can be achieved by diversifying developed market portfolios to emerging markets.

Thirdly, this research differs from prior studies in that it attempts to isolate and specifically examine emerging markets in Southern Africa and Eastern Europe in as much detail as Asian and Latin American markets. Prior studies scantily discuss African and Eastern European markets. Therefore the existing evidence seems to centre largely on South-east Asian and Latin American markets, thus limiting the amount of information on opportunities in emerging markets for global investors.

Finally, this study is different in that, studies using similar tests emphasise mostly the statistical significance of diversification benefits. In the spirit of Bekaert and Urias (1996) the efforts is made in this study to examine, using Sharpe ratios, the economic significance of diversification benefits in order to shed more light on the evidence from the statistical tests and on the magnitude of the benefits from diversification.

2.0 Portfolio Analysis and International Diversification

Studies on international diversification have mainly followed the theories developed for analysing domestic portfolios. In general, domestic portfolio analysis began from the mean-variance portfolio theory, the subsequent development of which gave birth to what has come to be termed the capital asset pricing model (CAPM).

Later studies have been concerned with developing alternatives to the CAPM or testing its efficiency, leading to the Arbitrage Pricing Theory (APT), Intertemporal Capital Asset Pricing Model (ICAPM) and Consumption-oriented Capital Asset Pricing Model (CCAPM). A more recent development in this direction has been the attempt to package all the portfolio theories into one all-encompassing model. This has led to the development of the Stochastic Discount Factor (SDF) Model.

The application of portfolio theory in the international context had followed the chronology in which they have been applied in the domestic context. The primary objective of this chapter is to review the relevant literature on the development and application of portfolio theories in both the domestic and the international setting.

This chapter commences in section 2.1 with an overview of portfolio theory and risk diversification that led to the development of the CAPM. Section 2.2 takes this further by considering the alternatives to the CAPM while section 2.3 discusses the early applications of portfolio theories in the international context. Section 2.4 discusses diversification to emerging equity markets and section 2.5 examines the argument on whether international capital markets are segmented or integrated.

Section 2.6 examines the intertemporal stability of correlation among international equity market returns and section 2.7 reviews the literature on the drivers of correlation and volatility in international equity markets. Section 2.8 discusses the issue of home-bias in international investment, while section 2.9 provides the summary of the review of literature and the lessons derived for this dissertation. The chapter ends in section 2.10 with questions still not answered in the literature.

2.1 The Beginning of Portfolio Theory and Risk Diversification

In an important study, **Fabozzi, Gupta and Markowitz (2002)** sum up the intuition behind the mean-variance portfolio analysis and risk diversification as follows:

"C*onventional wisdom has always dictated not putting all your eggs in one basket. In more technical terms, this adage is addressing the benefits of diversification. Modern Portfolio Theory (MPT) quantified the concept of diversification, or "under-diversification," by introducing the statistical notion of a covariance, or correlation.*

In essence, the adage means that putting all your money in investments that may go broke at the same time, that is, whose returns are highly correlated, is not a very prudent investment strategy – no matter how small the chance is that any one single investment may go broke. This is because if any one single investment goes broke, it is very likely, due to its high correlation with other investments, that the other investments are also going to go broke, leading to the entire portfolio going broke".

This quotation stresses the motivation for the development of portfolio theory and the need for diversifying investment into multiple securities with different risk-return characteristics. The beginning of portfolio analysis and diversification of investment risk may be credited to the seminal works of **Markowitz (1952, 1959)**.

In the influential papers on mean-variance portfolio theory, Markowitz (1952 and 1959) formulated the portfolio selection problem as a choice of the mean and the variance of a portfolio of assets and proved the fundamental theorem of the mean-variance portfolio analysis, namely; holding constant variance, maximised expected returns, and holding constant expected returns, minimise variance.

Markowiz's (1952, 1959) model is framed in a single period investment horizon where investors form portfolios at the beginning of the period primarily to maximise expected returns given the level of risk, or minimise risk given the expected return. The measurement of returns in single periods and the assumptions that investors are risk–averse and have homogeneous attitude towards risk, allow risk to be measured by the variance (or standard deviation) of returns.

In Markowitz's (1952, 1959) postulations, the addition of new securities to a portfolio changes the portfolio's expected return and standard deviation according to the degree of covariation between the returns of the added securities and the returns of the existing securities in the portfolio. The optimal choice of portfolios available to the investor is thus bounded by a curve (efficient frontier) that is the upper half of a hyperbola depicting the trade-off between the risks and returns of various portfolios.

Investors, therefore, select their portfolios along the efficient frontier based on their tolerance for risk. In this sense, an investor with high tolerance for risk might choose a portfolio with a higher expected return, *up the frontier*, while a more risk-averse investor would most likely choose a portfolio with low return, *down the frontier*. However, it is not prudent, *for the sake of diversification*, for assets to be selected for inclusion in a portfolio only on the basis of their risk and return characteristics.

This implies that consideration must also be given to the co-movements among the returns of all the assets in the selected portfolio. Stressing on this, **Elton and Gruber (1997)** assert that taking cognisance of the co-movement in asset returns results in an ability to select portfolios that have the same expected returns but with lower risk than a portfolio constructed without consideration to the interactions between assets.

Sharpe (1964), Lintner (1965) and **Mossin (1966)** continue from this and independently build on Markowitz's (1952, 1959) model. They collectively developed the underlying equilibrium equation that relates securities' return to risk in a linear fashion. By introducing the market line they, as a result, redefine the efficient frontier bounding the various point sets (efficient set) in a risk-return plane from which investors select optimal portfolios. **Merton (1972)**, provides the analysis leading to the algebra from which the efficient frontier is mathematically derived[2].

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[2] The algebraic expression derived by Merton (1972) yielded three Efficient Set Constants that define the shape of the Efficient Frontier and form the basis of the tests used in Chapter Five of this study.

The independent works of Sharpe (1964), Lintner (1965) and Mossin (1966), pieced together, constitute the capital asset pricing model (CAPM). This implies that the CAPM originates from the combination of the premise that investors construct portfolios following the logic in the mean-variance analysis and the assumption (of the presence of) a risk-free security with a certain (or predictable) rate of return.

The presence of a risk-free security extends the investment opportunity set and expands the avenues for the selection of optimal portfolios beyond the upper part of the efficient frontier stipulated by Markowitz (1952 and 1959). Thus, the introduction of the risk-free rate into the market portfolio leads to the market line (with the risk-free rate as it intercept) that is tangential to the efficient frontier and by stretching further than the point of tangency, the market line now serves as the new boundary, *for the investment opportunity set*, along which investors choose optimal portfolios.

In order for equilibrium to be established, the market portfolio must contain all risky securities in the economy. Through that risks arising from individual securities are diversified away by their inclusion in the market portfolio leaving only risk resulting from the market to be priced in the portfolio returns (as compensation for investors).

From this, it follows that the CAPM can be presented in an equation linking the expected return of risky securities to the covariation with the returns on the market portfolio in a linear functional relationship. This equation simply states that the return on a security is derived as the risk-free rate plus a risk premium, representing the additional return required by investors in exchange for bearing the market risk.

Building on the above premise, **Black (1972)** introduces the concept of zero-beta portfolio. Black (1972) suggests that similar functional relationship can be obtained from a linear combination of the returns on the market portfolio with the returns from the zero-beta security. In other words, the portfolio efficient set can change as a result of the formation of a unique portfolio, lying on the efficient frontier, which is also a combination of the market portfolio with a security having zero covariance with the market returns (but the zero-beta security is different from the risk-free rate of return).

This means that the addition of a zero-beta rate to the market portfolio enables investors to choose, optimally, any combination of risk and return as permitted within the constraints of the investment opportunity set in a similar manner as could have been obtained in the presence of the risk-free rate[3] . Stated differently, Black (1972) shows that investors would not necessarily need actual riskless asset (e.g. T-bill rate) to construct the efficient frontier in order to select optimal mean-variance portfolios.

In contribution to modern portfolio theory, **Tobin (1958)** provides the necessary conditions under which the utility function of investors or the return distribution of assets would result in mean-variance portfolios being optimal. Tobin (1958) shows that under certain conditions, following the mean-variance model, the process of investment choice can be broken down into two phases. The first is the choice of a unique combination of risky assets and the second is a separate choice concerning the allocation of funds between such a unique combination and a single risk-free asset.

2.2 Later Developments in Portfolio Theory and Risk Diversification

Subsequent developments in portfolio theory have sought to achieve two major objectives. The first is criticising and deriving alternative models, dwelling on the weaknesses of the mean-variance portfolio theory. The second is testing the validity of its offspring, CAPM. One of such criticisms comes from Roll (1977). **Roll (1977)** criticised the CAPM for its undue emphasis on a single risk factor (covariance of security returns with the returns on the market portfolio) and unrealistic assumptions.

Earlier on, Ross **(1976)** had attempted to address the drawbacks of the CAPM by developing the arbitrage pricing theory (APT) as a testable alternative or a natural successor providing a multifactor extension of the CAPM under less restrictive assumptions. However, the APT is also not "assumption-free" as it assumes that arbitrage opportunities should not be present in efficient financial markets.

Arbitrage exists if investors can construct zero investment portfolios with a sure profit. In efficient market, profitable arbitrage opportunities will quickly disappear

[3] This theory is applied in the statistical method used in the empirical analysis in Chapter 5 where the returns on the global minimum-variance portfolios are employed as proxies for the risk-free rate.

because, as in the law of one price, identical securities should command identical prices since information about security prices passes quickly among investors. Ross (1976) relied on these assumptions to show that in order to prevent arbitrage; an asset's expected return must be a linear function of its sensitivity to some *k* set of common factors. However, the theory does not specify how large the number *k* is.

Roll and Ross (1980) in their investigation of the arbitrage pricing theory only help by stating that at least three and probably four factors are 'priced' in the generating process of returns. They do not specifically identify these factors which cause asset returns to systematically deviate from their expected values. This, therefore, leaves both practitioners and academics in a dilemma. With no evidence from the APT as to the sources of risk, several tests are needed to identify those systematic forces.

In this respect, **Chen, Roll and Ross (1986)** propose macroeconomic variables such as the growth rate of industrial production, unexpected inflation, the term structure of interest rate, and the risk premia. In a similar research, **Burmeister and McElroy (1988)** also suggest the use of macroeconomic variables such as default risk, time premium, unexpected inflation, changes in expected sales, etc. From a different direction **Jorion (1990),** in applying the APT in the international context, identifies exchange rate fluctuations as a possible candidate in the *k*-factors of the APT.

Both the CAPM and the APT are static models that ignore the multi-period nature of participation in the capital market. To address this limitation, **Merton (1973)** develops the intertemporal capital assets pricing model (ICAPM) in continuous time to add a multi-period flavour to the single-period capital asset pricing framework. This was meant to capture the multi-period nature of financial market equilibrium.

Merton (1973) assumes securities' returns follow a lognormal diffusion process with investment opportunity set varying over time. The time-variation in the investment opportunity set implies that the risk and returns attributable to any security is also time-varying. To this end, investors consider the effects of such variations in the investment opportunity set sufficiently significant to hedge (themselves) against it.

In ICAPM postulations, if any security provides higher returns under conditions considered unfavourable for the whole investment opportunity set, investors will want to hold that security as a hedge against further unforeseen adverse conditions. This, in turn, increases the demand for such a security resulting in higher equilibrium price, *if all other things are held constant.* On the other hand, securities that provide low returns in adverse conditions experience low demand. This is because investors reduce their holdings for such securities, leading to a fall in their equilibrium prices.

The ICAPM is just a slight modification of Ross' (1976) APT. They differ only to the extent that the first factor in the ICAPM is explicitly identified as related to the market portfolio. Moreover, the APT gives little guidance as to the number and nature of factors in the generating process of security returns, but the factors that appear in the ICAPM are stated as those that describe the evolution of investment opportunity set over time and for which investors care well enough to hedge their effects.

In this context, the ICAPM, at least, offers some hint allowing those interested a room to search for factors signalling a shift in the investment opportunity set. For instance, **Fama and French's (1993)** distress factors and **Ferson and Harvey's (1993)** use of dividend yields, term structure variables and risk-free interest rates as conditioning variables that are intended to capture changes in investment opportunity set may be argued to be prime examples of this type of research (searching for such factors).

As the search continues for the factors that suggest shifts in investment opportunity set, **Breeden (1979)** provided a logical extension to the models of asset pricing in the form of the consumption-oriented capital asset pricing model (CCAPM). Breeden's (1979) CCAPM relates security returns to risk, measured as the marginal utility of consumption. Thus, on the basis of the CCAPM, it is possible to relate the utility derived from additional dollar worth of consumption with the level of aggregate consumption in the economy in such a way that the marginal utility derived from consuming an additional dollar is dependent on the level of aggregate consumption.

This implies that when aggregate consumption is low, the model posits that the marginal utility investors derive from an additional dollar worth of consumption will be high. On the other hand, when aggregate consumption rises, according to Breeden

(1979), the marginal utility worth of a dollar of consumption also falls. This is because investors now attach less and less value to each dollar consumed. In this context, following the CCAPM, in periods of higher aggregate consumption when people can afford high and comfortable standards of living, people feel less and less better off with each additional dollar of consumption and vice versa.

Accordingly, the marginal utility derived from a dollar of consumption diminishes as aggregate consumption increases. This diminishing marginal utility of consumption, in turn, suggests that securities whose returns co-move negatively with the level of aggregate consumption in the economy (i.e. provide high (low) returns in periods of low (high) aggregate consumption) are likely to be highly demanded by investors. This increases the prices of such securities and thus lowers their expected returns.

Conversely, securities that co-vary positively with the level of aggregate consumption will command higher expected returns. This is because such securities provide higher expected returns during states of the economy when higher returns are least beneficial to investors so limiting their demand and lowering their prices which also increase the returns. In spite of its intuitive appeal, the CCAPM has not received the needed empirical support compared to the other models of capital asset pricing (e.g. CAPM).

For example, **Breeden, Gibbons and Litzenberger (1989)** do not find any evidence suggesting that the CCAPM performs better than the Sharpe-Lintner-Mossin CAPM, which it was intended to replace or enhance. Due to its poor empirical performance, several studies have sought to introduce modifications into the CCAPM model with the hope that the revised (modified) versions would perform better empirically.

In this direction, **Campbell and Cochrane (1999)** introduced a slow-moving habit in consumption or time-varying subsistence level added to the power utility function, where optimal consumption depends on aggregate consumption, to modify the optimal choices of consumption over time. **Barberis, Huang and Santos (2001)** also graft prospect theory into the intertemporal optimisation problem by modelling utility to be dependent upon the volatility of the representative investor's portfolio.

From a different direction, **Eichenbaum, Hansen and Singleton (1988)** bring labour choice into the agent's intertemporal optimisation problem and test the empirical performance of the model in explaining interest rate over time. However, no amount of modification has brought this or the other models to the same empirical and practical acceptance equalling that accorded to the Sharpe-Lintner-Mossin CAPM.

Because of the limitations of the CAPM and the failure of the alternative models to enhance or replace it, the search for a better asset pricing model continues unabated. Building on the CCAPM, **Hansen and Jagannathan (1991)** have introduced the stochastic discount factor (SDF) model. This demonstrates how a given set of security market data can be used to restrict the admissible regions for the means and standard deviations for the intertemporal marginal rate of substitution of consumers.

On the assumption that arbitrage opportunity is absent and that security returns follow the law of one price, they derive the lower bound for the volatility of the SDF and relate it to the mean-variance analysis to derive a duality relationship which has become a general diagnostic tool forming the basis of many tests of asset pricing.

An important application of the SDF model is in testing for the shift in the mean-variance efficient frontier resulting from the addition of a new set of securities to an existing optimal, *in a mean-variance sense*, portfolio of securities. **Cochrane (2001)** sums up by pointing out that virtually all asset pricing models (including those just discussed) can be viewed as special cases or simplified versions of the SDF model.

2.3 International Diversification of Portfolio Risk

Another important development in portfolio analysis has been the extension to the international context. This section discusses studies on international diversification with emphasis on portfolio diversification among the developed equity markets.

Grubel (1968) presents the seminal paper that first applied Markowitz's (1952 and 1959) mean-variance portfolio theory to the international setting. He argues that given less than perfect correlation between the returns on foreign assets and returns on domestic (US) assets, it may be beneficial for investors to incorporate foreign assets in their domestic portfolios in order to reduce the overall portfolio risk.

Grubel(1968) draws on lessons from macroeconomics to suggest that international diversification of portfolios constitutes an entirely new kind of world welfare gains from international economic relations, different from the traditional "gains from trade" and increased productivity flowing from the migration of factors of production.

According to Grubel(1968), international portfolios can be viewed as a special case akin to two-country, two-asset investment model in which quadratic programming can be applied to derive efficient frontiers depicting the investment opportunity sets that allow investors to select portfolios by choosing the appropriate weights.

Basing on this, Grubel (1968) examines the benefits to a US investor from diversifying equity portfolios to ten other industrialised countries[4]. He argues that US equities may present better risk-return profile than foreign securities[5] but due to lower correlation; diversification can allow a US investor to obtain higher expected return or lower risk than is achievable from restricting the portfolio to only domestic assets.

Using the mean-variance framework, Grubel (1968) finds evidence of substantial diversification gains to a US investor from expanding portfolios to international markets. However, he cautions that since the benefits documented derive from past (ex post) returns international diversification is beneficial only to the extent that past experiences (ex post returns) reasonably reflect future developments (ex ante returns).

Moreover, the gains appear to reduce dramatically when Japan, Australia and South Africa (the developing countries in the sample) are excluded or when the portfolio is extended to markets such as the UK, Germany and France, (the developed markets), a sign of reduced opportunities for diversification among developed equity markets[6].

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[4] The countries are Japan, Germany, UK, France, Canada, Germany, Belgium, Italy, Netherlands and South Africa.
[5] The US had higher expected return than Belgium, France, Netherlands, Canada and West Germany and lower risk than Italy, Japan, Netherlands, UK, South Africa and France (pp 1304, Grubel,1968)
[6] Grubel views Japan, South Africa and Australia as developing rather than developed countries.

Levy and Sarnat (1970), henceforth LS (1970), following Grubel (1968), also apply the mean-variance portfolio theory to investigate the benefits accruing to a US investor from diversifying equity portfolios to 28 foreign markets. Comparing the risk and returns on the US market with the risk and returns on the foreign markets, they find the US equities to present better risk-return profile than the equity returns on most of the other markets in their sample, apparently suggesting that a US investor would achieve greater benefits by limiting the portfolio to the domestic equities.

However, as in Grubel (1968), LS (1970) also assert that as long as the correlation between the returns on US equities and returns on foreign equities remain low, lower portfolio risk can be achieved through diversification. To demonstrate this, they divide the sample into five portfolios (A to E) leading to five efficient frontiers, mapping the risk-return relations for each portfolio onto the mean-variance space.

Thus frontier A derives from the portfolio of returns on all the 28 markets, frontier B derives from the portfolio of only high income countries, frontier C from the Western European countries, D from what they termed the common market countries[7] and E for the portfolio consisting of only developing countries. The US equities represent a single asset and stands as a single point (F) in their mean-standard deviation map.

By comparing the efficient frontiers and the risk and return of each portfolio (see pp. 673 of their paper), they draw conclusions similar to Grubel (1968) that international diversification allows a US investor to achieve better portfolio performance than could have been achieved from only domestic investment. Furthermore, much of the benefits result from the presence of Japan, South Africa and the developing countries of South America and Asia in the portfolio (high benefits from developing countries).

Lessard (1973) reaches similar conclusions for a US investor diversifying equity portfolios to four Latin American markets; Argentina, Brazil, Chile and Columbia, using monthly returns on 110 equities. As in the antecedent literature, Lessard (1973) also emphasises the significance of the degree of correlation in the analysis of the

[7] These include Belgium, Germany, France, Italy and the Netherlands. These were the members of the European Economic Community (EEC) at the time of LS (1970) analysis.

benefit from diversification. He combines the mean-variance portfolio theory with principal component analysis and investigates diversification gains in three periods.

Thus, as an initial step, Lessard (1973) employs the principal component analysis to highlight the similarities and relationships among the markets but, then, examines the gains from diversification based on the mean-variance portfolio theory by comparing the historical performances of the markets using two portfolio selection strategies; a mean-variance efficient portfolio and a naïve strategy which allocates equal weights to investment in each country, in addition to a portfolio of only domestic (US) assets.

Consistent with Grubel (1968) and LS (1970), Lessard (1973) also concludes that, in general, the internationally-diversified portfolios dominate the domestic portfolio of only US equities. This also suggests that diversification to foreign markets provides better risk-reduction than holding purely domestic portfolios of only US assets.

Solnik (1973) raises concern that small sample bias can occur in the above studies because diversification benefits are being examined based on market index returns that select only a portion of the stocks registered on the markets (countries). In Solnik's (1973) opinion, market indices do not adequately capture the investment opportunities in the countries examined and hence do not fully reflect the benefits.

He also applies the mean-variance portfolio theory to investigate the diversification benefit achievable by a US investor from diversifying equity portfolios to Japan and nine European markets using the bi-weekly returns from 1966 to 1971. Comparing the efficient frontiers for the index returns of the combinations of these markets with the risk and returns of the US equities, Solnik(1973) concludes that large potential gains can be achieved from international diversification. However, the study provides no solutions to the small sample bias that was identified in the earlier researches.

In a related study, **Solnik (1974)** takes the analysis further by studying the benefits of diversifying a US portfolio to Japan and seven European markets. However, this time, attempt is made to overcome the problem pointed out in Solnik (1973) by generating a number of international portfolios of different sizes using comparatively larger sample of individual stocks. This paper also applies the Markowitz-Tobin mean-variance portfolio technique to examine the seven major European stock markets and the US market based on the same sample from 1966 to 1971.

He finds that the risk associated with an internationally well-diversified portfolio can probably be just one-tenth (10%) of the risk associated with a typical portfolio of US stocks with the same number of holdings. Moreover, for investors from countries such as Germany and Switzerland, Solnik (1974) shows that the benefits from international diversification can be much greater since, compared to the US; those countries have fewer opportunities (for diversification) in their home equity markets.

As a continuation, the study compares the risk-reduction effect of international diversification to diversification across industries. This analysis initially argued in favour of inter-industry diversification as better than inter-country diversification. However, the paper fails to provide support for the inter-industry hypothesis; hence he concludes that inter-industry diversification is inferior to inter-country diversification. Despite this counter-intuitive result, Solnik's (1974) findings also buttress the evidence in support of benefits from international diversification.

Taking a different view, **Jorion (1985)** questions the validity of the international diversification benefits documented in the earlier studies. He argues that international diversification may be beneficial but relying on the classical mean-variance portfolio theory for evaluating the benefits can produce misleading results because of the failure to consider estimation risk (which can significantly obscure the benefits).

The earlier studies employing the mean-variance analysis in the international context seem to assume that the required inputs to the formation of portfolios (the variances, covariance and expected returns) are known with certainty. However, from Jorion's (1985) standpoint, in reality, that is not the case and since the past rarely accurately predicts the future, neglecting estimation risk while using past data can pose problems in portfolio analysis due to the instability of the composition of optimal portfolios.

In particular, portfolio weights are sensitive to variations in expected returns such that the addition of few return observations dramatically changes the portfolio holdings.

Moreover, rational investors take uncertainties into account in forming expectations and would probably consider estimators that are less subject to estimation errors.

In general, the variance and covariance of portfolios can be computed with relatively high degree of precision in comparison to the sample mean returns. Thus estimation errors result mainly from wide fluctuations in sample mean returns hence accounting for estimation risk requires the use of estimators other than the sample mean return.

In Jorion's (1985) argument, the class of estimators such as those proposed by Stein (1955) account for the effect of estimation errors more accurately. Therefore he developed and employed what he terms the Bayes-Stein estimation technique to examine the benefits to a US investor from diversifying equity portfolios to other industrialised markets. He reports that while international diversification reduces portfolio risk, controlling for estimation errors produces better risk reduction.

In a similar research, **Eun and Resnick (1986 and 1988)**, hereafter ER (1988), reiterate the essence of considering estimation errors in international portfolio analysis. In their view, using "ex post" in place of 'ex ante' estimates of parameter values in analysing the benefit of international diversification sidelines the impact of estimation risk resulting from parameter uncertainty. This, in turn, leads to overestimation of the potential gains from international diversification.

They extend the contention on estimation risk to exchange rate fluctuations and regime changes, explaining that switching from one exchange rate regime to another has strong impact on the benefits from diversification, considering that exchange rate fluctuations constitute a significant proportion of foreign investment risk. But even more essential is the fact that exchange rate risk is to a large extent non-diversifiable due to high correlation among changes in the exchange rates of many countries.

In this way, exchange rate fluctuation becomes another factor that aggravates estimation risk and thus reduces the gains from international investment. In this context, efforts to limit the impact of exchange rate fluctuation are appropriate in reducing estimation risk and hence the overall risk of international portfolios.

In order to incorporate these in their analysis of the benefits from international portfolios, they suggest the simultaneous use of two exchange risk reduction strategies; multi-currency diversification and forward exchange contracts on a currency-by-currency basis in addition to employing the Bayes-Stein estimation technique developed by Jorion (1985).

In this framework, ER (1988) test the benefits to a US investor from diversification to other developed markets based on four portfolio strategies which compare portfolios constructed using the Bayes-Stein techniques with simple mean-variance efficient portfolios. Consistent with Jorion (1985), ER (1988) conclude that the Bayes-Stein strategies, on average, dominate those portfolios using ex post parameters, implying that controlling estimation risk produces better assessment of diversification benefits.

Izan, Jalleh and Ong (1991) (hereafter IJO (1991)) replicate ER's (1988) methodology in the examination of the benefits accruing to an Australian investor from diversifying equity portfolios to eight industrialised markets using the equity market index returns for the period 1986-1989. In the footsteps of ER (1988), they construct and evaluate the performances of four different portfolios; an equally-weighted naïve portfolio, a certainty equivalent tangency portfolio, a minimum-variance portfolio, Bayes-Stein tangency portfolio and the Australian market index.

Similar to ER (1988) the study shows, for an Australian investor, that international diversification provides better portfolio performance than investing in only the Australian market index returns. Most importantly, the combination of hedging strategies with the Bayes-Stein estimators to control for both exchange rate fluctuations and estimation risk resulting from the classical mean-variance analysis, without short-sale constraints, provides far better portfolio performance.

From a different direction, **Odier and Solnik (1993),** hereafter OS (1993), assess the benefits from international diversification for investors from different countries. This paper employs similar methodology (Markowitz mean-variance portfolio analysis) as in Solnik (1973 and (1974) to examine the benefit of international diversification from the perspective of investors from Germany, United Kingdom and Japan.

As in Solnik's previous studies, OS (1993) also construct efficient frontiers for German, British and Japanese investors which show significant similarities between the optimal portfolio allocations for these investors and those derived earlier for US investors, suggesting that similar diversification gains can be achieved by investors in other countries in as much the same manner as their US counterparts.

Restricting their paper to only US and Japanese investors, **Eun and Resnick (1994)**, henceforth ER (1994), also report significant diversification benefits. They consider, from the standpoint of US and Japanese investors, the benefit of diversifying both bond and equity portfolios to international markets, using monthly return data for national bond and stock market indices from January 1978 to December 1989.

In the same steps as in ER (1988), ER (1994) report evidence of much greater potential gains from international diversification for US investors than for Japanese investors. Most essentially, for Japanese investors their analysis show that gains from diversification result mainly from reduction in risk, while for US investors the gains result largely from improvement in returns, rather than from risk reduction.

Contrary to the above studies, **Ho, Milevsky and Robinson (1999)**, employing short-fall risk analysis to examine the benefits of international diversification for US and Canadian pensioners report only marginal diversification benefit for US pensioners. They find that Canadian pensioners substantially benefit from international portfolio diversification but only minimal diversification gains accrue to their US counterparts.

This difference derives from the fact that the US equities are highly correlated with the international equity portfolios which tends to reduce any benefit from combining US equities with other equities. But, even for the Canadian investors, their analysis suggests that the benefit applies "atomistically". That is, if every single Canadian investor is to diversify internationally the benefit may be competed off. This shows that the opportunities for portfolio diversification to developed markets have reduced.

This is also confirmed by **Hanna, McCormack and Perdue (1999),** henceforth HCP (1999), in their examination of whether a US investor can benefits from diversifying equity portfolios to the other six members of the G-7 industrialised countries[8] using ten years of historical data of stock market index returns from 1988 to 1997. This study centres on how diversification from the Standard and Poor's (S&P) 500 to a two-market (two-country) portfolio impacts on the risk and return characteristics.

However, they find that a portfolio consisting of the S&P500 alone dominates any portfolio constructed from the S&P 500 and the market indices of the other G-7 countries, a sign of absence of diversification gains. This is attributed to the rising correlation between the returns on the S&P index and the returns on the other six members of the G-7 group of industrialised countries. As a result, they conclude that:

" *contrary to the expectation that the US markets and the equity markets of the other G-7 members move in opposite directions, this movement did not happen with enough frequency across the decade studied to justify the assertion that foreign gains will compensate for domestic losses*". By implication there are fewer opportunities for reducing portfolio risk with diversification among developed equity markets.

Errunza, Hogan and Hung (1999) came to a similar conclusion in their attempt to verify whether the gains from international diversification can be achieved without trading abroad. By employing the test of mean-variance spanning in both the regression-based and the SDF framework, they fail to reject the hypothesis that the frontier for each of seven developed markets; Australia, Canada, France, Germany, Italy and UK shift significantly (both statistically and economically) by adding international assets. This paper simply concludes that while investors need to be aware of foreign risks to which they are exposed, they (investors) no longer need to trade abroad in order to obtain internationally mean-variance efficient portfolios.

However, in the most recent study, **Rowland and Tessar (2004)** provide different evidence. They used the test of mean-variance spanning in the SDF model to study the diversification potentials of multinational firms and foreign market indices from the perspective of investors in the G7 countries; Canada, France, Japan, Germany, Italy, UK and US, over the 1984 – 1995 period. This paper finds mix evidence. That

[8] These are the UK, Germany, Canada, Japan, France and Italy

is, while the addition of multinationals provide benefits to US and German investors, with no benefits to the other investors, the addition of foreign market indices – which include multinationals – provide significant benefits to investors in all G7 countries.

Despite this evidence, the implications of the findings from this literature overall to international investors are obvious. The opportunities for portfolio diversification among the developed equity markets appear to be reducing over time. This has necessitated the search for other avenues for achieving international diversification.

2.4 Portfolio Diversification to Emerging Financial Markets

As the opportunities for diversifying equity portfolios among developed markets diminish, the focus of international investors has turned to emerging equity markets[9].

In summing this up, **Harvey (1995)** states: "In recent years a number of new equity markets have emerged in Europe, Latin America, Asia, the Middle East, and Africa. Little is known about these markets other than that the expected returns can be impressive and these markets are highly volatile. Importantly, the correlations of these equity market returns with developed countries' returns are low. As a result, it may be possible to lower portfolio risk by participating in emerging equity markets".

To verify this assertion, he employs the F-test of mean-variance spanning, supported by Monte Carlo simulation to examine, for a US investor, the benefits of diversifying a portfolio of 18 developed markets to 18 emerging markets. Harvey (1995) finds that due to lower correlation, emerging markets are not spanned by developed market returns. Thus, US investors can significantly improve the mean-variance performance of their developed market portfolios with diversification to emerging equity markets.

In a similar research, **Odier, Solnik and Zucchinetti (1995),** henceforth OSZ (1995), explain that emerging markets offer significantly higher expected returns as well as higher levels of volatility and coupled with low correlation with the world index of

[9] It can be argued Grubel (1968), Levy and Sarnat (1970) and Lessard (1973) all found diversification to developing countries (emerging markets) to be beneficial than to developed markets but it is just recently that the required attention appears to be given to emerging markets.

developed markets of about 0.31; developed market investors stand to benefit significantly from diversifying developed market portfolios to emerging markets.

By mapping the efficient frontiers for global asset allocation with and without emerging markets they report evidence of substantial gains from diversification to emerging markets and suggest that the minimum-risk strategy would be to invest 22% in emerging markets and 78% in developed markets, a proportion not too different from the relative GNPs for emerging and developed economies.

Also highlighting the benefits from emerging markets, **Bekaert and Urias (1996),** henceforth BU (1996), recast the test of mean-variance spanning in the SDF model to examine whether diversification to emerging equity markets provide benefits for US investors. They begin by arguing that all the earlier studies using country market index returns to measure the gains from diversification exaggerate the benefits.

Country index returns are compiled based on either all or a proportion of the stocks registered on each market, but as most countries restrict foreigners from owning certain proportion of the equities, not all the stocks included in the country market indices are within the reach of international investors or are attainable by them[10].

Thus, failure to recognise the impact of investment restrictions in the measurement process simply leads to over-estimation of the gains from diversification to foreign equity markets. Therefore, instead of country market index returns, BU (1996) propose using the returns on closed-end country funds[11] for evaluating gains from diversification to emerging markets in order to provide more reasonable results.

With the test of mean-variance spanning in SDF framework, BU(1999) evaluate the benefits from adding 42 emerging market closed-end funds to 38 developed market closed-end funds. However, they find conflicting evidence in that using unconditional test of mean-variance spanning; UK funds provide statistically significant gains with comparable US funds providing only minimal benefits to international investors.

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[10] This argument is discussed in more detail in Chapter Three on the choice of investment vehicle.

[11] Close-end country funds are mutual funds based in developed markets that specialise in investment in specific emerging markets. Because they invest only in those equities that are open to foreign ownerships, the returns on closed-end funds can be more attainable to foreigner investors.

On the other hand, in using conditional test they report significant diversification gains for both UK and US funds which seems to contravene the evidence under the unconditional test. To explain this conflict, BU (1996) further conduct Monte Carlo experiment to confirm the exact distribution of their test statistics which reveals that their unconditional test is less powerful compared to the conditional test.

In a later study, **Bekaert and Urias (1999),** hereafter BU (1999), question whether *diversification free lunch* exists in emerging equity markets in response to the suggestion by Speidell and Sarpenfield (1992). This paper introduces new investment vehicles; American Depository Receipts (ADRs) and open-end country funds, in addition to the closed-end country funds and their corresponding IFC investable indices and applies the test of mean-variance spanning as in BU (1996).

This study provides several new insights into emerging market investment. First, it shows that diversification benefit is sensitive to the time in which the analysis is conducted and in some cases to the investment vehicles used. Close-end funds, open-end funds and ADRs provide statistically significant diversification benefits in the 1993-1996 test periods (but the evidence of benefits seems weak in other periods).

Secondly, direct exposure to market index returns leads to diversification benefits that are at least as strong as those from managed funds or ADR portfolios. Thirdly, as emerging markets mature the restrictions and costs associated with participation in emerging markets are likely to reduce and the diversification potential reflected in market indices will gradually become attainable benchmark for all types of investors.

Finally, BU (1999) show that global capital market integration is likely to strengthen or increase the level of correlation between developed and emerging markets and reduce the benefit to investors from emerging market investment. To this end, they caution investors to be selective in proceeding with emerging market investment.

Stevenson (2000) examines the use of downside risk measures in the construction of optimal international portfolios with particular emphasis on allocations to emerging markets. In downside risk models, portfolio risks are measured in terms of failure to reach a target rate of return rather than deviation of returns from expectation[12]. In this sense, using downside risk allows asset pricing models to accommodate asymmetry in return distribution and avoid the limitations of the mean-variance portfolio theory.

In this framework, Stevenson (2000) investigates the benefits to a US investor from incorporating the returns on 15 emerging markets in a portfolio of equities from 23 developed markets over the period 1988-1997. He compares the performance of mean-variance efficient portfolios with portfolios constructed using downside risk, combined with Bayes-Stein estimators to correct for estimation errors (Jorion (1985)).

He documents significant benefits from diversification to emerging markets but also finds that the risk preferences of investors appear to play a role as to the attractiveness and the extent to which investors can benefit from investing in emerging markets. In brief, Stevenson's (2000) study portrays that the higher the degree of investors' risk aversion the less likely they can benefit from investing in emerging equity markets hence higher risk need be accepted to gain from emerging market investment.

DeRoon, Nijman and Werker (2001), henceforth DNW (2001), find the gains from diversification to emerging markets dissipating with the imposition of short-sale constraints. Their paper introduce short-sale constraints and transaction costs into the Wald test of mean-variance spanning to investigate whether a US investor benefits from diversification to emerging markets in Latin America, South-east Asia and Other markets consisting of four countries; Greece, Jordan, Zimbabwe and Nigeria.

They find that diversification is beneficial when investing in some individual Latin American or Asian emerging markets, but the benefit seem to evaporate when investing optimally in the combination of these markets, especially when short-sale constraints are imposed. To explain the reasons for this counterintuitive evidences, DNW (2001) suggest that their results are driven by the loss of power in the asymptotic mean-variance spanning test when more emerging markets are included.

[12] The use of downside risk measures in asset allocation was first suggested by Fishburn (1977) Bawa and Lindenberg (1977) and has recently been popularised by Navroski (1999).

Also imposing short-sale constraints, **Li, Sankar and Wang (2003),** employ Bayesian inference to measure the magnitude of the benefits to US investors diversifying equity portfolios to the Group of Seven (G-7) countries and eight emerging markets using the dollar-denominated monthly market index returns for the period 1976 to1999. Unlike the previous studies, this paper attempts to decompose the benefits from diversification into risk reduction, ψ, and return improvement, δ.

Their analysis reveals that when benefit is measured in terms of return improvement, diversification to emerging markets yields substantial benefit by way of improving expected returns than diversification to the G-7 countries. Thus, while investing in emerging market is costly, the magnitude of the gains is big enough to justify the cost of the investment when short-sale constraints are not imposed. But the imposition of short-sale constraints reduces the diversification benefit similar to DNW (2001).

However, when diversification benefits are measured in terms of reduction in risk only moderate changes in portfolio risk can be reported irrespective of whether short-sale constraints are imposed or not. In a sense, the imposition of short-sale constraints has minimal impact on the diversification benefit measured in terms of portfolio risk reduction. In short, the paper concludes that whether the benefits from international diversification are measured as risk reduction or return improvement, emerging markets offer diversification gains to US investors better than developed markets.

The main basis for the attention to emerging financial markets for international risk diversification derives from the belief that in comparison with the developed markets emerging markets are less integrated into the global financial market stream. The reason for this is traced to several factors. The next section takes this further.

2.5 Integration vs. Segmentation of International Equity Markets

The opportunities for diversification among developed equity markets are diminishing because developed capital markets have become more integrated. Equity markets are integrated when assets of identical risk command the same risk-adjusted expected return irrespective of their domicile (**Rangunnathan (2002)**) or when assets with perfectly correlated returns have the same prices regardless of where they are traded.

Stehle (1977) may perhaps be the first to investigate whether international capital markets are integrated or segmented. His study focuses on the extent to which the US equity market is integrated with the world equity market using the traditional Fama-McBeth (1973) cross-sectional, time series, model. Stehle (1977) finds inconclusive evidence. The study could not reject the integration or segmentation of the US capital market with the world capital markets. Jorion and Schwarzt (1986) have attributed this inconclusiveness to co-linearity between the US and the world capital markets.

On their part, **Brennan and Schwartz (1986)** also could not find evidence to accept the integration of the Canadian stock market with a North American market over the period 1968-1980. Again their study is argued to have serious limitations in that it fails to segregate purely domestic stocks from inter-listed stocks which account for about 30% of the Canadian market. Because of this, the dual-listed stocks are double-countered in the global North American index making the test of mean-variance efficiency of this global index difficult to interpret (Jorion and Schwartz (1986)).

Jorion and Schwarzt (1986), hereafter JS (1986), sought to address the limitations in these earlier studies by introducing a number of innovations. Firstly, they examine the degree of integration of the Canadian stock market relative to a global North American market that encompasses US and Canadian stocks. Compared to the US (as in Stehle (1977)), Canada represents a relatively smaller percentage of the world index which reduces possible collinear relationship with the world market index.

Secondly, they use maximum likelihood approach which according to Gibbons (1982) is more appropriate than the Fama-McBeth approach to the estimation of the betas and the cross-sectional parameters. Thirdly, they classify the Canadian stocks into purely domestic and inter-listed stocks following Brook and Johnson (1984) in order to avoid double-counting of inter-listed stocks (as in Brennan and Schwarzt, 1986). Finally, they delineate the causes of integration into legal and indirect barriers.

Despite these innovations, JS (1986) also could not find evidence suggesting the integration of the Canadian equity market with the global North American markets. In particular, they find that for the Canadian stocks, national factors not present in the global index form an essential component of the expected return, an indication of failure to find evidence of integration of the Canadian market with the world index. JS (1986) show that the Canadian stock market is segmented from the world capital market from 1968 to 1982 mainly due to legal barriers between the US and Canada.

Gultekin, Gultekin and Penati (1989), hereafter GGP(1989), provides a different perspective to the investigation of equity market integration by arguing that general test of international capital market integration (such as Stehle (1977)) are likely to be inconclusive for two reasons. First, because it is difficult to specify a testable capital asset pricing model in an open economy and second, because it is difficult to distinguish between segmentation due to objective restrictions to trade in financial assets and segmentation that arises from individual's attitude and irrationality.

They examine the integration of the Japanese capital market with the US, focusing exclusively on the elimination of capital controls in Japan in 1980 with the objective of identifying whether government policies, as opposed to investor attitudes and irrationality, are the only sources of segmentation. The paper employs the arbitrage pricing model in the international context with the view that if segmentation results from regime-switch, the price of risk in the US and Japan (expressed in one currency) would be different before 1980 but the difference would disappear afterwards.

To verify this, they estimate the risk premia based on 22 size-sorted portfolios with five-, ten-, twenty-factor analytic model within the international arbitrage pricing model and compute the chi-square test of significance for the vector of estimated risk premia to test their equality between the US and Japan. However, all three multifactor models suggest evidence of differences in the risk premia between the US and Japan during the regime of capital control with the differences reducing after the controls.

This implies that the relaxation of capital controls in Japan (government policy or change in economic regime) rather than the irrationality of individual investors has made the Japanese capital market more integrated with the US capital market.

In a paper challenging the findings in JS (1986), **Mittoo (1992)** also employs the Fama-McBeth model as in Stehle (1977) to re-examine the integration of the Canadian equity market with the US, using only stocks listed on the Toronto stock exchange (TSE) 35 index, from 1977 to1986. Unlike JS (1986), Mittoo (1992) adds the arbitrage pricing model to the ICAPM (used by JS (1986)) and also estimates the betas and cross-sectional parameters using the maximum likelihood technique.

In a similar step to JS (1986) this paper again categorises the Canadian stocks into purely domestic and interlisted stocks to enable the effects of different forms of barriers to investment on market integration to be highlighted. In this way, Mittoo's (1992) study differs from JS (1986) only in terms of the sample selected and the time period within which the analyses are conducted. Therefore, it would be expected that both studies would reach similar conclusions.

Mittoo's (1992) paper provides two contrasting results. The paper finds evidence of segmentation between the Canadian and the US capital markets in both the ICAPM and the APT frameworks in the period from 1977 to 1981 which is consistent with the evidence reported in JS (1986) for the period from 1968 to 1982.

However, over the period from 1982 to 1986, the study suggests integration of the Canadian capital market with the US capital market, contrary to the result in JS (1986). This implies that the Canadian capital market has migrated from a period of segmentation to integration with the world capital markets from 1982 onwards.

Campbell and Hamao (1992), hereafter CH (1992), follow GGP (1989) to examine the level of integration between the US and Japan in the 1980s after Japan's revision of the law on foreign exchange and trade. They test a single-latent-variable model for the US and Japanese stock returns using data from January 1970 to March 1990 and the MSCI world index in order to avoid the problem of having to specify benchmark with observable returns which they view to be the limitation in the previous studies.

CH (1992) measure the log dollar excess returns for both the US and the Japanese markets using the US Treasury bill rate as proxy for riskless return to examine whether common factors predict expected returns in both the US and Japan as evidence of integration of the two markets. They find that in the 1970s, in both countries, excess stock returns relative to the US Treasury bill rate could be predicted relatively easily using similar sets of domestic variables and that US variables were also able to forecast Japanese excess stock returns in the 1980s.

Moreover, despite evidence of perfect positive correlation (at 5%) between the US and Japanese capital markets, their study finds common international factors that can explain about 70% and 60% of the variance of returns in the US and Japan respectively and conclude that the two markets are at least partially integrated.

Heston, Rouwenhorst and Wessel (1995), hereafter HRW (1995), could not find evidences of the integration of the US equity market with the equity markets of 12 European countries. They employ unconditional tests to examine the integration of the US capital market with the capital markets of 12 European countries for the period 1978-1990. They begin by estimating a set of k risk factors that are meant to price asset returns. By assuming that excess returns on assets, measured in a common currency, follow a k-factor structure they test for integration versus segmentation by examining whether risk (or the factors) is priced uniformly across the countries.

Thus, if international capital markets are integrated, different countries would share similar risk factors so that vast difference in risk implies segmentation. Using the F-test of mean-variance efficiency proposed by Gibbons, Shanken and Ross (1989), their study fails to reject the hypothesis that the risk factors in individual markets are priced by the world market factors hence it could be concluded that the US and the European capital markets are integrated with the world capital markets.

While all the above studies concentrate on integration among developed equity markets, **Bekaert and Harvey (1995),** hereafter BH (1995), developed a regime-switching model to study the integration of a number of emerging markets to the world capital markets. Their study suggests that capital markets seem to evolve from periods of full segmentation to full integration depending on whether countries strengthen or relax policies limiting foreigners to participate in their markets.

To this end, a change in regime (political or economic) may cause segmentation or integration. Following this proposition, BH (1995) developed the regime-switching model which allows the conditional expected returns in a market to be affected by their covariance with a world benchmark portfolio when the market is perfectly integrated and by the variance of market returns when it is completely segmented.

By applying the model to a group of emerging markets over the period 1975 to 1992, they show that in most developing countries there is a regime-switch to integration when policies that favour foreign investment are instituted. For instance, they find higher degree of integration for the entire period for Malaysia, with less investment restrictions, and for Korea and Taiwan, which had substantial (but had subsequently relaxed) foreign ownership restrictions. For Taiwan a shift from segmentation to integration is noted in 1987 when foreign ownership restrictions were relaxed.

Levin and Zervos (1998) buttress this evidence using both international capital asset pricing model and the arbitrage pricing model to examine the integration of 27 emerging markets that had embarked on financial liberalisation. Using the estimation procedure developed by Korajczyk and Viallet (1989), they find significant evidence that many emerging markets have become more and more integrated with the world capital markets after relaxing their investment and dividend repatriation restrictions.

Groenen and Franses (2000) using graphical analysis to depict the time-varying nature of the correlations among thirteen stock market returns also find similar evidence. They demonstrate that within the period January 1986 to November 1988, the returns on a number of Asian stock markets, particularly Taiwan, correlated reasonably high with Madrid, Brussels and Milan and that Taiwan seems to have transformed from an emerging market to a more matured capital market.

The evidence of integration of emerging markets into the world financial system does not seem to be strong, but its implications for diversification to emerging equity markets is vital as strong integration implies higher co-movements of asset returns.

2.6 Intertemporal Stability of Correlations among Equity Markets

The evidence of integration among international equity returns means increased co-movement and reduction in the benefits from international diversification. The focus of many studies has been to examine whether the co-movements are stable over time.

Ripley (1973) provides the seminal paper on this subject by applying factor analysis to investigate the sources of systematic covariations among the returns on 19 equity markets. He identified four factors, namely; the incomes levels in different countries; the formation of currency area; the presence of dominant financial centre within an area and cross-listing by multinational firms, as the causes of systematic covariations among international equity market returns. However, Ripley (1973) fails to show whether the impact of these factors on asset return covariation is stable or unstable.

Panton, Lessig and Joy (1976), hereafter PLJ (1976), extend the analysis to incorporate the stability of covariation among international equity returns. They contend that Ripley's work is limited in terms of its failure to examine the stability or instability of the factors identified as the sources of covariation among international stock price indices. Using the weekly stock market index returns for the world's 12 largest equity markets for the ten-year period from 1963 to 1972, PJI (1976) test the intertemporal stability of the co-movements among international equity returns.

Unlike Ripley (1973), they employ cluster analysis, a stronger technique that facilitates the identification of groups and subgroups within a sample that have highly similar or dissimilar co-movement characteristics. The examination of the inter-temporal stability of the covariance structure commences by dividing their sample into four different year-periods; one-year, three-year, five-year and ten-year periods.

PLJ (1973) find considerable stability for the one-year and three-year periods with relatively weaker evidence of stability for the five-year periods. Most essentially, they observe that the high degrees of similarities are common among the developed equity markets in their sample (such as the US, Canada, Netherlands, Switzerland, and Germany and to a lesser extent, Belgium) that are open to international capital flows.

Moreover, strong ties are noticed between the US and Canada and less but identifiable ties between France and Belgium, Germany and Netherlands, and between the UK and Australia. The least similarities are between Austria and Italy. These relationships are also confirmed by the ten-year analysis. From this, it may be inferred that chances are higher for asset returns in the developed equity markets to share more lasting (stable) commonalities comparative to under-developed markets.

Philipatos, Christofi and Christophi (1983), hereafter PCC (1983), applying a different methodology also reach similar conclusion. They employed the Box-Jenkins technique and principal component analysis to determine if inter-temporal stability exists among the monthly stock markets indices of 14 industrialised countries in the 1959-1978 periods. PCC (1983) document a strong empirical support for the hypothesis of non-randomness and for the existence of stability in the inter-temporal relationships among the returns on all the 14 national stock market indices examined.

Following PCC (1983), **Maldonado and Saunders (1983),** hereafter MS (1983), also employ the Box-Jenkins estimation of autocorrelation function and spectral analysis. To these, they add non-parametric run tests to examine the stability of the correlation structure between the US market and the markets indices of Canada, Japan, Germany and the UK using twenty-one years of weekly data for the period from 1957 to 1978.

They find evidence of fairly stable inter-country correlations for periods within two quarters (i.e up to six months). However, for periods exceeding six months the study finds the correlation structure to be relatively unstable, and concludes that it is not possible to reject the hypothesis that the correlation structure follows a random walk. Based on MS' (1983) findings, it may be deduced that the covariation in international equity returns is intertemporarily unstable over periods exceeding six months.

Similar evidence seems to emanate from the study by **Kaplanis (1988)** who also examines the stability of the correlation and covariance matrices of monthly returns of 10 markets over a fifteen-year period from 1967 to 1982. Kaplanis (1988) divides the sample into four sub-periods of 46 months and compared the covariance matrices over the 46-month sub-periods using the Box (1949)-Jenrich (1970) test.

In line with the evidences provided in MS (1983), Kaplanis (1988) could not reject the null hypothesis that the correlation matrix is constant over even two adjacent sub-periods at 15% confidence level, a sign of intertemporal stability. However, the study finds the covariance matrix to be much less stable at the 5% confidence level for most of the sub-periods, which signals a rejection of the hypothesis of constant correlation.

Thus, overall, the structure of covariance of the returns on the equity price indices in different countries is unstable. This creates confusion. However Longin and Solnik (1995) quoting Kaplanis'(1988), suggest that this may have stemmed from changes in the conditional variances with constant international conditional correlations.

Meric and Meric (1989), hereafter MM (1989), applying Box's M statistical test find evidences of inter-temporal stability and seasonality in international stock market relationship in 17 countries over the period 1973-1987. Their analysis suggests that the longer the time period, the greater the degree of stability among international stock market relationships.

The most striking element in their study is the suggestion that the co-movement is stable in September-May period, but relatively unstable in May-September period which can be interpreted to mean that the extent to which the returns on equity price indices of different countries relate to one another can be stable or unstable depending on the time of the year. This shows evidence of seasonal variations in the degree to which returns on international equity market correlate with one another.

In a study covering similar time frame, **Ratner (1992)** claims that correlation among international equity market returns has remained stable over the period from 1973 to 1989. It is difficult to reconcile MM's (1989) findings with the claim by Ratner (1992) except by arguing that they differ in terms of the markets studied and the methodology or, arguably, that Ratner (1972) has two more years of observations.

Perhaps, to avoid similar confusion **Koch and Koch (1991)**, hereafter KK (1991), conducting their analysis within that time period divide their sample into three separate sub-periods; 1972, 1980 and 1987). KK (1991) studied the correlation of 8 markets using daily data for the three sub-periods of 1972, 1980 and 1987. They employ the test of parameter stability developed by Chow (1968) and conclude that: "*international markets have recently grown more interdependent*" implying rising and stable correlations among international equity market returns.

Longin and Solnik (1995), hereafter LS (1995), identify two major limitations in the previous studies. LS (1995) argue that all the previous studies have considered unconditional correlation computed over different sub-periods and have also used relatively short samples. In order to avoid these problems, they use a comparatively longer sample spanning 30 years from 1960 to 1990 and model the conditional multivariate distribution of international asset returns in a GARCH framework.

Their objective is to test for the existence of predictable time-variation in conditional correlation for returns over the 30-year period by applying the GARCH model to the monthly excess returns on the market indices of the US, Japan, Germany, UK, France, Canada and Switzerland over the period 1960-1990. They find evidence of time-variation and instability in the structure of correlations among international equity market indices but conclude that during the 30-year period the correlations among international equity market indices have experienced only modest increase.

Ball and Torous (2000), hereafter BT (2000), criticise the use of multivariate GARCH models in investigating the intertemporal stability of international equity market return relationships. In their view, using multivariate GARCH models for conditional covariance suffers from increasing parameter dimensionality and is often practical to estimate only after imposing severe restrictions.

To avoid this pitfall, BT (2000) adopt a new methodology which treats stochastic correlation not as observable, but rather as a latent variable whose dynamics must be estimated using data on observables. Thus, they employ nonlinear filtering methods to extract stochastic correlations using the daily return data on six major international stock market indices: Canada, Germany, Hong Kong, Japan, the UK and the US over the period; January 1987 to May 1999. This paper also finds evidence of changing correlation among international equity returns, a sign of intertemporal instability.

Meric, Leal, Ratner and Meric (2001) conduct their analysis in three phases combining the test of co-movement with the test of intertemporal stability of the correlation structure between the US and a group of Latin American countries; Argentina, Brazil, Chile and Mexico over the periods before and after the October 1987 international equity market crash.

To begin, they employ correlation analysis to compare the co-movements among the five equity markets for three time periods, before (February 1984-September 1987) and after the market crash (November 1987 to June 1991 and July 1991- February 1995). This reveals significant variations in the correlation over time, that is, from negative to positive in the three periods.

As a further evidence, the paper applied Box's M test to pairs of consecutive sub-periods to determine the significance of the changes in the correlations. This shows that the variance-covariance matrix of the second sub-period differs from that of the first sub-period at slightly higher than 5% level of significance while the variance-covariance matrix of the third sub-period is significantly different from that of the second sub-period at 1% level of significance, indicating intertemporal instability.

So far the evidence presented by the above literature appears to suggest instability of co-movement among international equity market returns. The question is; what drives asset return co-movements?. The next section searches for the drivers of volatility and the co-movement structure among the returns on assets in different equity markets.

2.7 Drivers of Volatility and Correlation among Equity Markets

Several studies have been concerned with the factors that determine the structure of volatility and correlation among international equity market returns. Because the literature hardly distinguishes drivers of volatility from those of correlation structure, the review of literature in this section discusses both together, without distinction.

Lessard (1976) first mentioned the impact of industrial factors on the proportion of individual stock returns that are unexplained by a world market factor. He first hinted on the importance of industrial factors in the explanation of stock market volatility.

In a related research, **Grinold, Rudd and Stefeks (1989),** henceforth GRS (1989), also point out the importance of industry and country factors in asset pricing models. They attempt to develop a framework for examining the relative importance of the two factors in explaining the structure of return volatility among national stock market indices and the effects on the benefit from international diversification.

Their analysis is silent on which of the two factors, country or industry, determines the volatility structure of international equity returns. However, the suggestion that a multi-factor asset pricing model incorporating both industry and country factors is better than a single-factor model in explaining the structure of return volatility provides important clues as to the relevance of the two factors in asset pricing.

Roll (1992) provides a more vivid explanation of the role of industry factors in determining equity return volatility. Roll (1992) examines the differences in stock market behaviour to the extent that it can be explained as resulting from industrial composition of market indices or country characteristics, using daily data for 24 countries and 7 industries.

This paper employs dummy-variable regression analysis and decomposes stock returns into part explainable by industrial composition and part explainable by country factors and compares the behaviour across international stock markets. Roll (1992) observes that, even after nominal and inflation differences are taken into account by converting returns into common currency units at the ruling exchange rates, there are still large differences in volatilities across national equity markets.

Roll (1992) shows that while countries such as Hong Kong and South Africa have higher volatilities, Canada and the Netherlands have low volatilities. These disparities in the behaviour of stock market returns are traceable to three main sources; the differences in the number of constituent individual stocks and their diversification; the idiosyncrasies of the country's industrial structure and exchange rate fluctuations.

With regard to the number of firms and the level of diversification of country market indices, Roll's study shows that the larger the number of firms and the more well-diversified the market index, the less volatile the returns may be. This suggests that stock market indices reflect the idiosyncrasies of each country's industrial structure. As a result, countries with significant components of the stock market indices concentrated in a single industry are likely to exhibit higher volatility than countries whose market indices consist of firms evenly spread across sectors and industries.

It is thus not a surprise that South Africa and Hong Kong, the two emerging economies in the sample, exhibit the highest volatilities. Combining these factors, Roll's (1992) study seems to suggest that the greatest portion of the structure of correlation and volatility among international equity returns emanates from the industrial composition of the market indices of the countries concerned.

In contrast to Roll (1992), **Heston and Rouwenhorst (1994 and 1995)**, henceforth HR (1994), find the effect of industrial composition to be minimal in explaining the volatility and correlation structure of international equity market returns. They examine the volatility and correlation structure of twelve European markets, using a dummy-variable regression model. Like Roll (1992), HR (1995) also introduced a set of industry and country dummies into the model to separate pure country effects and pure industry effects from individual stock returns.

They find the cross-sectional differences in return volatility between country indices to result predominantly from country-specific sources of return variation rather than the industrial composition of the indices. Specifically, the paper shows that the industrial structure of the countries examined is accountable for only a small fraction of about 4% of the cross-sectional differences in return volatility. This implies that the remaining 96% could be argued to be explainable by country-specific factors.

On the basis of this, HR (1994) conclude that because industry effects are so small (account for insignificant proportion of equity return variation) relative to the effects of country factors, diversification across countries can provide effective portfolio risk reduction for investors than diversification across industries in different countries.

Arshanapalli, Doukas and Lang (1997), henceforth ADL (1997), find similar evidence as Roll (1992) from a study which combines the US, European and Pacific-Rim capital markets. They investigate the nature of the volatility process among the security prices in these capital markets using the common ARCH- feature testing methodology (developed by Engel and Kozicki (1993)) with a view to finding commonalities in the volatility process among nine industry groups in each country.

They find evidence that the majority of industry-return series for the US, Europe and the Pacific-Rim exhibit time-varying volatility in addition to high degree of intra-industry integration among different economic regions. The implication of this is that investors can reap greater diversification benefits if they invest across regions and industries rather than diversify within an industry across various geographical regions. It can thus be inferred that the industrial mix of global investment portfolios is more likely to account for a significant portion of the benefits from diversification.

This assertion is reinforced by **Griffin and Karolyi (1998),** henceforth GK (1998). They examine the role of country and industry-specific sources of variation in international assets returns for global portfolio diversification strategies employing the Dow Jones Stock Index. Unlike the other studies, this is a relatively new database with daily prices for 66 different classifications of industries for over 25 countries.

Like Roll (1992) and HR (1994), they also use a dummy-variable regression model and decompose stock returns into country and industry components and compare the industry and the country components based on nine aggregate industry sectors as well as a more refined industrial classification of the Dow Jones World Stock Index.

Consistent with HR (1994), GK (1998) find industrial composition to have only a minimal effect on the structure of volatility of market indices and hence does not feature much in the explanation of the gains from international diversification. This paper indicates that industrial classification explain just about 4% of the variations in country index returns with the pattern varying across different industry groups.

This is supported by **Rouwenhorst (1999)** who also examines the relative importance of country and industry effects in Western Europe, a region entering regional economic integration and for which there is the high expectation that national boundaries will soon be eroded away. By computing separate mean absolute values for the country and industry factors, Rouwenhorst (1999) finds that in Western

Europe, country effects in stock returns still overwhelm industry effects even with the convergence of interest rate and the harmonisation of fiscal and monetary policies.

These findings have important implication for portfolio managers extending their investment to the Western European markets. For passive managers who attempt to match the performance of their portfolios to the European market, Rouwenhorst (1999) postulates that getting the country composition of their portfolios right is more important than getting the sector composition right. In the same way, for active portfolio managers, country selection still offers opportunities for diversification.

However, from a critical examination of the findings, it could be seen that the success of active country and sector strategies depends on investors' ability to exploit the opportunities and time them as they occur, a task not easy to undertake in practice.

Bacca, Garbe and Weiss (2000), henceforth BGW (2000), question whether the recorded dominance of country factors still persists. They argue that, historically, country effects have been dominant in explaining variations in global stock returns even in developed stock markets and investors have segmented their allocation strategies accordingly. However, it is questionable whether that still prevails.

Using monthly data for seven industrialised countries and 10 industries from March 1979 to March 1999 they observe a significant shift in the relative importance of national and economic influences in the stock returns of the world largest equity markets. Thus, from their perspective, the impacts of industrial sector is now roughly equal to that of country effects indicating shrinkage in the gap between the effect of country factors and that of industrial composition of the markets studied.

Apart from highlighting the increasing global capital market integration, BGW (2000) also suggest that country-based approaches to global investment management may be losing their effectiveness. This provides advance caution to international investors.

In a similar context, **Cavaglia, Brightman and Aked (2000)** also disagree with the findings of studies claiming that country factors generally dominate industry factors. They use monthly data for 21 developed equity markets and 36 industries covering the period from January 1986 to November 1999.They report evidence of increase in the proportion of global stock market returns that are explained by industry factors.

This paper explains that in the preceding five years (up to 1999) diversification across global industries has provided greater risk reduction than diversification by countries which indicates increasing importance of portfolio allocation based on industrial factors as a criterion for active global equity portfolio management. On the basis of this they speculate that investors would reconsider home-biased equity allocation strategies given the rising significance of industry effects on global stock returns.

However, **Serra (2000)** finds country factors as significant (relative to industrial composition) as the drivers of volatility and correlation structure of returns. She uses a sample of 364 weekly series for between 629 stocks in January 1990 and 1702 stocks in December from 26 markets in the IFC emerging market indices.

Serra (2000) investigates the relative influence of industrial composition and country factors on the cross-sectional variances and the structure of correlation on the index returns of the 26 emerging equity markets. Contrary to the studies by Roll (1992) and ADL (1997) for developed markets, Sera (2000) finds country effects to be the most important factor driving the behaviour of emerging market returns with cross-market correlation insignificantly affected by the industrial composition of the indices.

In effect, cross-country (market) diversification seems to be better than cross-industry diversification. Even after a finer industry partitioning of the indices Sera (2000) still observed evidence of the dominance of cross-country effects over industry effects. Despite this, the study concludes that ignoring the industrial mix of stock market indices could lead to a significant loss of diversification benefits overall.

Kuo and Satchel (2001) henceforth KS (2001) provides a more comprehensive analysis by using a methodology which combines value investment strategies with the analysis of the country and industry effects on the correlation and volatility structure of stock returns. Their method extends the model used by HR (1994) by decomposing the variations in return volatility into the effects of size, value, country and industry.

Based on the monthly excess returns of an average of 1056 stocks they form four size-based portfolios, four value-based portfolios based on equities from six countries and seven broad economic sectors and examine the correlation structure of excess stock returns in the four categories of factors; size, value, country and industry. In this way the effect of each factor is separated so that an analysis of the contribution of each factor to the total variation of excess stock returns could be conducted.

Based on this procedure, they find country factors to dominate all the other factors in explaining the variance of excess stock returns and attribute this to the fact that pure country effects are usually more volatile than the other factors. Thus investors can obtain much risk reduction from investing on the basis of country-specific factors (top-down strategy) as opposed to investing on the basis of industrial factors (bottom-up strategy) when making decisions on the allocation of investment funds.

The essence of the foregoing discussion to international investors is clear. The decision to diversify internationally depends on the determinant of volatility and correlation. In particular, the view that industrial composition, rather than country-specific factors determine volatility and correlation structure can seduce investors in countries with well-diversified industrial mix to limit investment to home assets.

2.8 The Home Bias Phenomenon in International Investment

Many authors have focused on the reasons for investors' preference for home rather than foreign assets, commonly referred to as the home-bias. This has generated a voluminous literature but this section centres on those relevant to this dissertation.

Stulz (1981a) may be deemed to be among the first to touch on the home-bias puzzle. He develops an international asset pricing model in which investors incur cost for investing in foreign assets by arguing that international capital markets are not fully integrated to the extent of removing all barriers to investment in foreign markets.

Since investors aim to maximise the utility of their wealth, barriers such as taxation and restrictions on foreigners' participation in equity markets normally imposed by some countries have the effect of inducing investors to consider limiting portfolio holdings to home equities as such restrictions may be absent in the home markets.

In continuation to Stulz's findings, **Adler and Dumas (1983),** henceforth AD (1983), add inflation risk and deviations in purchasing power parity (PPP) to the barriers in foreign investment to explain the causes of the home-bias. According to AD (1983), international portfolio theory has two features that may not be present in domestic portfolio analysis and therefore can provide the explanation for the home-bias puzzle.

They posit that since investors in different countries consume different bundles of goods, the presence of inflation risk and deviation from purchasing power parity (PPP) can serve as inducements for investors from different national markets to hold portfolios that differ by the component designed to hedge against home inflation risk.

In this sense, AD(1983) seek to propose that the bias towards home assets results from investors' desire to hold domestic equities as a hedge against home inflation risk and deviation in purchasing power parity (both of which are not easily predictable).

French and Poterba (1991), hereafter FP (1991), find investor optimism about the performance of home markets to be the main cause of the home-bias. They examine the equity portfolio holdings of investors in five countries; US, Japan, Germany, UK and France by presenting actual figures on the percentage of investment funds allocated by investors in these countries to home as compared to foreign assets.

In particular, the figures show that at the end of 1989, Japanese investors had only 1.9% of their equities in other countries, while US investors held 6.2% of equity portfolios overseas. Only British investors, by comparison, appear to hold a relatively larger amount (that is 18%) of their investment portfolios overseas which are divided almost equally among the developed markets in US, Japan and continental Europe.

In explaining this investor specialisation in home assets, FP (1991) suggest the reason derives from the systematic variations in return expectations across groups of investors in different countries. Thus, investors are more optimistic about the performance of their domestic markets but remain pessimistic about foreign markets.

This, in addition to the lack of information, induces investors to allocate more of their wealth to assets in the seemingly riskless home market than the risky foreign markets.

Corroborating this finding **Ueda (1999)** claims that, because of inadequate information, investors are likely to deem foreign assets as more risky than domestic assets since lack of information increase the possibilities of estimation errors in the risk associated with foreign assets. Thus, even if the domestic and foreign assets have similar risk and return characteristics, the demand for home assets is more likely to exceed the demand for foreign assets because investors have less information upon which to make meaningful decision concerning investment in foreign assets.

Following Ueda's (1999) framework, it may be deduced that the inaccessibility of the required foreign information could lead to errors in estimating the risk of foreign assets and lead investors to consider foreign assets as comparatively risky than domestic assets whose risk-return characteristics can be estimated relatively more accurately. This buttresses the results in FP (1991) which also attribute home-bias in part to limited access to information about the performance of foreign securities.

Cooper and Kaplanis (1991), hereafter CK (1991), also provide similar evidence. They examine the home-bias phenomenon by extending the model of international portfolio choice and equity market equilibrium developed by AD(1983) in a way that incorporates deviations from the purchasing power parity (PPP), inflation risk and a tax structure similar to that in Black (1974) (which they refer to as deadweight cost).

Like AD (1983), they also test whether the home-bias in equity portfolios results from investors' desire to hedge purchasing power parity deviations based on two forms of equilibrium positions that are deemed to significantly impact on international corporate finance and international investment decisions (i.e. equilibrium under an Adler-Dumas type of model and equilibrium under the deadweight costs analysis).

They find that deviations in purchasing power parity alone has little explanation for the home bias except when investors have very low levels of risk aversion and equity returns are negatively correlated with domestic inflation. But even after integrating deviations from PPP, inflation risk and tax in estimating the cost required to generate home bias, the costs suggested by the model was still inconsistent with the observable costs in international investment, except investors have low risk aversion. In short the home bias results from hedging relative price risks and information asymmetry.

According to **Tesar and Werner (1995),** hereafter TW (1995), home bias results from the geographic proximity of foreign markets to investors' home markets. They examine the international investment behaviour of Canadian, German, Japanese, UK and US investors from 1975 to 1990. In a similar line of analysis as FP (1991), TW (1995) also present numerical data (pp. 470-471) on the proportion of investors' holdings in foreign countries to portray the long-term international investment patterns in these countries as reflected in the holdings of equities and bonds.

While acknowledging that there are gains available from international diversification TW (1995) suggest there is still a strong bias towards domestic securities with the level of bias seemingly dependent on the type of investor; institutional or individual. That is, compared to institutional investors, individual investors seem to devote a lesser proportion of their portfolios to assets in foreign (than their home) markets.

Moreover, observation of the portfolio choices for Canadian and US investors indicates that their investment decisions are driven more by geographic proximity of the foreign markets to their home country rather than pure diversification motives.

According to TW (1995), Canadian and US investors consider nearness or ease of access to markets to be more important than higher gains from their investment in deciding to hold international portfolios. In addition, they do not find high transaction cost on foreign investment to offer any explanation to the home-bias phenomenon, in stark contradiction to the findings that have been presented by the earlier researches.

Smith (1995) relates the home bias to the uncertainties surrounding investors' tax obligation. He argues that because of the obligation to pay taxes, risk-averse asset-holders allocate part of their wealth to the portfolio of assets which has the maximum covariation with tax payment. He develops a model of international asset pricing that incorporates nominal exchange rates and equities by describing the behaviour of a representative investor in the domestic market by the solution to an infinite-horizon continuous time portfolio choice problem as in Merton (1973).

In Smith's (1995) arguments, if asset-holders maximise the expected value of their discounted utility subject to a budget constraint, the solution to their optimal portfolio can be said to conform to a standard problem in stochastic optimisation while the demand function for foreign securities can also be viewed as following a mean-variance efficient portfolio and a tax-hedged portfolio. In this framework, the mean-variance efficient portfolio takes into account the expected return differentials and is independent of tax payment variations.

On the other hand, the tax hedge portfolio is highly correlated with taxes and thus provides the best protection against tax payment variations. Applying this framework for investors in the US, UK and Germany, Smith (1995) finds their tax hedge portfolios to consist chiefly of home-country short-term bonds, suggesting that hedging against the obligation to meet tax payments denominated in home currencies explains investor preference for home assets.

In spite of the numerous evidence explaining the causes of home-bias **Iwaisako (2002),** considering a number of factors including the effects of transaction cost and hedging of international portfolios, simply concludes that the so-called home-country bias may not be as large as portrayed (in the literature) or may not even exist at all.

2.9 Summary of Review of Literature

The discussions in the preceding sections have attempted to piece together the different but related subject areas that impact on the evaluation of the benefits of international diversification. The review began with brief exposition on the development of the theories underlying portfolio analysis, risk diversification and asset pricing models commencing with Markowitz's (1959) portfolio theory and ending with the SDF model by Hansen and Jaganathan (1991).

Proceeding from this is the discussion on the application of those theories in the international setting, starting from the seminal paper by Grubel (1998) leading to the subsequent studies providing corroborative evidence on the gains from international diversification, particularly among developed markets. These suggest that the reduction in the gains from diversifying portfolios among developed markets has directed investor attention to emerging markets, proposed by Harvey (1995), Li, Sankar and Wang (2002) and others, as the next opportunities for diversification.

Implicit in these studies is the assumption that international equity markets are segmented. The challenge of this assumption in the light of other evidence that propose integration of international capital markets, as first hinted by Stehle (1977) has significant implications on the benefits that could be expected from international diversification. Strong integration implies identical risk-return behaviour among international asset returns which reduces the benefits from diversification overall.

From the issue of market integration emerges the need to examine the stability or instability of the co-movements among international equity market returns. This affects the stability of the benefits from diversifying portfolios among international equity markets as intertemporal instability in the correlation among returns can lead to significant time-variation in the benefits from international equity portfolios.

With asset return co-movements dependent on the determinant of the structure of correlation this issue was discussed thereafter. But, because the discussion of this subject in the literature is interwoven with the discussion on volatility structure both needed to be examined in tandem. The interest in reviewing this body of literature centres on whether industrial composition of stock market indices or macro-economic forces within countries determine the volatility and correlation among asset returns.

Thus granted that country-specific forces are the main drivers of volatility and correlations among the returns on international assets, this justifies diversifying portfolios internationally since investors would achieve better portfolio performance than obtainable from domestic investment. However, if the industrial composition is the main driver of volatility and correlation, portfolio diversification across industries within countries may be more beneficial than diversification across countries.

To this end, investors in economies with well-diversified industrial structure, especially in the developed equity markets such as the US, UK, Germany and Japan can benefit more by limiting portfolios to only domestic assets, giving rise to the issue of home-bias first suggested by Stulz (1981) and spearheaded by French and Porteba (1991), Tessar and Werner (1995) and others which is still a puzzle.

2.10 Lessons from Literature Review and Research Questions

The review of literature provides many lessons and many unanswered questions. Most early studies on international diversification, for instance Grubel (1968), Lessard (1973), Levy and Sarnat (1970) employed the mean-variance portfolio theory with simple comparisons of the efficient frontiers of different international portfolios.

Recent studies focusing on emerging markets have employed relatively stronger test methods. Harvey (1995), Bekaert and Urias (1996 and 1999) and DeRoon, Nijman and Werker (2001) for instance, have gone beyond simple comparisons of efficient frontiers to the measurement of the statistical significance of the distance, in the mean-variance space, between the frontiers using the test of mean-variance spanning.

However, each of these studies uses only one version of the spanning test based on either regression or the SDF model. DeRoon, Nijman and Werker (2001) employ the Wald test of mean-variance spanning, Harvey (1995) employs the F-test of spanning while Bekaert and Urias (1996) use the mean-variance spanning in the SDF model. The problem is each of these tests provides different conclusions about the gains from diversification when implemented on the same data set. This leads to the question:

1. *can the use of more than one version of the test of mean-variance spanning at the same time on the same data leads to more meaningful conclusions than employing only one version at a time?*[13].

[13] In Chapters 5 and 6 Kan and Zhou (2001) are quoted as showing that there are about five different versions of the test of mean-variance spanning each of which provide different result when used at the same time.

Moreover, all the studies discussing emerging markets have concentrated on the benefits to US investors from diversifying developed market portfolios to emerging markets in South-east Asia and Latin America or to a combination of emerging markets as a standalone asset class. Two important questions emanating from this are:

2. *can a UK investor with an optimal, in a mean-variance sense, portfolio of developed (Western European) market equity returns also benefit, similar to the US investors, from diversifying the portfolio to emerging equity markets considered a standalone asset class?*

Also:

3. *can the addition of African and Eastern European emerging markets as regional assets expand the range of investment opportunities for a UK investor with an optimal portfolio of developed market equities?*

Finding the answers to these questions and many more constitutes the theme of this study and the basis of the empirical investigation that follow in the next few chapters.

3.0 Sources and Organisation of Data

This study is based on equity market returns from August 1991 to February 2003. However, different length of time is used in some cases (with explanations provided).

The main source of data for this study is Datastream International but data was also obtained from the Harare Stock Exchange (Zimbabwe) and the British Bankers Association (BBA). The study uses three forms of data; stock market index returns, exchange rate and risk-free interest rate. The risk-free interest rate is the monthly London Interbank Offer Rate (LIBOR) provided by the British Bankers Association.

The stock index returns were obtained from two sources for a total of nineteen markets (countries).These consist of five developed markets, namely UK, Germany, France, the Netherlands and Switzerland and fourteen emerging markets consisting of Argentina, Brazil, Chile, the Czech Republic, Hungary, Indonesia, Malaysia, Mexico, Romania, South Africa, South Korea, Thailand, Turkey and Zimbabwe.

The stock market index for Zimbabwe was obtained from the Harare Stock Exchange (HSE).The Harare Stock Exchange keeps two forms of market indices; the Mining Index for mining sector companies only and Industrial Index for companies in other sectors. This study uses the Industrial Index which is relatively more diversified in terms of the industrial composition and the number of stocks represented.

The stock market index returns for the remaining eighteen countries and the exchange rate were obtained from Datastream. The choice of Datastream is driven by a number of reasons. In general, data for researches involving emerging markets are derived from one or several of different data providers. These include International Finance Corporation (IFC), Morgan Stanley Capital International (MSCI), ING Barings' Emerging Markets Indices (BEMI) and Thomson Datastream International (TDI)

Each of these offers value-weighted indices covering a representative portion of each stock market. Because they analyse virtually the same data from different standpoints, there is always high possibility of great similarities among the indices from all three data sources hence the choice among them depends mainly on availability of the data.

Bekaert, Erb, Harvey and Viskanta (1997) find an average correlation of more than 94% between the MSCI and the IFC indices, and a very small tracking error. Between the IFC and the BEMI indices they find an even higher average correlation of about 96%. The high correlations imply that data from these three different sources can be used interchangeably for empirical analysis as the difference between them is slight.

However, Barings, from the start, followed an "investable indices", tracking, in each market, only stocks that are most accessible to foreign investors while in the case of TDI, MSCI and IFC accessibility of the stocks traded to foreign investors was initially not a major selection criterion[14]. Because of that TDI, MSCI and IFC are argued to have high flexibility in the selection of stocks for inclusion in the indices. Thus, it may be deduced that, in comparison with the BEMI indices, the indices compiled by TDI, MSCI and IFC are likely to contain greater number of stocks.

For this reason, the choice among these data providers boils down to two broad factors; investability and representation. Using investability as the major criterion, BEMI may be better, while in terms of representation TDI, MSCI or IFC may be better. However, compared to BEMI, TDI, MSCI and IFC are more readily available, thus narrowing down the decision to a choice among these three. Since they are similar, TDI was selected. Thus Datastream market indices are used for this study.

3.1 Brief Overview of Datastream Market Return Indices

Datastream market indices are drawn from around 35 equity markets with a representative sample of stocks chosen from each market. Using the Financial Times Stock Exchange Actuaries classification the constituent stocks are allocated into industries or sectors with the global indices calculated in three basic classifications.

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[14] Recently, both MSCI and IFC have started publishing investable indices. However, these do not have enough observations to be used for serious empirical analysis. It may take a longer period of time.

That is, within each market, indices and aggregates are kept for sectors (Sector Indices); for each market, an aggregate index of all sectors is available (Market Index) and the markets are aggregated at both market and sector levels to form indices for the world and certain geo-political regions (Regional and World Indices)

The indices are available in two main forms; stock price and total return indices, which are maintained in parallel, recognising the distinct merit of each for market analysis. The stock price indices are maintained only for periodic stock prices while the total return indices compose of both stock prices and the effects of dividend (by assuming dividends are reinvested in further stocks). This study uses the total return indices because investment returns consist of both capital gains and dividend yields.

3.2 Problems and Biases in the Datastream Market Indices

Due to the process by which Datastream builds up the market indices a number of problems may be encountered in using the index returns for empirical research. It is therefore deemed important to highlight some of these problems and how they were mitigated before proceeding to employ the index returns for the empirical analysis.

The number of markets categorised as "emerging" by the World Bank are numerous. But, Datastream includes data on only those markets considered successful and have good track records of increasing in capitalisation, leaving out those with poor records. This limits the selection and the sample size for a study on emerging equity markets.

Furthermore, Datastream does not explicitly select stocks on the basis of historical financial performance or expected future performance. However, they use size and liquidity as the main selection criterion. This implicitly reveals information about the past performances of the companies selected. Thus, to some extent, only profitable or expanding companies are selected for inclusion in the Datastream market indices.

This is evidenced by the fact that stocks are added to or removed from the indices as and when the market capitalisation expands or shrinks. Also changes to the indices are made on the basis of changes in firms' market capitalisations. As a result, only surviving firms remain in the indices, creating survivorship-bias (Harvey 1995)).

Moreover, many of the emerging markets have low volume of stocks and trading in most of the stocks is highly infrequent. Though Harvey (1995) found the trading activities of some emerging markets to be more impressive than most of the developed markets, the problem of infrequent trading still constitutes a persistent feature of emerging market stocks which can have impact on the level of volatility.

To mitigate the effect this has on emerging market portfolio analysis, most studies use lower frequency, as opposed to higher frequency, returns. For instance, monthly returns data seems to perform better than weekly returns data in such circumstances. Following Harvey (1995) this study solves the problem by using monthly return data.

It is also important to point out the problem of re-emerging bias with regard to some of the markets as observed by **Goetzman and Jorion (1996)**. Many of the markets being studied have had unstable history. Argentina, for instance, is said to have a long history beginning in the latter half of the 19th century. At one point in the 1920s Argentina's market capitalisation exceeded that of the UK. However, the market submerged and has re-emerged. Little is known about its period of submergence.

Because of this, estimates of expected returns on the Argentine stock market index measured over a short time using data in the most recent period are usually higher than returns measured using data covering longer periods, especially prior to 1976.

While the literature singles out Argentina as posing problems due to its unstable stock market history, in this study the problem of re-emergence (or unstable history) is not related to Argentina alone. Many of the other emerging markets being studied have also had long histories parts of which remain not well accounted for. It could be possible that the problem identified with Argentina can be a general phenomenon.

For instance, stock market began in Turkey in 1866, in Brazil in 1877, in Zimbabwe in 1896 and in South Africa around the end of the 1890s. The Zimbabwean stock market has operated and collapsed several times in the past. It is until just recently, around 1974, that stock market trading gained foothold and became well-regulated in Zimbabwe and thus paved the way for returns data on the index to become available.

Bekaert, Erb, Harvey and Viskanta (1998) postulate that for most of the markets taking sample returns from the 1980s onward (as is the case with Datastream) only measures the "re-emergence" period. Thus, similar to the case of Argentina, it is possible that a longer horizon average return may be significantly different from the average returns calculated based on recent return data for these markets also.

Harvey (1995) also reports of backtracking of most of the IFC indices. This is also applicable to Datastream indices. For many of the countries the pre-1975 data were backfilled based on survival in 1975 following their inclusion in the indices in 1975. Firms that ceased to exist in 1975 were left out thus aggravating the survivorship bias.

In this thesis, this problem is mitigated by the use of reduced time length. Not all the markets have history of backtracking because they were included in Datastream after 1975. Therefore, using data that begins from 1980 has the advantage of having more countries in the sample and also, incidentally, cutting off the backfilling periods.

3.3 Considerations for the Choice of Countries

Choosing countries for the analysis was a core decision in this thesis. As stated earlier, the objective of this dissertation is to analyse, from the viewpoint of UK investors, the benefits of including emerging market assets in developed (Western European) market portfolios. The major decision was which markets to select to represent the developed markets and which to represent the emerging markets.

In the case of the developed markets, it was decided to select some of the most advanced among the Western European markets, to fit the objective in this study. The problem was the definition of advancement as regards stock markets. Trading systems, information flow and level of efficiency, volume of trading and size based on market capitalisation are among factors normally considered in this respect.

Since the main focus of the study is on emerging markets, the choice of developed equity markets does not constitute a serious consideration. Because of that, the market index returns for the UK, Germany, France, the Netherlands and Switzerland were found to be sufficient in representing the advanced European financial markets.

As concerns the emerging financial markets, the decision was harder due to the problem of availability of data. It was decided to have adequate representation of emerging markets from the various geographical regions of the world, subject to availability and length of data series. Thus the initial target was to include at least six countries from four geographical areas: Latin America, Africa, Asia and Europe.

This yielded a number of potential candidates (countries). However, only a few have data series long enough for viable academic research. The major problem was posed by the African countries, excluding South Africa which has data in Datastream. In the search for data on other African markets, direct contacts had to be made with the stock exchanges of Botswana, Ghana, Kenya, Nigeria, Zambia and Zimbabwe.

This follows directives given by **Appiah-Kusi and Menyah** (2000) who have written an article discussing the efficiency of African stock markets with data received by direct contacts with the various stock markets in Africa. However, this time, luck was absent and response was received from only the Zimbabwean stock exchange. As a result, the remaining African countries had to be excluded because of lack of data.

The question then was whether South Africa and Zimbabwe are adequate to represent the African emerging markets. Fortunately, **Kenny and Moss (1998)** report that as at 1996 there were 11 stock exchanges in Sub-Saharan Africa, outside South Africa, with a market capitalisation of over U.S. $15.8 billion. During the same period the total capitalisation of the South African Stock Exchange was U.S. $241billion, about 15 times the combined capitalisation of the remaining Sub-Saharan African markets.

These statistics mean that South Africa and Zimbabwe constitute almost 90% of the market capitalisation in sub-Saharan Africa. Thus the absence of the other markets, from investment point of view, does not appear significant to have any serious impact on the results since the benefit forgone, assuming there is any, by excluding those markets in a developed market portfolio can be considered not to be significant.

In view of this, the decision was made to select four markets from each of the other geographical regions; Latin America, Eastern Europe and South-East Asia. Therefore Argentina, Brazil, Chile and Mexico were selected for Latin America while Hungary, Romania, Turkey and the Czech Republic were also selected for Eastern Europe. South Korea, Malaysia, Indonesia and Thailand were chosen for South East Asia.

3.4 Considerations for the Choice of Investment Vehicle

Selection of the countries is not the endpoint of the decision as a choice had to be made concerning the appropriate investment vehicle to use for the analysis. The investment vehicle needs to be one that investors would most likely use in practice and the returns on the vehicle must also be achievable. The selection therefore required due consideration of both practical and empirical factors.

The practical factors address the issue of what investment vehicles are practically available and accessible to investors. Thus, due consideration had to be given to the factors enumerated for the selection of countries, especially availability of the investment vehicles in Datastream. These factors had to also be balanced with empirical considerations. The most important was the length of time for which the data series on the chosen investment vehicle has been available in Datastream.

Most statistical methods (based on asymptotic properties of data series) require long time series of data to be feasible. In this context, the length of return observations constitutes a key ingredient in the selection of the investment vehicle. The statistical methods to be employed in chapters five and six of this thesis demand that the length of time series of data exceeds the number of assets to be included in the test[15]. Thus too short observation relative to the number of assets can make the test impracticable.

[15] The study employs test of mean-variance spanning. The resulting statistics are chi-squared distributed with degrees of freedom computed as 2(T-K-N) when the F test is used. Here, T is the length of time series and K and N are the assets returns to be used in the tests.

In order to avoid such a problem a minimum qualification of at least twelve years of continuous monthly data was set for the particular investment vehicle to be chosen for the analysis. However, achieving this target requires assessing the various investment vehicles, whether data can be found in Datastream and the time the data is available.

3.4.1 The Investment Vehicles Available to International Investors

Making the practical decision on the choice of appropriate investment vehicle requires knowledge of the various avenues by which globally-minded investors achieve international diversification. In this respect, **Aiello and Chieffe (1999),** henceforth AC (1999), provide a comprehensive review of the various options (investment vehicles) available to investors wishing to hold international portfolios.

Most frequently, international investors invest directly in foreign securities that trade on foreign exchanges. However, as discussed in chapter 2, such direct investors incur high cost (Stulz (1981)), and may sometimes be handicapped by lack of information ((French and Porteba (1991)) and Ueda (1999)). Besides, currency fluctuations and political risks present difficulties for direct investors. As a result of these limitations, it is essential to search for alternative avenues for investing in foreign assets.

One alternative option that AC (1999) identify is the purchase of Euro-equities by investors. These are securities listed on any of the foreign stock exchanges and also on a domestic (or the investor's home) stock exchange. Such dual-listed stocks give domestic investors the chance to take advantage of international investing while avoiding the disadvantage of direct investment in foreign equity markets.

As another option, multinational corporations (MNCs) based in the domestic market but with significant exposure in foreign countries also offer investors good avenues for international diversification. Russell (1998) views MNCs as simply a portfolio of internationally-diversified cash flows which may exhibit low correlation with one another, depending upon the economic cycle in countries where they are located.

On this basis, investing in an MNC should assist investors to at least, theoretically, achieve international diversification. This is because such an investment amounts to acquiring foreign and domestic cash flows. MNCs offer increased diversity of foreign investment at a lower cost of domestic investment but are represented in few markets.

A further option available to international investors as pointed out by AC (1999) is American Depository Receipts (ADRs). These are receipts for shares of foreign companies held by local banks (US banks), called Depositories. ADRs also offer diversification opportunities in the sense that by buying ADRs, the investor has implicitly bought shares in a foreign company through the banks.

The banks receive and convert the dividends from the foreign currency and pay them in local currencies (dollars) to the shareholders. The popularity of ADRs lies in the fact that investors do not have to leave domestic market to invest in foreign firms.

An important and one of the most preferred options for international investment is the purchase of shares in internationally diversified mutual funds. Unfortunately, these mutual funds are relatively new investment vehicles. One that has received significant attention in the literature is the World Equity Benchmark Shares (WEBS), which are designed to track international stock market indices developed by MSCI.

WEBS are modelled after Standard and Poor's Depository Receipts (SPDRs), which tracks the S&P 500 index for the US stock market. Technically, both WEBS and SPDRs are open-end index funds but are traded on the American Stock Exchanges like closed-end funds. However, unlike most closed-end funds they have a feature that prevents the existence of significant discount or premiums to net asset value.

A sixth and perhaps the most preferred option for international investment is the holding of shares of closed-end country funds. Closed-end country funds are collective investment companies that typically hold other publicly traded securities. Normally, the funds' market capitalisation is fixed hence the stock prices have only indirect link with the value of the assets corresponding to each share.

These securities are unique in that they provide contemporaneous and observable market rates of returns for both the fund and the underlying asset portfolio. For most funds the value of the underlying portfolio could be determined with considerable accuracy since the component assets are listed on the stock market.

However, closed-end funds typically trade at substantial discount to the underlying value of their holdings, the net asset value (NAV) of the fund. The discount is not constant, and varies considerably over time. Moreover, closed-end country funds hold shares in companies from "targeted" countries. This limits their geographical spread.

The question which arises at this stage is; which of the six investment vehicles to choose for the investigation? This is answered in the subsequent three sections.

3.4.2 Pros and Cons of the Different Investment Vehicles

Having identified the investment vehicles available, the next task is to parallel this with the empirical factors. There are arguments as to which investment vehicle reflects or duplicates the returns investors can achieve from holding foreign assets.

As noted in chapter 2, several of the studies testing for the benefits of international diversification use market index returns of the countries selected for investigation. However, this has received a lot of criticisms centring mainly on the attainability of the returns of such indices by individual investors. Thus with new vehicles arriving, the choice is now among market index returns and the five vehicles identified above.

BU (1996) are the most critical of the use of market indices for testing the benefits from international diversification. Their argument dwells on the fact that market indices ignore the high transaction costs associated with investment in emerging markets and overlook the low liquidity of those markets. Furthermore, there are constraints on investment in foreign markets such as limitations on capital and profit repatriation that are not accounted for by studies using market index returns.

In view of such limitations, BU (1996) suggest market index returns represent unrealistic performance benchmarks that may be too high and optimistic to be attained by individual investors investing directly in the markets. In a sense, studies basing conclusions on returns on market indices violate the investability assumptions behind the test since investors may not be able to attain the index returns. In order to avoid these limitations, they propose using closed-end country funds instead.

Using closed-end country funds to test for the benefit from international equity investment has many merits. Closed-end country funds provide a convenient package of securities that duplicate direct investment in the foreign stock markets. The funds are listed on the national stock markets and trade as if they were domestic stocks thereby helping investors obviate the transaction costs and the numerous hurdles that are normally associated with direct investment in foreign equity markets.

Moreover, closed-end funds share prices generally deviate from their net assets values (NAV) and often trade at a premium when the funds are invested in closed or restricted markets. Consequently, the returns from holding the funds' shares may differ from the underlying assets in which the funds invest. Thus investors may forgo some of the diversification benefits in emerging markets by holding the funds' shares instead of their underlying assets in exchange for avoiding the associated costs.

By implication, returns on the funds shares represent the *net benefit* available to investors while the returns on the indices may perhaps represent the *gross benefit*. Therefore using returns on closed-end country funds for testing the benefit from international diversification apparently represents investors' intuition and preferences and better reflect what is due them more than using the market index returns.

Arak and Taylor (1990), Patro (2001) and Lee and Hong (2002) also find closed-end funds to be better investment vehicles from investors' perspective. However, Woodward (1983) conducting research on UK closed-end country funds and Bailey and Lim (1992), Chan, Eun and Kolodony (1995), Barry, Peavy and Rodriguez (1997) and Madura and Bers (2002) using data on US closed-end funds produce evidence against the use of closed-end funds for testing diversification benefits.

They report that fund returns exhibit more of the characteristics of the returns on the market of the country where the funds' shares are traded rather than the returns on the market containing the underlying asset (the funds are supposed to represent).

Similarly, Chandar and Patro (2000) and Borensztein and Gelos (2002) all find close-end funds to be more risky than their underlying assets. It thus follows that the empirical evidence supporting the use of returns on closed-end country funds for testing the benefits of international diversification appears mixed and inconclusive.

Attention has therefore turned to international index tracking mutual funds. Once again while much praised by Peters (1988) as a means of achieving diversification, Cumby and Glen (1990) conclude that there is *no evidence that the funds, either individually or as a whole, provide investors with performance that surpasses that of a broad international equity index over the same period.* Droms and Walker (1994) and Aiello and Chieffe (1999) reach similar conclusions while O'Connor and Downe (2000) find that for this reason investors have turned to WEBS as the next alternative.

Unfortunately, WEBS do not appear very suitable for serious academic work because of shorter time series. WEBS are recent developments in investment thinking. They were introduced in 1994 and thus do not cover horizons that are long enough for empirical research. Besides, like their closed-end counterparts, they are designed to mimic the returns of certain indices chosen by MSCI; hence they are not exonerated from most of the problems associated with the use of closed-end country funds.

From this, the searchlight turns to American Depository Receipts (ADRs). Bekaert and Urias (1999), Alagnar and Bhar (2001), Mastumoto and Hoban (1999), Officer and Hoffmeister (1997) and Wahab and Khnadwala (1993) find ADRs to be good representatives of their underlying assets. However, Webb, Officer and Boyd (1995), Kim, Szakmarry and Mathur (2000) and Fatemi and Park (1996) suggest ADRs are also not without problems hence a new investment instrument still needs to be found.

On their part, Jorion and Roisenberg (1993) find that by using stock index futures they are able to replicate international equity indices. Their five-country synthetic portfolio is found to be highly correlated with the MSCI world stock index, a global benchmark. It seems that stock index futures can provide the much-needed replica (for academic work) of what investors can attain from investment in international markets. However, data on returns on stock index futures are hard to come by.

From the foregoing discussions it is clear that, while direct investment in international equity markets has serious limitations for academic purposes, all the other means of achieving international diversification do also have their pros and cons. None of the alternative investment vehicle discussed so far can accurately replicate the returns that investors obtain from direct investment and also avoid the related hurdles.

Moreover, of most relevance is the fact that the length of time series for most of the vehicles appears too short to render them useful for serious academic research. One needs to consider a number of factors before settling on any one investment vehicle.

3.4.3 Final Choice of Suitable Investment Vehicle

In the midst of the numerous pros and cons of the investment vehicles identified above a choice still has to be made. The various practical and empirical factors put forth above offer several viewpoints. These are summed up by **Russel (1998)** in a paper entitled *The Diversification Fallacy of Exchange-listed Securities.*

Russell (1998) reviews the various investment vehicles and examines their international diversification potential, primarily focusing on the ability of US exchange-listed investments such as closed-end country funds, ADRs and MNCs to provide a diversification effects similar to direct investment in foreign equities. Russell (1998) sums up what appears to be the fallacy in the choice of investment medium for testing the benefits from international diversification as follows:

"There is still debate regarding the use of US exchange-listed securities as a means for portfolio diversification. The results from this paper and other studies indicate that it appears as though these securities are more indicative of the exchanges where they trade rather than the index of the countries where the cash flows may be generated. This paper suggests that exchange-traded "international" securities are not the ideal vehicles for diversification".

This evidently demonstrates that it is still not settled which investment vehicle can best reflect what investors actually achieve in practice. For this reason, this study uses market index returns for the analysis. The next section discusses retrieval of the data.

3.5 Data Retrieval and Preparation for Analysis

Identifying the appropriate investment vehicle for investigation is merely the beginning. The raw equity price and foreign exchange indices of the countries selected had to be retrieved from Datastream. There may be several different ways of retrieving data from Datastream but the procedure outlined in this section provides just the basic steps followed in retrieving the stock indices required for this study.

The main steps necessary for retrieving data from Datastream may be said to involve:

(a) Choice of appropriate codes (mnemonics).
(b) Choice of the right program number that leads to the required data.
(c) Knowledge of the type of request to make to obtained the needed data.
(d) Requesting for the right data-type.
(e) Downloading the data in a suitable format for exportation.

3.5.1 Choice of Appropriate Codes (Mnemonics) and Program

Each series of data in Datastream; equity, derivatives or commodities has a code, also called *mnemonic* that facilitates access and selection. Therefore, to access the required data the relevant code (for the data) must first be identified to be entered into the code field in the database. Furthermore, data series are grouped according to types of data. Thus, stock indices are appropriately placed in one category called "Indices"

Because of this, Datastream provides a range of options (or *programmes*) for displaying and working with the required data. Thus, in a way, retrieving data from Datastream involves two principal operations. The first is to look up for codes or mnemonics and the second is to choose the program suitable for retrieving the data.

There are a variety of methods for looking up codes in Datastream. However, for this thesis the "Code Lookup" was used to help select the necessary codes for the various countries required. This was chosen because it is relatively easy to use.

Using the Code Lookup brings two possible options for looking up the required code: "Find"-option and "Search"-option. The "search-option" is relatively slow but has the advantage of enabling a more complete result to be obtained and permit the inclusion of additional information in finding the appropriate codes for the required data. Therefore, it was decided to use the Search-option.

Due to the scale of the data and *data qualifiers* available in Datastream many selections within programs had to be made so as to select the appropriate codes. To facilitate this otherwise lengthy process, Datastream attaches both numeric and alphanumeric codes to all data items so that a program number plus a letter identify each program. The program used was 900B which gives stock indices.

3.5.2 Specifying the Type of Data and Type of Request

Having looked up for the right codes, it was then important to find the right data-types and other data-qualifiers that enable a more vivid and direct search to be made. Several options come up at this stage but the focus was on "Indices" which was the category of data required. Stock price indices in Datastream have a number of data-types such as Total Return Index (which includes effect of dividends), Periodic Stock Price Index (only capital gains), etc. The data required was the Total Return Index for each of the countries (names of countries and codes used are provided in Table 3.1)

Besides specifying the right data it was also important to specify the program best suitable to offer the lead to the data required (which is already stated above). Two ways are available for selecting the program. The program finder can be used which brings out three specific information; (i) type of request, (ii) type of data and (iii) the program required which enable the selection of the appropriate program depending on the need and the program number displayed in the program number field.

On the other hand, the same purpose can be achieved by typing the program number (900B for stock return indices) directly into the number field. Specifying the data required and entering the number provide the required data. Whichever method is used to select the needed program the important consideration (at that stage) is the form or the medium by which the data is to be retrieved from Datastream.

Datastream allows three main types of requests to be made in loading out the needed data: Reports, Graphics and Time Series (Data for Spreadsheets). In this circumstance only "Data for Spreadsheet" was of interest and relevant for the purpose. This is because it helps to produce one (long) list of a single sort of data either on one variable, which may be a company or country through time, or on several variables; companies or countries in a single moment of time.

This characteristic makes the data for spreadsheet type of request fit data production that need further analysis, like a regression analysis. Given the purpose for which the data is to be used, the data for spreadsheet type of request was viewed as the most suitable. However, using the "data for spreadsheet" type of request also leads to two possibilities for downloading the data.

The request allows one to either download data concerning several series on a specific moment in time or download data on one specific series over a period of time. Since the data required is time series the obvious choice was to request for specific series over a period of time for the stock and the foreign exchange indices for the countries (markets selected for the investigation).

Two important issues at this stage are the frequency of the data interval and the time length of the data required. Data can be downloaded on daily (D) weekly (W), monthly (M), quarterly (Q) or yearly (Y) basis. Besides, the process requires specifying the start and end date for each data. In this instance monthly data was required. For the start and the end dates it was decided to have the longest series possible for all the markets hence the date specified was January 1980 to June 2003.

Because only few of the markets selected had that long data, a number of not available (N/A) was identified in the series for markets with short return indices.

However, this does not pose problems because the returns for markets with longer time series were reduced. Table 3.1 summarises the outcome of this process.

For each country the name is abbreviated and included in the mnemonics to facilitate identification. Zimbabwe is not included in this list because the stock index returns for Zimbabwe (already explained) was received through direct contact with the HSE.

Table 3.1: Name of Countries and Codes for Data Retrieval

Country	Name of Market Index	Code (Mnemonics)
United Kingdom	DS Market – TOTRETURN IN	TOTMKUK(RI)
Switzerland	DS Market – TOTRETURN IN	TOTMKSW(RI)
Netherlands	DS Market – TOTRETURN IN	TOTMKNL(RI)
Germany	DS Market – TOTRETURN IN	TOTMKGE(RI)
France	DS Market – TOTRETURN IN	TOTMKFR(RI)
South Korea	DS Market – TOTRETURN IN	TOTMKKO(RI)
Indonesia	DS Market – TOTRETURN IN	TOTMKID(RI)
Malaysia	DS Market – TOTRETURN IN	TOTMKMY(RI)
Thailand	DS Market – TOTRETURN IN	TOTMKTH(RI)
Hungary	DS Market – TOTRETURN IN	TOTMKHN(RI)
Romania	DS Market – TOTRETURN IN	TOTMKRM(RI)
Turkey	DS Market – TOTRETURN IN	TOTMKTK(RI)
Czech Republic	DS Market – TOTRETURN IN	TOTMKCZ(RI)
Argentina	DS Market – TOTRETURN IN	TOTMKAR(RI)
Brazil	DS Market – TOTRETURN IN	TOTMKBR(RI)
Chile	DS Market – TOTRETURN IN	TOTMKCL(RI)
Mexico	DS Market – TOTRETURN IN	TOTMKMX(RI)
South Africa	DS Market – TOTRETURN IN	TOTMKSA(RI)

3.5.3 Loading to Comma Separate Values (CSV) Files

Having accessed the required data the next (and most crucial) phase in the retrieval process involves loading the data onto one of the Microsoft (MS) office programmes (Excel, etc). Downloading data from Datastream onto other programmes needs great attention as it has to be implemented via a mode directly readable in the "destination programme", in this case, MS-Excel. This also depends on the type of file selected.

Therefore, while there may be many suitable modes of executing this task, it was found expedient to implement this through "Comma Separated Values" (CSV) files. CSV files are directly linked to and present data in Excel spreadsheet format which makes data presented in CSV files easily transferable to or readable in MS- Excel.

Moreover, downloading via CSV files also facilitate further exportation, if necessary, to statistical packages such as Statistical Package for Social Sciences (SPSS). The retrieval process ended up in two groups of CSV files. The first group, presented in Table 3.2, consists of the raw stock market indices for the eighteen countries with data in Datastream and the second, in Table 3.3, covers the exchange rate between the British Pound and the national currencies of the other countries in the sample.

Table 3.2: Total Return Indices for Eighteen Markets (in Local Currencies)

a) TMktRet UK	j) TMktRet Turkey
b) TMktRet Germany	k) TMktRet Hungary
c) TMktRet France	l) TMktRet Czech Republic
d) TMktRet Netherlands	m) TMktRet Romania
e) TMktRet Switzerland	n) TMktRet Argentina
f) TMktRet South Korea	o) TMktRet Brazil
g) TMktRet Malaysia	p) TMktRet Chile
h) TMktRet Thailand	q) TMktRet Mexico
i) TMktRet Indonesia	r) TMktRet South Africa

Table 3.3: Local Currency/Sterling Exchange Rate for Eighteen Countries

a) Euro/Sterling /DMK (Germany)*	j) Forint/Sterling (Hungary)
b) Euro/Sterling /FFR (France)*	k) Krona/Sterling (Czech Republic)
c) Euro/Sterling /GDER (Netherlands)*	l) Lira/Sterling (Romania)
d) Swiss Franc/Sterling (Switzerland)	m) Peso/Sterling (Argentina)
e) Won/Sterling (South Korea)	n) Real/Sterling (Brazil)
f) Malaysian Dollar/ Sterling (Malaysia)	o) Escudo/Sterling (Chile)
g) Baht/Sterling (Thailand)	p) Peso/Sterling (Mexico)
h) Ruppia/Sterling (Indonesia)	q) Rand/Sterling (South Africa)
i) Lira/Sterling (Turkey)	r) Zim Dollar/Sterling (Zimbabwe)

***Euro/sterling exchange rate is via the original currencies of the countries concerned.**

3.5.4 Importation to Microsoft Excel Spreadsheet Files

With the data in CSV files the next task was the exportation to Microsoft excel spreadsheet files for the preparatory work that presents the data in a suitable shape for analysis. For this purpose, two excel files were opened; "Return Index File" for the stock market indices and "Forex Index File" for the exchange rate series. The CSV files for each category of data was imported to the appropriate excel file with each (Microsoft Excel) file having the columns as presented in Tables 3.4 and 3.5 below.

The information in the tables can be explained as follows. For the stock return indices represented by the Table 3.4, the first column (A) in the excel file presents the years in which the returns are available (i.e. 1991 for the reduced data). This is followed by the return months (which begin from August after reducing the data for the markets with longer data series) in column B. In column C each month's return is numbered with August 1991 as number 1 through to February 2003 as number 139. Columns D to V present the monthly total return indices for each country, starting with the UK. The same arrangement was applied to the foreign exchange indices in Table 3.5

Table 3.4: Monthly Market Indices Denominated in Local Currencies

A. RetYear (Return Year)	L. Thai-RetIndex (Thailand)
B. RetMon (Return Months)	M. Turk-RetIndex(Turkey)
C. NumRetOb (Observations)	N. Hung-RetIndex (Hungary)
D. UK-RetIndex (UK Index)	O. Czech-RetIndex(Czech Rep)
E. Germ-RetIndex (Germany)	P. Rom-RetIndex (Romania)
F. Fran-RetIndex (France)	Q. Arg-RetIndex (Argentina)
G. Neth-RetIndex (Netherlands)	R. Braz-RetIndex (Brazil)
H. Switz-RetIndex(Switzerland)	S. Chi-RetIndex (Chile)
I. Kor-RetIndex (South Korea)	T. Mex-RetIndex(Mexico)
J. Mal-RetIndex (Malaysia)	U. Safri-RetIndex(South Africa)
K. Ind-RetIndex (Indonesia)	V. Zim-RetIndex (Zimbabwe)

Table 3.5: Monthly Foreign Exchange Rate Indices in Sterling per Local Currency

A. ForexYear	L. ForexIndThai
B. ForexMon	M. ForexIndTurk
C. ForexNumObs	N. ForexIndHung
D. ForexIndUK	O. ForexIndCzech
E. ForexIndGerm	P. ForexIndRom
F. ForexIndFran	Q. ForexIndArg
G. ForexIndNeth	R. ForexIndBraz
H. ForexIndSwitz	S. ForexInChil
I. ForexIndKor	T. ForexIndMex
J. ForexIndMal	U. ForexIndSafri
K. ForexIndInd	V. ForexIndZim

After this stage the task is to convert the raw indices to returns (on market indices and on foreign exchange rate). This, in the case of the equity market indices, required the addition of nineteen more columns (X to AP), one for the returns of each country, to Table 3.4. The returns for each month were calculated based on the formula:

Monthly Index Return = $\frac{P_1 - P_0}{P_0}$ where P_0 denoted the stock price for month t_0 and P_1 denote the stock price for month t_1.

Thus column X records the monthly equity returns for the UK market index, which is followed in column Y by the returns for Switzerland in that order up to AP for the returns on the Zimbabwean market index.

However, the foreign exchange rates required the addition of thirty-six more columns. The first eighteen columns (X to AO) are dedicated to the conversion of the monthly exchange rates in local currencies per sterling to sterling per unit of the local currencies for the various countries. This was achieved using the following formula:

$$\text{Sterling Per Unit of Local Currency} = \frac{1}{\textit{Units of Local Currency Per Pound}}$$

Having expressed the exchange rates in terms of pound sterling it becomes easy to compute the returns on exchange rate in sterling terms. This was based on the following formula:

$$\text{Return on Exchange Rate in Pound Sterling } R_E = \frac{E_1 - E_0}{E_0}$$

where E_1 refers to the exchange rate in month t_1 and E_0 is the exchange rate in month t_0.

Thus the next eighteen columns (AP to BG) in Table 3.5[16] were for the calculation of returns on foreign exchange (in sterling). After calculating the monthly equity returns and the returns on foreign exchange, the next task should have involved the calculation of sterling-denominated returns.

However, it was detected that the time series for stock returns differ between the countries. Moreover, for the same country the stock return series and exchange return series also differ in length of time suggesting that the two needs to be brought at par.

[16] Because the equity returns are to be converted into sterling the foreign exchange returns were required to be calculated for the remaining eighteen markets, excluding the UK market.

3.6 Dealing with Disparities in the Length of Return Series

The disparities in the length of data series for different countries arise because Datastream includes countries in the database as and when data becomes available. As a result, some countries entered the database earlier than others. Besides, for the same country some data-types, for example exchange rate, may have become available and hence entered Datastream earlier than other data-types (e.g. equities).

For empirical investigation, it is ideal to have return series of the different countries covering the same time period. However, because of these disparities it was difficult to find a common starting point for the equity returns of all the countries. Also, for the same country, the difference between the exchange rate series and the stock returns series implies that one had to be reduced for the two series to have the same length for the purpose of converting the local currency returns into sterling-denominated returns.

All the markets in this study, except Zimbabwe, have data extending to the present time with most starting from the 1980s. The market index received from Zimbabwe spans the period February 1990 to February 2003. For the countries in Datastream, Romania has the shortest return series beginning from February 1997, lesser than the target of twelve years of monthly data for each country (144 observations).

In order to have a common ending date for all the countries, February 2003 was chosen to correspond with the end date for the data from Zimbabwe. This led to a reduction in the returns for Romania to 73 observations (from February 1997 to February 2003). The problem after that was finding a common starting date as it was important to balance the desire to have longer return series with the need to have more countries in the investigation.

Fortunately, because many of the indices begin from the late 1980s and the middle of the 1990s this makes it possible to have the returns on many of the markets starting and ending at the same time by truncating from the bottom those markets with data series spanning longer time periods.

However, since the returns have to be converted into Sterling this truncation could be implemented only with due consideration to the exchange rate data. The returns on the UK market, denominated in sterling needed no conversion. But for the rest of the countries, the difference between the length of equity returns data and exchange rate data posed much problems because one had to be reduced to make the two equal.

Therefore, for each country the shorter of the two (equity price or exchange rate) return observations was chosen. Table 3.6 shows the comparison of the dates of availability of the equity returns and the exchange rate returns as well as the period or the number of month (observations) data has been available for each country.

Table 3.6 Comparison of Equity Return and Foreign Exchange Return Observations

Name of Country	Length of Equity Market Returns Data	Length of Exchange Rate Returns Data	Period Chosen for Basic Statistics	Number of Observations in Months
United Kingdom	Feb.80-Feb.03	Feb.80-Feb.03	Feb.90-Feb.03	157
Switzerland	Feb.80-Feb.03	July 80-Feb.03	Feb.90-Feb.03	157
Netherlands	Feb.80-Feb.03	Feb.80-Feb.03	Feb.90- Feb03	157
France	Feb.80-Feb.03	Feb.80-Feb.03	Feb.90-Feb.03	157
Germany	Feb.80-Feb.03	Feb.80-Feb.03	Feb.90-Feb.03	157
South Korea	Nov.87-Feb.03	July.80-Feb.03	Feb.90-Feb.03	157
Malaysia	Mar.86-Feb.03	July.80-Feb.03	Feb.90-Feb.03	157
Indonesia	May.90-Feb.03	July.80-Feb.03	May90-Feb.03	154
Thailand	Mar.87-Feb.03	July.80-Feb.03	Feb.90-Feb.03	157
Hungary	Aug. 91-Feb.03	Aug.89-Feb.03	Aug.91-Feb.03	139
Romania	Feb. 97-Feb.03	Jan.90-Feb.03	Feb.97-Feb.03	73
Turkey	Mar.88-Feb.03	Feb.83-Feb.03	Feb.90-Feb.03	157
Czech Rep.	Janu.94-Feb.03	Jan.90-Feb.03	Jan.94-Feb.03	110
Argentina	Sept.93-Feb.03	Jun.84-Feb.03	Sep.93-Feb.03	114
Brazil	Sept.94-Feb.03	Feb.90-Feb.03	Sep.94-Feb.03	102
Chile	Aug.89-Feb.03	July.80-Feb.03	Feb.90-Feb.03	157
Mexico	July.89-Feb.03	July.80-Feb.03	Feb.90-Feb.03	157
South Africa	Feb.80-Feb.03	July.80-Feb.03	Feb.90-Feb.03	157
Zimbabwe	Feb.90-Feb.03	July.80-Feb.03	Feb.90-Feb.03	157

As shown in Table 3.6, thirteen markets; consisting of the five developed markets – UK, Switzerland, Germany, France and the Netherlands – and eight emerging markets – South Africa, Zimbabwe, Chile, Mexico, Turkey, South Korea, Malaysia and Thailand – have 157 monthly return observations, exceeding the target of 144.

However, the six markets remaining have varying lengths of data series. Indonesia has 154, Hungary 139, Argentina 114, the Czech Republic 110, Brazil 102 and Romania has the shortest data length of 73 monthly observations. This presents difficulties in that it is impossible to combine the emerging markets in one portfolio without having to drastically reduce the data available for those markets with 157 month of returns.

In effect, a way has to be found to circumvent this problem. However, it was deemed necessary to defer this to chapter 5 in order to focus on the next hurdle involving the actual conversion of the equity returns from local currencies to sterling. The problem at this stage emanates from markets with euro-denominated equity returns. That is, France, the Netherlands and Germany (the euro-zone countries) have equity returns denominated in euros and not in franc, guilder or deutschmark as the case should be.

This is due to fact that Datastream "back-converted" all returns from local currencies to euros following the introduction of the euro as a single currency in those countries. As these countries had equity return data before the euro was introduced, Datastream used the euro-equivalent of each country's currency to "back-convert" the equity market indices for these countries into euros. For instance, the equity index for France was converted into euros using the euro-franc exchange rate when it was introduced.

The problem posed by such "back-conversion" is the need for re-conversion of the euro- denominated returns into the currency of a country outside the European single currency zone. Perhaps to solve this problem Datastream provides, in addition, the euro-equivalent of sterling via the various national currencies. That is, France has euro-sterling via French franc, Germany has euro and sterling exchange rate via the deutschmark while the Netherlands has euro-sterling exchange rate via the guilder. These rates are "back-converted" rates but they represent the closest that could be obtained for converting the euro-denominated returns of these markets to sterling.

3.7 Conversion to Sterling-Denominated Returns

The total return from international equity investment consists of two components: local currency returns on equities and returns on foreign exchange rate. Thus having calculated stock index and the exchange rate index returns the next task is to convert these into total investment returns. This was achieved through the following formula:

Sterling Denominated Returns, $R_S = (1+R_H)x(1+R_E)-1$ where R_S is sterling-denominated total investment returns, R_H stock return in local currency for the month and R_E is the sterling-denominated return on exchange rate for the same month.

After this stage two purposes were in focus (i) calculation of the basic statistics in chapter 4 and (ii) the actual empirical investigation in chapters 5, 6 and 7.

4.0 Evaluation of the Basic Characteristics of the Returns

This chapter prepares the ground for the empirical analysis in the next three chapters. The objective in this chapter is to present a set of statistics detailing the basic characteristics of the data. For each market the following statistics are calculated: mean (expected) return, standard deviation, coefficients of skewness and excess kurtosis, correlation coefficients, JB test of normality and parameter stability.

Expected returns are measured in terms of simple average and continuously compounded (geometric) average. Risk is measured as the standard deviation of returns. The coefficient of skewness and excess kurtosis and the JB test of normality complement the mean and standard deviation to highlight the distribution (i.e. normal or non-normal) of the return data and also provide a clearer picture of the risk level.

The correlation coefficient signifies the extent of co-movement between the returns on any two of the markets while the test of stability of slope coefficients is aimed at determining whether the co-movements among the returns on the developed and emerging markets have remained stable or unstable over the period of this study.

By presenting these statistics, the present chapter highlights the effects of the problems discussed in the previous chapter on the market returns and also provides results that serve to guide the direction of the empirical analysis in the next three chapters. Thus the results obtained in this chapter are to help in determining the procedures to be employed in testing the benefit of international diversification.

4.1 Measurement of Expected Return and Risk

As explained in chapter 3, the process by which emerging market returns data is generated presents problems that can affect portfolio performance expressed in terms of the mean and standard deviation of returns. In view of this, the estimation and interpretation of emerging market expected returns and risks require ample caution. The low liquidity and unstable stock market history result in high return volatility.

Because of the high volatility of emerging market returns even modest differences in holding periods can have dramatic impacts on estimate of expected returns **Eaker, Grant and Woodward (2000)**. Therefore, while the problem of backtracking is avoided by using shorter return series the loss of data due to reduction in the return observations can be expected to impact on the estimates of expected returns and risks.

The greatest impact of such problem may be observed when comparisons are made of the risk and returns of the emerging markets with the risk and returns of the developed markets that have reasonably stable return histories. Eaker, Grant and Woodward (2000) suggest that, in such instances estimation of both the arithmetic and the geometric expected returns provide a better picture than estimating only one.

The arithmetic expected returns are useful for empirical analysis while geometric expected returns are better for comparison between markets with stable and markets with unstable return history. Geometric expected returns help throw more light on the level of volatility of asset returns. In general, the higher the volatility of returns on an asset, the higher is the difference between the geometric and arithmetic expected returns on that asset **(Eaker and Grant (2002))**.

Because emerging markets are typically characterised by high periodic negative returns the difference between their geometric and simple average returns can be very striking. Thus for a better comparison of the performance of emerging and developed markets it is important to estimate both geometric and arithmetic expected returns.

Having decided on the measurement of expected return, it is also important to consider the measurement of risk as investment performance requires the estimation of both expected returns and the degree of exposure to risk factors. When using the mean-variance portfolio theory the standard deviation of returns suffices as a proxy for the level of return volatility (risk). Therefore the standard deviations are computed in addition to the two measures of expected returns for each market in this section.

With the exception of Argentina, Brazil, the Czech Republic and Romania, the expected return and volatility for each of the remaining 15 markets are calculated based on the index returns over the period from August 1991 to February 2003. The expected return and volatility for Argentina are based on return series from September 1993 to February 2003, for Brazil, from September 1994 to February 2003, for the Czech Republic from January 1994 to February 2003 and for Romania from February 1997 to February 2003 according to the data available. Table 4.1 shows the results.

Table 4.1 Annualised Expected Returns and Standard Deviations (Risk) in Sterling

Country	Annualised Simple Average Returns: Local Currencies (%)	Simple Average Returns: Sterling Annual (%)	Geometric Average Returns Sterling Annual (%)	Standard Deviation of returns: Sterling Annual (%)
UK	8.97	8.97	7.75	15.44
Switzerland	11.57	12.71	11.04	18.16
Netherlands	11.63	11.52	9.79	18.23
France	11.01	10.97	8.95	20.04
Germany	6.55	6.40	4.50	19.29
S. Korea	13.03	12.00	1.81	49.30
Malaysia	10.14	9.35	1.91	39.00
Indonesia	8.41	-0.52	-11.56	47.61
Thailand	10.42	7.89	-2.44	46.79
Hungary	25.21	16.12	8.05	43.06
Romania	54.00	20.08	-0.18	69.52
Turkey	76.90	27.40	5.36	67.96
Czech Rep	8.53	8.10	2.06	36.80
Argentina	15.35	1.54	-5.07	36.25
Brazil	17.22	4.60	-4.26	42.12
Chile	14.32	9.40	5.75	27.13
Mexico	20.16	11.98	5.25	36.00
S. Africa	16.38	8.43	4.39	28.04
Zimbabwe	43.97	20.65	11.07	44.02

4.1.1 Analysis of Expected Return and Risk

Table 4.1 provides the measures of annualised risk and expected returns (both sterling and local currencies) of individual markets. Since this study examines the benefits from international diversification from UK investors' perspective it would have been essential and sufficient to concentrate on the sterling-denominated returns only.

However, it is informative to also consider the magnitude of the local currency returns. This stems from the simple reason that for some emerging markets the expected returns measured in local currencies can be extremely different from foreign-currency-denominated expected returns. Harvey (1995) attributes this difference to high inflation, especially for the emerging markets in Latin America.

In this study, high exchange rate fluctuation is also found to be a cause of the difference between local currency and foreign currency-denominated expected returns. To emphasis this, the local currency expected returns for each market is presented together with the sterling-denominated expected return.

The risks and expected returns are annualised following the procedure in Li, Sakar and Wang (2003). Expected returns are annualised by multiplying the monthly average return of each market by 12 while the standard deviations (risks) are annualised by multiplying the monthly standard deviations by the square root of 12.

The statistics begin from the second column in Table 4.1 with the annualised expected returns in the currency of each country (local currencies), the third column provides sterling-denominated annualised expected returns while the fourth column shows the sterling-denominated annualised geometric expected returns. The fifth column gives the annualised sterling-denominated standard deviation. To better differentiate between the performances of individual markets, the risk and returns are ranked. Tables 4.2 assigns rankings to the expected returns presented in Table 4.1.

Table 4.2 Rankings of Annualised Expected Returns (in Sterling)

Countries	Annualised Simple Average Returns Sterling (%)	Rankings	Countries	Annualised Geometric Average Returns Sterling (%)	Rankings
Turkey	27.40	1	Zimbabwe	11.07	1
Zimbabwe	20.65	2	Switzerland	11.04	2
Romania	20.08	3	Netherlands	9.79	3
Hungary	16.12	4	France	8.95	4
Switzerland	12.71	5	Hungary	8.05	5
South Korea	12.00	6	UK	7.75	6
Mexico	11.98	7	Chile	5.75	7
Netherlands	11.52	8	Turkey	5.36	8
France	10.97	9	Mexico	5.25	9
Chile	9.40	10	Germany	4.50	10
Malaysia	9.35	11	South Africa	4.39	11
UK	8.97	12	Czech Rep	2.06	12
South Africa	8.43	13	Malaysia	1.91	13
Czech Republic	8.10	14	South Korea	1.81	14
Thailand	7.89	15	Romania	-0.18	15
Germany	6.40	16	Thailand	-2.44	16
Brazil	4.60	17	Brazil	-4.26	17
Argentina	1.54	18	Argentina	-5.07	18
Indonesia	-0.52	19	Indonesia	-11.56	19

Table 4.2 shows both arithmetic and geometric expected returns in sterling. The ranks are assigned to the statistics for individual markets to compare the performance of each market with the others. Expected returns are ranked in descending order such that the country with the highest expected return is assigned a rank of 1 and the next highest assigned a rank of 2, up to the lowest expected return with a rank of 19. The ranking is done in line with the intuition that investors generally prefer higher expected return to lower expected return. Therefore the highest is ranked first.

Similar to the expected returns, the standard deviations are ranked in Table 4.3. The ranks are assigned with the intuition that investors prefer lower risk to higher risk. Therefore the ranking is in ascending order. That is, the country with the lowest risk is ranked 1 and the next lowest ranked 2, ending with the highest ranked as 19.

Table 4.3 Rankings of Annualised Standard Deviations in Sterling

Country	Annualised Standard Deviation of Returns in Sterling	Rankings
UK	15.44	1
Switzerland	18.16	2
Netherlands	18.23	3
Germany	19.29	4
France	20.04	5
Chile	27.13	6
South Africa	28.04	7
Mexico	36.00	8
Argentina	36.25	9
Czech Republic	36.80	10
Malaysia	39.00	11
Brazil	42.12	12
Hungary	43.06	13
Zimbabwe	44.02	14
Thailand	46.79	15
South Korea	47.30	16
Indonesia	47.61	17
Turkey	67.96	18
Romania	69.52	19

From Table 4.2, the simple expected returns range from 27.40% to -0.52%. For the emerging markets, Turkey provides the highest expected return of 27.40%. This is followed by Zimbabwe, 20.65%. Indonesia offers the lowest expected return of -0.52% and Argentina comes next with 1.54%. Among the developed markets, Switzerland provides the highest expected return of 12.71%, followed by the

Netherlands with expected return of 11.52%. Germany offers the lowest expected return of 6.40% while the UK comes with the next lowest expected return of 8.97%.

Similarly, the geometric expected returns also range from 11.07% to -11.56%. Among the emerging markets, Zimbabwe makes the highest annualised sterling-denominated geometric average return of 11.07%. This is followed by Hungary with 8.05%. Brazil, Argentina, Romania, Thailand and Indonesia all present negative geometric expected returns. For the developed markets Switzerland has the highest geometric mean return of 11.04% and the Netherlands comes next with 9.79%.

From Table 4.1, the expected returns measured in local currencies range from 76.90% to 6.55%. As evidence from Table 4.1, Turkey records the highest local currency expected return of 76.90%. This is followed by Romania with 54.00%.These values are far different from the sterling-denominated returns. Again Indonesia presents the lowest local currency expected return of 8.41% among the emerging markets. In the case of the developed markets the Netherlands presents the highest local currency expected return of 11.63% while Germany presents the lowest return of 6.55%.

The discussion of expected returns seems to view the emerging markets in a more favourable light compared to the developed markets. However, the picture turns to be different when the return volatilities are analysed. As evident in Table 4.3, the standard deviations range from 15.44% to 69.52%. Among the developed equity markets, the UK presents the lowest risk level of 15.44%. This is followed by Switzerland with 18.16% while France presents the highest risk level of 20.04%.

For the emerging markets, Chile has the lowest risk level of 27.13% and South Africa comes next with 28.04%. Romania turns out to be the most risky among the emerging markets with return volatility of 69.52% while Turkey follows with a volatility of 67.96%. Surprisingly, Indonesia with negative sterling denominated expected return again records a high return volatility of 47.61%. On the whole, these are in no way comparable to the volatility levels recorded for the developed equity markets.

4.1.2 Lessons from Analysis of Expected Return and Risk

The analysis in the last few sections provide valuable insights about emerging and developed markets returns which help draw a line of distinction between the two classes of markets. Comparing local currency returns to the sterling-denominated returns a clear contrast is revealed. The emerging markets provide much higher local currency expected returns than the developed markets. However, when expressed in sterling the returns seem to dissipate. For instance, the annualised expected Lira return of 76.90% for Turkey falls by approximately 60% to just 27.40% in sterling.

Similarly, Romania and Zimbabwe both have their local currency returns reducing from 54.00% to 20.08% in the case of Romania, and from 43.97% to 20.65% for Zimbabwe. In each case the sterling-denominated return is less than half the local currency return. The other emerging markets follow this trend by having their local currency expected returns being wiped out by exchange rate fluctuations.

Indonesia provides an even more acute case as the conversion of the returns from Rupiah into sterling turns the expected return of 8.41% in Ruppiah to a sterling-denominated return of -0.52%. In Comparison, the expected returns on the developed markets change only slightly when converted from local currencies to sterling.

Considering the arithmetic expected returns and the geometric expected returns another picture of emerging market investment comes to light. Emerging markets expected returns experience greater reduction as compared to the developed markets when expected returns are expressed in geometric averages. For instance, the arithmetic average return of 27.40% for Turkey turns to a geometric average return of just 5.36% (reduced by almost 85%). Similarly, the arithmetic average return of 20.65% for Zimbabwe reduces to 11.07% geometric expected return.

The Czech Republic, Malaysia, South Korea, Thailand, Romania, Argentina, Brazil and Indonesia provide very interesting stories. The Czech Republic and Malaysia have their arithmetic average return of 8.10% and 9.35% respectively quashed by three-quarters to 2.06% and 1.91% when the returns are calculated in geometric averages. For Romania, the arithmetic average return of 20.04% falls all the way down to -0.18% geometric expected return.

Similarly, Brazil, Argentina and Thailand have their positive simple average returns of 4.60%, 1.54%, 7.89% turned to negative geometric average returns of -4.26%, -5.07%, and -2.60% respectively. For Indonesia, the simple average return of -0.52% turns into a geometric average return of -11.56%. These are demonstrations of the high level of return volatility associated with emerging equity markets.

In the case of the developed markets, the differences between the arithmetic average and the geometric average returns are very minimal. For the UK, the arithmetic average return of 8.97% falls just slightly to 7.75% geometric average return and for Switzerland, the Netherlands, France and Germany, while the geometric average returns are lower than the arithmetic expected returns, the differences are slight.

For example, Switzerland experiences a fall from 12.71% to 11.04% when the returns are continuously compounded while for the Netherlands the arithmetic expected returns of 11.52% changes to 9.79% geometric expected returns. For France and Germany, the change is still slight, from 10.97% to 8.95% and 6.40% to 4.50% respectively. These are indications of the low level of volatility on these markets.

It is clear that when discussed individually many of the emerging markets offer higher average returns than the developed markets (Table 4.2) and at the same time present higher risk than the developed markets (Table 4.3). From Table 4.3 the first five markets offering the lowest risk to investors are developed markets. Thus the most risky developed financial market is better than the least risky emerging markets.

By implication, all the emerging markets can be considered riskier than their developed counterparts but not all of them offer the much-vaunted higher average return. Some of the emerging markets; Argentina, Brazil and Indonesia have both lower expected return and higher risk levels. Individual emerging market's poor performance can overshadow the good performance of others and it is possible that emerging markets as a group can be less or more profitable than individual markets.

4.2 Skewness, Excess Kurtosis and JB Test of Normality

The previous section has measured the expected returns and standard deviation. However, the direction of deviation of returns is not obvious. It is unclear whether positive (desirable) or negative (undesirable) deviations dominates the measurement of risk. To deepen the investigation of the basic properties of the returns, this section calculates the higher order moments of return dispersion –skewness and kurtosis.

The case for including these statistics in the analysis of investment risk had been proposed for a long time in the literature. **Lee (1977), Elton and Gruber (1974), Kraus and Litzenberger (1976)** all suggested risk measures that extend beyond the second moment (variance or standard deviation) and take into account other measures of return distribution such as the coefficients of skewness and (excess) kurtosis. The estimation of these coefficients enables investment risk to be seen in a clearer light.

Harvey and Siddique (2000) formalised this by claiming that if asset returns have systematic skewness, then the estimation of expected returns should include rewards to investors for accepting this risk. They estimate the presence of systematic skewness in returns to be so economically important as to command a risk premium. Table 4.4 provides the coefficients of skewness, excess kurtosis and JB statistics.

Table 4.4 Coefficients of Skewness and Excess Kurtosis and JB Test of Normality

Country	Coefficient of Skewness	Coefficient of Excess Kurtosis	Jarque-Bera Test of Normality	P-Values for JB Test of Normality
UK	-0.48	-2.21	33.52	0.0000
Switzerland	0.22	0.90	5.89	0.0526
Netherlands	-0.76	-0.18	12.92	0.0012
France	-0.12	-2.27	13.42	0.0000
Germany	-0.73	-1.54	26.03	0.0000
South Korea	1.37	1.44	55.29	0.0000
Malaysia	0.49	-0.28	6.07	0.0481
Indonesia	0.73	-0.04	12.52	0.0019
Thailand	0.91	-0.60	21.18	0.0000
Hungary	2.37	13.10	720.80	0.0000
Romania	1.93	7.29	101.37	0.0000
Turkey	0.56	-2.21	35.55	0.0000
Czech Rep	2.18	13.90	626.12	0.0000
Argentina	0.01	-2.45	28.44	0.0000
Brazil	0.13	-2.35	23.77	0.0000
Chile	0.11	-2.58	38.82	0.0000
Mexico	-0.51	-1.99	28.85	0.0000
South Africa	-0.32	1.36	13.06	0.0015
Zimbabwe	0.21	-2.32	32.13	0.0000

The second and third columns of the table respectively present the coefficients of skewness and excess kurtosis while the fourth and the fifth columns respectively provide the statistics for the JB test of normality and the corresponding p-values[17].

In general, if the returns were normally distributed the coefficients of skewness and excess kurtosis would be zero for each market and the JB test would have a high p-value. From Table 4.4, with the exception of Malaysia which shows some evidence of normality, there is less evidence to accept normal distribution for the index returns on the remaining markets. The absence of normality means that the test in the next few chapters will need to reflect the lack of symmetry in the distribution of the returns.

4.3 Analysis of Correlation Coefficients

With risk and returns discussed at length the focus now turns to the analysis of correlations. The core ingredient in portfolio diversification is the correlation between the returns on the assets in the portfolio. Similarly, the correlations among developed and emerging market returns determine the extent to which risk may be reduced by adding emerging market assets to developed market portfolios.

In general, the literature proposes three patterns of correlations among international asset returns. First, there are higher correlations among the returns on assets from different developed markets. Secondly, the correlations among returns on emerging market assets and developed market assets are low and thirdly, there are low correlations among asset returns from different emerging financial markets.

In order to verify these relationships, this section examines the correlations among the nineteen markets under consideration, beginning with the correlation among the developed markets. The information in Tables 4.5 indicates the matrix of correlation coefficients for the returns on the five developed markets in the sample computed based on the sterling returns from August 1991 to February 2003 for all the markets.

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[17] For the formula used in computing the JB statistics refer to Verbeek (2002) page 174.

Table 4.5 Matrix of Correlations for Developed Market Returns

Markets	UK	Switzerland	Netherlands	France	Germany	Average
United Kingdom	1.00					77%
Switzerland	0.74	1.00				73%
Netherlands	0.82	0.78	1.00			83%
France	0.77	0.70	0.85	1.00		79%
Germany	0.73	0.69	0.85	0.84	1.00	77%
Average	77%	73%	83%	79%	77%	78%

The information in Table 4.5 shows, for each market, the correlation with the other markets and the average of the correlations with all the other markets. The results clearly show that the correlations among the returns on equities in the developed markets are high. The correlations range from 0.69 between Germany and Switzerland to 0.85 between Germany and the Netherlands and Germany and France.

In average terms, the correlations of each market with the rest shows a range of between 73% for Switzerland to 83% for the Netherlands and an overall average of 78%. This provides a strong confirmation to the evidence in the literature suggesting that developed market returns are highly correlated with one another.

Continuing from this, the attention turns next to the matrix of correlation coefficients for the developed and the emerging market assets in Table 4.6, the mainstay of the argument for diversification to emerging equity markets. This shows for each emerging market the correlation with the developed markets. The calculation of correlations is based on the same data as the estimates of expected return and risk.

Thus between any two markets with unequal data length, the correlation is calculated based on the data for the market having the shorter return series. This concerns only four markets: Argentina, Brazil, the Czech Republic and Romania. Calculations for all the remaining markets cover the time period from August 1991 to February 2003

The table below shows from the second to the fifth column (vertically) the correlation of each developed market with each of the emerging markets with the overall average shown in the bottom row. The same information considered horizontally (in rows) shows the correlation of each emerging market with each of the developed markets with the overall average indicated in the last column (at the right hand side).

Table 4.6 Matrix of Correlations for Developed and Emerging Market Returns

Markets	UK	Switzerland	Netherlands	France	Germany	Average
S. Korea	0.49	0.43	0.43	0.39	0.38	42%
Malaysia	0.28	0.18	0.29	0.22	0.30	25%
Indonesia	0.34	0.39	0.40	0.29	0.32	35%
Thailand	0.45	0.40	0.42	0.34	0.42	41%
Hungary	0.46	0.49	0.45	0.47	0.41	46%
Romania	0.09	0.14	0.13	0.09	0.11	11%
Turkey	0.23	0.20	0.26	0.28	0.33	26%
Czech Repub.	0.31	0.33	0.26	0.32	0.23	29%
Argentina	0.44	0.32	0.40	0.42	0.37	39%
Brazil	0.61	0.46	0.60	0.54	0.59	56%
Chile	0.43	0.39	0.39	0.36	0.34	38%
Mexico	0.55	0.41	0.49	0.45	0.41	46%
S. Africa	0.54	0.51	0.52	0.47	0.52	51%
Zimbabwe	0.07	0.05	0.06	0.07	0.01	5%
Rough Average	38%	34%	36%	34%	34%	35%

Taken individually, the correlation between the developed and the emerging markets ranges from as low as 0.01 between Germany and Zimbabwe to as high as 0.61 between the UK and Brazil. When viewed in terms of "rough" averages, it can be seen (from the bottom row of the table) that each of the developed markets is lowly correlated with the emerging markets. This ranges from the lowest correlation of 34% for Switzerland, France and Germany to the highest of 38% for the UK.

Compared to the developed markets these degree of correlations may be considered quite low in both average and for individual emerging markets. For instance Zimbabwe has an average correlation of 5% with all the developed markets, while Romania has 11% average correlation with the developed market returns. To a significant extent, these provide some confirmation to the literature that emerging market returns are lowly correlated with returns on developed market assets.

Turning to the correlations across the emerging markets, again the evidence appears to follow the pattern in the literature. The correlations range from as low as -0.04 between Turkey and Romania to as high as 0.76 between Hungary and the Czech Republic. In between are a number of low correlations among the various emerging markets. This is reflected in the calculation of rough averages for each market.

As shown in the table, the average correlations range from the lowest of 12% for Zimbabwe, with the rest of the emerging markets, to the highest of 42% for Brazil. The average correlations for the remaining emerging markets are all below 40% as shown in the bottom row of the table. These can be considered low compared to the results in Table 4.5, a sign of low average correlation among emerging markets.

Table 4.7 Matrix of Correlations for Emerging Market Returns

	Kor	Mal	Indo	Thai	Hun	Rom	Turk	Czec	Arg	Bra	Chil	Mex	S.A	Zim
Kor	1.00													
Mal	0.29	1.00												
Indo	0.42	0.41	1.00											
Thai	0.60	0.51	0.52	1.00										
Hun	0.30	0.10	0.35	0.19	1.00									
Rom	0.08	0.24	0.18	0.04	0.27	1.00								
Turk	0.17	0.12	0.19	0.18	0.29	0.04	1.00							
Czec	0.30	0.16	0.23	0.15	0.76	0.21	0.20	1.00						
Arg	0.29	0.24	0.31	0.39	0.43	0.09	0.38	0.29	1.00					
Braz	0.38	0.27	0.42	0.38	0.51	0.19	0.42	0.38	0.58	1.00				
Chil	0.37	0.37	0.38	0.41	0.40	0.27	0.17	0.36	0.58	0.69	1.00			
Mex	0.39	0.35	0.37	0.40	0.48	0.10	0.17	0.34	0.62	0.65	0.57	1.00		
S. A	0.47	0.33	0.47	0.57	0.39	0.32	0.25	0.30	0.39	0.53	0.43	0.50	1.00	
Zim	0.11	0.23	0.14	0.09	0.18	0.19	0.09	0.12	0.01	0.07	0.07	0.06	0.16	1.00
Ave	32%	28%	34%	34%	36%	17%	20%	30%	35%	42%	39%	38%	39%	12%

Note: the Correlation between Romania and Turkey is -0.04.

The correlation matrices seem to conform to the evidence in previous researches, yet another interesting pattern can be seen from this data. The correlation between emerging markets appears to be on the rise. For instance, the correlation between Thailand and South Korea is 0.60, between Brazil and Mexico and Argentina and Mexico are 0.62 and 0.65 respectively. These are near the correlation of 0.69 between Switzerland and Germany, a sign of increased correlations among emerging markets.

Even more striking is the correlation between Hungary and the Czech Republic of 0.76, which exceeds the correlation between Germany and Switzerland and that between the UK and Germany. Moreover, a high correlation of 0.61 and 0.60 can be noticed between Brazil and the UK and Brazil and the Netherlands. Also noteworthy are the average correlations of 51% and 56% respectively for South Africa and Brazil with the developed markets. These are indications that the correlations among returns on emerging markets assets and returns on developed market assets are increasing.

Furthermore, compared to studies such as Harvey (1995) that find a number of emerging markets being negatively correlated with one another and with the developed markets, there is only one case of negative correlation in this study. This is between Turkey and Romania. Though the returns in this study are denominated in sterling as opposed to dollar in Harvey (1995) and the two studies are also conducted in different time periods, it can still be explained that the evidence in this study is suggestive of an increasing correlation among international equity market returns.

This evidence of rising correlation can have significant implications on the benefits of international diversification. On the whole, however, since these are isolated cases for individual emerging markets, the overall low average correlation among the emerging and the developed market assets combined with the relatively higher expected returns on the emerging market assets can mean that diversification may still be beneficial.

4.4 Test of Stability (Constancy) of Regression Parameters

This section is a step forward to the correlation analysis in the preceding section. The analysis measures the extent of change in the slope coefficient (in two sub-periods) from regressing the developed market returns on the emerging market returns to asses the stability of the relationship between the developed and the emerging markets.

As discussed in Chapter 2, the degree of co-movements among international equity market returns appears to be changing over time which can impact greatly on the benefits from international diversification. Unstable correlations among returns on international assets can imply unstable benefits from international diversification.

To this end, simply examining the correlations among asset returns may be insufficient as a signal to the gains from diversification unless there is reasonable certainty that the correlations have remained constant over time. The essence of this section is to verify the constancy of the correlations among the developed and the emerging market returns already examined in the previous section in two sub-periods.

For a market to be included in this analysis it should have at least 120 months of continuous returns that can be divided into two sub-periods of at least 60 months each to enable the correlations for the first period to be compared with that for the second period and the significance of the difference tested. Of the nineteen markets, fifteen satisfy this criterion, having 139 monthly returns from August 1991 to February 2004.

Four countries; Brazil, the Czech Republic, Argentina and Romania are excluded due to extremely short returns series. For the fifteen markets meeting the selection criterion, the elongated period from August 1991 to February 2003 was divided into two sub-periods; August 1991 to April 1997 and May 1997 to February 2003. The year 1997 is chosen as the breakpoint because 1997 marks a turning point for a number of emerging markets which can have serious effects on investors' decisions.

The period after 1997 begins most of the world's financial events starting with the Asian crisis, Turkish financial crises, troubles in Zimbabwe and crisis in Latin America, in addition to the events of September the 11th, 2001, all of which impacts on international investment decision. All these, arguably, implies that periods before and after 1997 should have different implications for investor decisions to emerging markets, making 1997 a suitable point for assessing the changes in correlations.

From this, the next consideration entails choosing the appropriate test technique. **Chow (1960)** provides an F-statistic for structural breaks that is helpful in testing the equality between subsets of coefficients in two linear regressions. However, this requires three separate regressions at a time; one based on the whole sample and two based on two sub-periods in order to examine the correlation between any one developed and one emerging market chosen at a time. Given the number of markets under consideration, using the Chow test would be a time-consuming exercise.

Gujarat (1995) proposes the use of dummy variable regression that abridges the multi-step Chow procedure into a one regression equation of the form; $Y_i = \alpha_1 + \alpha_2 D_i + \beta_1 X_i + \beta_2 (D_i X_i) + \varepsilon_i$ where, Y_i is the returns on individual developed market and X_i is the returns on the emerging market whose relationship with Y_i is being tested.

D_i stands for dummy variables for the returns on market X_i for the first sub-sample period denoted D_i=0 to indicate the period before the chosen breakpoint and D_i= 1 to indicate returns after the chosen breakpoint. α_1 and β_1 are the intercept and the slope coefficient respectively for the normal regression of Y_i on X_i (based on the pre-breakpoint return series with D_i=0) while α_2 is the differential intercept.

Similarly, β_2 denote the differential slope coefficient, indicating by how much the slope coefficient of the regression in the first sub-sample period (pre-break point) differs from the slope coefficient of the regression in the second sub-sample period (post-breakpoint) and ε_i is the regression error term. This was chosen due to the simplicity in interpreting the results and the ease of calculation.

While the equation involves changes in both the slope and the intercept coefficients the attention centres on only the statistical significance of the differences between slope coefficients in the first and the second sub-periods as signals for the change in correlation between each emerging market and the developed markets. Table 4.8 presents the result for the change in the slope coefficients from regressing the returns on each of the developed market on the return on each of the emerging markets

Table 4.8 Test of Constancy of Regression Parameters (Slope Coefficients)

Countries	UK	Switzerland	Netherlands	France	Germany
	P-value	P-value	P-value	P-value	P-value
South Korea	0.787	0.532	0.133	0.270	0.063
Malaysia	0.003♠	0.001♠	0.053	0.028♠	0.027♠
Indonesia	0.616	0.327	0.638	0.761	0.431
Thailand	0.580	0.155	0.349	0.362	0.254
Hungary	0.001*	0.000*	0.000*	0.000*	0.000*
Turkey	0.000*	0.022*	0.000*	0.001*	0.001*
Chile	0.006*	0.002*	0.000*	0.003*	0.000*
Mexico	0.000*	0.006*	0.000*	0.003*	0.000*
South Africa	0.682	0.559	0.387	0.354	0.844
Zimbabwe	0.140	0.259	0.250	0.349	0.180

*Significant increase in the slope coefficient at 5 percent. ♠ Significant fall in the slope coefficient at 5percent.

The statistics in Table 4.8 signify the extent of the stability in the relationships between the developed and the emerging market returns as reflected in the change in the regression slope coefficient over two separate periods. Only p-values for the t-test statistics are provided for each country. P-values closer to zero indicate significant change and higher p-values (away from zero) imply insignificant change.

As shown in Table 4.8, five emerging markets; South Korea, Indonesia, Thailand, South Africa and Zimbabwe, demonstrate fairly stable correlations with the developed markets over the entire period from August 1991 to February 2003. Four emerging markets; Hungary, Turkey, Chile and Mexico have experienced increased correlation with the developed markets. Therefore, of the ten emerging markets, only Malaysia shows evidence of reduced correlation with the developed markets returns.

For the developed markets, a simple comparison is made between the correlations for the first and the second sub-period. The results in Table 4.9 show the percentage increase in the correlation among the developed markets in the period from August 1991 to April 1997 as compared to the period from May 1997 to February 2003. A clearer picture of this is presented in appendices D, E, F, G and H on pages 188-9.

Table 4.9 Developed Markets % increase in Correlations: 1991-1997 and from 1997 - 2003

Markets	UK	Switzerland	Netherlands	France
United Kingdom	-			
Switzerland	62%	-		
Netherlands	27%	29%	-	
France	25%	68%	18%	-
Germany	68%	52%	19%	38%

It could be seen that none of the developed markets has experienced a reduction in correlation with another developed market over the period from 1991 to 1997. Also the increase in correlation is phenomenal between the UK and Switzerland (62%) and between the UK and Germany (68%) from 1991-1997 to 1997-2003. Similar increases are recorded for Switzerland and France (68%) and Switzerland and Germany (52%). The Netherlands records the lowest increases of 18% and 29%.

Compared to the correlations among the emerging and the developed markets, the increase in the correlations among the developed markets is more significant. This evidence will have serious implications for the tests for diversification benefits to be conducted in chapter 5. This is taken care of in Chapter 6 with the returns divided into sub-periods in order to examine how this has impacted on the diversification benefits.

5.0 The Test of Mean-Variance Spanning

This chapter begins the empirical investigation. The preliminary tests carried out in the previous chapter have provided valuable insights into the characteristics of the data by underlining the differences and the relationships between the returns on the emerging markets and the developed markets. The present chapter draws on those insights to examine the benefits from including the emerging market equity returns in optimal portfolios generated from the returns on the developed market equities.

The chapter begins in section 5.1 with an overview of the concept of mean-variance spanning, the statistical method to be used for the investigation. Section 5.2, relates the test of mean-variance spanning to the fund separation theorem, from which it was originally derived. Section 5.3 briefly discusses the issue of mean-variance spanning and the existence of a risk-free asset while section 5.4 presents the statement of the research hypothesis that is to be tested in the mean-variance spanning framework.

Section 5.5 discusses the derivation of the statistic for the F-test of mean-variance spanning and in section 5.6 the search is made for alternative or complementary test methods. The first alternative, the likelihood ratio test of mean-variance spanning, is discussed in section 5.6.1, the second alternative, the Wald test, follows in section 5.6.2 and the third alternative, the Lagrangian multiplier test, is next in section 5.6.3. In section 5.7 the effects of small sample properties of spanning tests are examined

Section 5.8 follows with application of the four statistical methods in testing for the benefit from diversifying the developed market portfolio to the emerging markets, considered a standalone asset class. Section 5.9 also applies the same four statistical tests in the investigation of the benefits from diversification to the emerging markets grouped into geographical asset classes, while section 5.10 summarises the results.

The contribution of this chapter to studies on emerging market investment is reflected in the employment of four different versions of the regression-based test of mean-variance spanning in examining the gains from diversifying developed market portfolios to emerging markets. Given that different tests yield different results, using four tests on the same returns provides more comprehensive and meaningful results than can be achieved by employing only one statistical test as in the extant literature.

5.1 The Concept of Mean-Variance Spanning

The concept of mean-variance *spanning* implies that the mean-variance efficient frontier of a risky portfolio formed from one group of assets (the benchmark assets) plus a new set of assets (the test assets) coincides with the efficient frontier derived from the benchmark assets only. Thus, there is mean-variance spanning when the efficient frontier derived from the returns on the benchmark assets spans the space, *in a mean-variance (-standard deviation) plane*, that may be occupied by the efficient frontier for the expanded asset set (i.e. the benchmark portfolio plus the test assets).

In this sense, no mean-variance investor can benefit from adding the test assets to an optimal portfolio of the benchmark assets because the risk-return characteristics of the benchmark portfolio are the same as the risk-return characteristics of the expanded opportunity set. The test assets therefore become redundant to the investor. This also means that an investor benefits from adding the test assets when the frontier for the expanded asset set differs significantly from that of the benchmark assets.

Quite simply, the coincidence of two efficient frontiers (mean-variance spanning) can be determined graphically by superimposing the efficient frontier for the benchmark assets on the efficient frontier for the expanded opportunity set and visually examine the distance, measured in mean-variance terms, between the two frontiers. This may provide some evidence on the extent to which the efficient frontier for the portfolio formed from the expanded asset set shifts from the benchmark portfolio frontier.

However, Harvey (1995) argues that the graphical analysis fails to provide statistical evidence about the shift in the efficient frontier for the benchmark assets resulting from the inclusion of the test assets. To this end, the appropriate test of spanning requires a statistical quantification of the distance (in mean-variance sense) between the frontier for the benchmark portfolio and the frontier for the expanded portfolio.

The statistical measurement of the magnitude of the difference between two efficient frontiers was first suggested by **Huberman and Kandel (1987),** henceforth HK

(1987). They derive an F-statistic for the joint test of the hypothesis that the efficient frontier derived from a set of benchmark assets is the same as the efficient frontier derived from the benchmark asset set plus additional set of assets (test assets).

This statistical procedure has come to be known as the test of mean-variance spanning and forms the main tool for examining the significance of adding a new set of assets to an existing optimal mean-variance portfolio. The most important application of the test has been for the evaluation of the benefits from adding international assets to domestic assets. This has generated several innovations.

De Santis (1993) and Bekaert and Urias (1996) present a version based on the SDF model and DNW (2001) provide a Wald test version with short-sale constraints and transaction costs. **Kan and Zhou (2001)** have followed HK to derive other versions; likelihood ratio and the Lagrangian multiplier tests in addition to a Wald test version of the form derived by DNW (2001) without transaction cost and short-sale constraints. By introducing Hansen's (1982) GMM procedure into the Wald test they derive a generalised version that suits all forms of asset return distributions.

Both HK (1987) and **Jobson and Korkie (1989)** (statistically) distinguish between mean-variance intersection and mean-variance spanning. **DeRoon and Nijman (2001)** describe mean-variance intersection as when the two minimum-variance frontiers have exactly one point in common so that there is just one mean-variance utility function for which a mean-variance investor with the optimal portfolio of the benchmark assets obtains no benefit from including the test assets in the portfolio.

Therefore, the distinction between mean-variance spanning and mean-variance intersection is mainly whether the two efficient frontiers being compared meet at just one or at more than one point in the mean-variance (-standard deviation) space.

5.2 Mean-variance Spanning and Fund Separation Theorem

Mean-variance spanning originates from the fund separation theorem. Mean-variance spanning does not necessarily require that the minimum-variance frontier of the expanded asset set completely overshadows the frontier of the benchmark assets.

Rather the essence of spanning is that the two frontiers should have at least two points in common or intersect at two separate points in the mean-variance (-standard deviation) plane. The Mutual Fund Separation Theorem assumes that all investors are quadratic utility-maximisers so that any two efficient portfolios on a mean-variance efficient frontier could be deemed to span all mean-variance portfolios on the frontier.

In the CAPM, for instance, the mutual fund separation theorem suggests that any portfolio on the frontier is equivalent to a linear combination of only two portfolios; the market portfolio and the risk-free asset. Since quadratic utility implies mean-variance preferences, all individual investors hold mean-variance efficient portfolios. Therefore, instead of holding a single portfolio (market portfolio) the fund separation theorem allows the investor to hold linear combination of two portfolios, that is, the market portfolio in addition to the risk-free asset (which is the same for all investors).

Under similar assumption, spanning could be explained to imply that if the two minimum-variance frontiers intersect at two separate points in a mean-variance space then those two points of intersection span all other points on the whole of each of the frontiers. Investors will thus be indifferent between holding a portfolio formed from the benchmark assets only and a portfolio formed from the benchmark plus the test assets (because both may be seen to possess similar risk-return characteristics).

In other words, if the minimum-variance frontier of the benchmark assets and that of the expanded asset set have at least two points in common, it constitutes a sufficient condition to conclude that the minimum-variance frontier of the benchmark assets span the frontier of the expanded asset set. This also suggests that the return on the test assets could be priced in terms of the benchmark assets by a linear projection of the returns on the test assets onto the (mean-variance) space of the benchmark assets.

5.3 Mean-Variance Spanning and Risk-Free Asset

It is essential to point out the impact of the presence or absence of risk-free assets in portfolio selection and in the test of mean-variance spanning. When there is a risk-free asset and investors have access to unlimited lending and borrowing at the risk-free rate then the choice of the optimum portfolio of risky assets is unequivocal and independent of investors' taste for expected return or variance. In this sense the portfolio selection problem simply reduces to finding the tangency portfolio to a ray passing through the riskless asset in expected return-standard deviation plane.

In such circumstances investors who care about the mean and variance of their portfolios will only be interested in the tangency portfolio of the risky assets, that is, the portfolio that maximises the ratio of expected return minus the riskless asset to the standard deviation, the Sharpe ratio, (Elton and Gruber (1997)). Thus the concern of investors is about whether the tangency portfolio resulting from using the benchmark risky assets is the same as the one from using all the expanded set of risky assets.

But in the absence of a risk-free assets[18] or when there is no unlimited borrowing and lending at the risk-free rate, then investors' interests revert to whether the minimum-variance frontier generated using the benchmark assets only is identical to the frontier generated using the expanded opportunity set. This has two important interpretations.

The first questions whether given the expanded set of all the risky assets the investor can maximise his/her utility by holding just the benchmark assets instead of the complete asset set. Thus, the investor begins with the whole investment opportunity set and needs to decide whether to hold all the set of assets at his/her disposal or hold just a smaller portion of the total assets available in order to achieve maximum utility.

The second dimension of interpretation is whether an investor, conditional upon having a portfolio of the benchmark assets, can benefit by also investing in a new set of risky assets (the test assets). This is also essential in portfolio management when considering the benefit of extending investment into international markets. In this line of interpretation, the investor begins with an optimal portfolio of the benchmark assets and needs to consider the benefit of adding the test assets to the portfolio.

This study takes the latter dimension of interpretation because the study is about investigating whether a UK investor with optimal portfolio of developed market assets can benefit by also investing in emerging market assets. The developed markets represent the benchmark portfolio while the emerging market assets represent

[18] In the absence of a risk free interest rate the zero-beta rate equivalent to the in-sample expected return on the minimum-variance portfolio of the assets may serves as a proxy for the risk-free rate.

the new set of assets to be incorporated in the portfolio. The objective is to assess the shift in the efficient frontier generated from the portfolio of returns on the developed markets that results from the addition of the returns on the emerging markets.

5.4 Statement of Research Hypothesis

In the context of the test of mean-variance spanning the objective just stated may be summarised in two alternative hypotheses as follows:

Null Hypothesis:

The minimum-variance frontier derived from the developed market portfolio does not shift significantly from the minimum-variance frontier that can be generated by adding the emerging market assets to the developed market portfolio. Therefore the portfolio's risk and return characteristics remain the same even with the presence of the emerging market assets. The addition of the emerging markets is not beneficial.

Alternative Hypothesis:

The minimum-variance frontier generated from the developed market portfolio shifts significantly from the minimum-variance frontier that can be generated by adding the emerging market assets to the developed market portfolio. Therefore the portfolio's risk and return characteristics changes with the addition of the emerging market assets. It is thus beneficial to include the emerging market assets in the portfolio.

In the mean-variance spanning framework, testing the null hypothesis is tantamount to the linear projection of the returns on the emerging market assets onto the (column) space occupied by the returns on the developed market assets.

Stated differently, this is equivalent to a multivariate regression of the returns on the emerging markets on the developed market returns (i.e. pricing the emerging market returns in terms of the developed market returns) and jointly testing the restrictions that the regression intercepts equal zero and the slope coefficients sum up to unity.

Thus if $R_{DE} = \{R_D, R_E\}$ represents the set of investment opportunities available to the investor, where R_D is the matrix of returns of the five developed market assets and R_E represents the matrix of returns of the fourteen emerging market assets, the test that the minimum-variance frontier formed from R_D spans the minimum-variance frontier that can be formed from R_{DE} is achieved by a multivariate regression of R_E on R_D.

In matrix format, this ends up in the multivariate linear regression of the form:

$$R_{E_t} = \alpha + \beta R_{Dt} + \varepsilon_t \qquad t = 1,2,3..........,T \tag{2}$$

and testing the parameter restrictions:

$$\alpha = 0_E \qquad \text{and} \qquad \beta \iota_D = \iota_E \tag{3}$$

where $E(\varepsilon_t) = 0_E$ and $E(\varepsilon_t R_{Et}^{'}) = 0_{DxE}$ with 0_E being an E-vector of zeros and 0_{DxE} an D *x* E matrix of zeros. T is the length of the time series and ι_E is a E-vector of ones.

From this the hypotheses stated above can be restated mathematically as:

$H_0 : \beta 1_D = 1_E$ and $\alpha = 0_E$

$H_1 : \beta 1_D \neq 1_E$ and $\alpha \neq 0_E$

Since these hypotheses are linear restrictions on the parameters of linear regressions, it is clear that the test of mean-variance spanning can simply be implemented using econometric techniques proposed in the literature for testing linear restrictions on regression parameters. As noted earlier, HK proposed an F-test and other authors have suggested additional versions which are all based on linear regressions.

This chapter employs, first, the original F-test by HK(1987), with modification following Jobson and Korkie (1989) and Kan and Zhou (2001) in addition to the recent regression-based versions suggested by the other authors. The next sections explain the derivation of the test statistics and their application in examining the benefits from adding the emerging markets to the developed market portfolio.

5.5 The F-Test of Mean-Variance Spanning

The explanation of the F-test of mean-variance spanning is based on the work of HK, Jobson and Korkie (1989) and Kan and Zhou (2001). From the statement of research hypothesis the test of mean-variance spanning is a joint test of significance of the restrictions on the intercept and beta coefficients in a multivariate linear regression.

According to **Verbeek (2002)** and **Green (2000)** the test of restrictions of this type can simply be implemented by comparing the sum of the squared residuals of two separate regression models. The first consists of the sum of squared residuals of an unconstrained regression (the full) model. The second is the sum of squared residuals of a constrained regression model and investigating how far the sum of squared residuals of the unconstrained model differs from that of the constrained model.

Thus, granted that the null hypothesis is correct, the constrained sum of squared residuals is expected to be only slightly larger than the unconstrained sum of squared residuals. This procedure is used in cases where the regression has only one dependent variable. However, the F-test of mean-variance spanning involves a larger number of dependent variables because it requires regressing (in turns) the returns on each of the emerging markets on the returns on all the developed markets at the same time, first, using the constrained model and second using the unconstrained model.

To this end, instead of simple summation of the squared residuals, the approach adopted by HK was to compute the ratio of the *determinants of the covariance matrices of the residuals of the constrained and the unconstrained regression models, which yields the quantity U.* The determinant of the unconstrained model is the numerator while the determinant of the constrained model is the denominator.

Thus taking the quantity $\hat{\Sigma}$, as the determinant of the covariance matrix of the unconstrained regression residuals, and the quantity $\tilde{\Sigma}$, as the determinant of the covariance matrix of the residuals of the constrained regression model and taking the ratio of these quantities as $\left(\frac{\hat{\Sigma}}{\tilde{\Sigma}}\right)$ produces another quantity U, i.e. $U = \left(\frac{\hat{\Sigma}}{\tilde{\Sigma}}\right)$, sometimes referred to as Wilk's Lambda (See Andersen 1984).

From the quantity U the F-test statistic for mean-variance spanning simply becomes:

$$\left(\frac{T-D-E}{E}\right)\left(\frac{1}{U}\right) \tag{4}$$

where D denotes the number of assets in the benchmark portfolio and E the number of test assets and T is the number of time series observations. The test has an F distribution with 2E degrees of freedom in the numerator and 2(T-D-E) degrees of freedom in the denominator, if the hypothesis of mean-variance spanning holds.

This has been the F-test of spanning originally presented in HK's (1987) seminal paper (as published in the Journal of Finance) and has been used in many tests for benefit of international diversification, for instance BU (1996) and Errunza, Hogan and Hung (1999).

Kan and Zhou (2001) detected a typographical error in the derivation of the quantity U that it was rather supposed to be $U^{1/2}$ which is what was originally intended in the seminal paper by HK (1987). Indeed failure to correct for this error leads to a huge F–test statistic with high possibilities of **type I error**, that is, the error of rejecting the null hypothesis even when it is true. This may lead to accepting that there are diversification benefits when indeed there are no benefits from adding the test assets.

This error is corrected in Jobson and Korkie (1989) in which the formula is restated correctly as

$$F_{Span} = \left(\frac{(T-D-E)}{E}\right)\left(\frac{1-\sqrt{U}}{\sqrt{U}}\right) \tag{5}$$

The presence of the square root sign √helps avoid raising U to $U^{1/2}$ as required in the original formula.

This formula is useful but it has limitations in that the calculation of the determinant of the regression residuals becomes cumbersome with a large number of test assets. It is therefore necessary to search for a less tedious alternative presentation that not only provides the required statistic but also enhances the understanding of the test.

According to Jobson and Korkie (1989) and Kan and Zhou (2001) the F–test of spanning has a beautiful geometrical interpretation. That is, the same statistic derived above can be interpreted as the sum of two quantities. The first is the ratio of the global minimum-variance portfolios of the benchmark assets and the expanded asset set, and the second is the ratio of the tangency portfolios of these assets (with the tangent line originating from expected return on the global minimum-variance portfolio of the benchmark assets in the mean-standard deviation space).

In this regard, the spanning test can be decomposed into its two constituent quantities and interpreted as, first, a comparison of the distance (in mean-variance space) between the points of tangency of the benchmark assets and that of the expanded asset set and second, the comparison of the standard deviations of the global minimum-variance portfolios of the benchmark assets and the expanded asset set.

Because these two (global minimum-variance and the tangency portfolio) lie on the efficient frontiers it implies that the F-test can be obtained from the set of constants that determine the shape of the efficient frontiers for the developed market assets and for the developed plus emerging market assets. Because of the number of test assets (fourteen emerging markets) this approach seems more feasible. However, to proceed further there is the need to define the efficient set constants for the two sets of assets.

As noted within the review of literature, Merton (1972) provides (three) efficient set constants (i.e. the algebraic expressions) that determine a portfolio efficient frontier based on Markowitz's (1952) mean-variance analysis. Following Jobson and Korkie

(1989) and Kan and Zhou (2001) these constants are applied in the derivation of the F-test of spanning.

For this purpose, the total population of assets available to the UK investor is represented as D+E with a multivariate normal return vector

$$R_{DE} = [\{R_D, R_E\}, \{(D+E)x1\}] \qquad (6)$$

that is assumed to have mean return vector μ_{DE} {(D+E) x 1} and positive definite return covariance matrix V_{DE} {(D+E) x (D+E)}. On the assumption that the mean return vector μ_{DE} have at least two different elements (R_D, R_E), the set of portfolios of the D+E assets that are mean variance efficient can be described by the equation:

$\sigma_P^2 = \lfloor a - 2b\mu \ + c\mu^2 \rfloor / \lfloor ac - b^2 \rfloor$, with: a, b and c as the constant that determine the shape of the efficient set hyperbolae in the mean-standard deviation plane and given by:

$a = \mu' V^{-1} \mu$, $b = \mu' V^{-1} \iota$, $c = \iota' V^{-1} \iota$ and ι {(D+E) x 1}is a vector of ones (unities)[19].

Ingersoll (1987) explains this equation as tracing the locus of mean-variance efficient portfolios, $D+E$ of risky assets, with mean μ_P and variance σ_P^2. Therefore how far the efficient frontier formed from the developed market portfolio shifts from the frontier formed from the portfolio of the developed plus the emerging market assets can be performed as the difference between the efficient set constants that determine the shape of the frontier of the developed market assets and the efficient set constants determining the shape of the efficient frontier of the expanded assets set.

This again implies that separate efficient set constants have to be derived for the developed market assets and the expanded asset set which requires defining the vector of mean returns of the developed markets and the expanded asset set. Let μ'_{DE} be the vector of expected returns on the expanded asset set and V_{DE} the covariance matrix

[19] For further explanation of the derivation of these constants see Merton (1972) and Roll (1977).

while μ'_D represents the vector of expected returns on the benchmark assets with a covariance matrix of V_D.

The efficient set parameters a, b and c are defined first for the expanded asset set as follows: $a_{DE} = \mu'_{DE} V_{DE}^{-1} \mu_{DE}$, $b_{DE} = \mu'_{DE} V_{DE}^{-1} \iota_{DE}$ and $c_{DE} = \iota'_{DE} V_{DE}^{-1} \iota_{DE}$

Similarly, the efficient set constants for the benchmark assets, D, given the expected returns, μ_D (Dx1) and the variance-covariance matrix, V_D (DxD), can be written as:

$a_D = \mu'_D V_D^{-1} \mu_D$, $b_D = \mu'_D V_D^{-1} \iota_D$ and $c_D = \iota'_D V_D^{-1} \iota_D$

where μ_D, V_D and ι_D are sub-matrices of μ_{DE}, V_{DE} and ι_{DE} respectively.

Out of this two directions emerge. The direction taken by Jobson and Korkie (1989) is to define the test in terms of the marginal contribution of the test assets (the emerging market equity returns), E, to the efficient set of the benchmark assets, D.

In this case one will need to find the change in the efficient set constant terms, a_{DE}, b_{DE} and c_{DE} for the expanded asset set as against the efficient set constants a_D, b_D and c_D for the benchmark assets. This gives $a_{DE} - a_D = \Delta \hat{a}$, $b_{DE} - b_D = \Delta \hat{b}$ and $c_{DE} - c_D = \Delta \hat{c}$. Jobson and Korkie (1989) refer to as *marginal information matrix.*

The direction given in Kan and Zhou (2001) is to define a fourth efficient set constant, **d** as the difference between the product of **a** and **c** minus the square of **b**. Thus $d_{DE} = a_{DE} c_{DE} - b_{DE}^2$ is defined for the expanded asset set and $d_D = a_D c_D - b_D^2$ for the benchmark assets.

This is more straightforward (than the information matrix). Using these constants the F-test statistic for spanning now becomes simplified in terms of the constituent parts as:

$$F_{span} = \left[\left(\frac{T-D-E}{E} \right) \left[\left(\frac{\sqrt{c_{DE}}}{\sqrt{c_D}} \right) \left(\frac{\sqrt{1+\frac{d_{DE}}{c_{DE}}}}{\sqrt{1+\frac{d_D}{c_D}}} \right) - 1 \right] \right] \quad (7)$$

From Ingersoll (1987) it is well known that the constant **c** for any set of assets is the *ex post* global minimum variance of a portfolio formed from that set of assets. Therefore the quantities $\sqrt{c_{DE}}$ and $\sqrt{c_D}$ can be interpreted as the standard deviations of the ex post global minimum-variance portfolios of the expanded asset set and of the benchmark assets respectively.

Thus, the first portion of the F-test statistic $\sqrt{c_{DE}} / \sqrt{c_D}$, is interpreted as the ratio of the standard deviations of the global minimum-variance portfolio of the expanded asset set to the standard deviation of the global minimum-variance portfolio of the benchmark assets. This ratio is always greater than or equal to one (1).

For the second portion of the statistic:

$$\sqrt{1+\frac{d_{DE}}{c_{DE}}} \Big/ \sqrt{1+\frac{d_{DE}}{c_D}},$$

it noted that the absolute value of the slopes of the asymptotes (straight lines drawn from the return axis in the mean-standard deviation space) to the efficient set frontier (curve or hyperbolae) of the expanded asset set and of the benchmark assets are respectively

$$\sqrt{\frac{d_{DE}}{c_{DE}}} \text{ and } \sqrt{\frac{d_D}{c_D}}.$$

From this it follows that $\sqrt{1+\frac{d_{DE}}{c_{DE}}}$ can be interpreted as the length of the asymptote to the hyperbola of the expanded asset set and $\sqrt{1+\frac{d_D}{c_D}}$ is the length of the asymptotes to the hyperbola of the benchmark assets as one moves from a standard deviation of zero to a standard deviation of one (1), [i.e. $\sigma = 0$ to $\sigma = 1$] in the mean-standard deviation space.

Similarly, $\sqrt{1+\frac{d_{DE}}{c_{DE}}}$ can be interpreted as the length of the asymptotes to the hyperbola of the expanded asset set as result of moving from a standard deviation of zero to a standard deviation of one (1).

Since the *ex post* frontier of the expanded asset set dominates the ex post frontier of the benchmark assets, the ratio:

$\sqrt{1+\frac{d_{DE}}{c_{DE}}} \Big/ \sqrt{1+\frac{d_{DE}}{c_D}}$ must be greater than one (1).

Under the null hypothesis of spanning, the minimum-variance frontier of the benchmark asset and the minimum variance frontier of the expanded asset set are *ex ante identical* so the two ratios:

$\sqrt{c_{DE}} \big/ \sqrt{c_D}$ and $\sqrt{1+\frac{d_{DE}}{c_{DE}}} \Big/ \sqrt{1+\frac{d_{DE}}{c_D}}$ should be close to one (1) and the F-statistic should be close to zero (0).

This implies that when either the standard deviation of the global minimum-variance portfolio of the expanded asset set is far from the standard deviation of the global minimum-variance portfolio of the benchmark assets or when the tangency portfolio (i.e. the asymptote to the hyperbola) of the expanded asset set is different from the tangency portfolio (i.e. asymptote to the hyperbola) of the benchmark portfolio, the resulting F-test statistic becomes large and the null hypothesis of spanning is rejected.

The statistic has an F-distribution; hence the acceptance or rejection decision entails a comparison of the value calculated from this formula with the critical value provided in the statistical table for *F distribution.* If the computed value exceeds the critical value spanning is rejected implying the emerging market assets offer diversification benefits. Conversely, if the computed statistic is less than the critical value spanning is accepted and implies that the emerging market assets are redundant in the portfolio.

5.6 The Search for Complementary Test Techniques

Even though using the F-test only can provide important clues about the benefits from diversification, yet, since different test methods produce different results, the F- test alone may be insufficient for drawing meaningful conclusions. By implication further test procedures may be necessary to present a more comprehensive analysis.

Most econometric literature, for instance **Engel (1984)**, **Verbeek (2002), Green (2000), Maddala (1995)** and others discuss the maximum likelihood ratio, the Wald and the Lagrangian multiplier tests as *a trinity of tests* that are used complementarily or interchangeably in testing linear restrictions on linear regression parameters.

Gibbons, Ross and Shanken (1989), henceforth **GRS (1989),** compare the statistics for these three tests and find some close relationships among them. Most essentially, when used in testing for the efficiency of a given portfolio each of the three is seen to have asymptotic chi-square distribution (with degree of freedom equal the total number of assets in the portfolio) as the length of time series approaches infinity ($T \cong \infty$). Moreover they can all be derived from the same regression model.

They differ only to the extent that the Wald test is derived from unconstrained regression model; the likelihood ratio test derives from both constrained and unconstrained regression models while the Lagrangian multiplier test derives from only the constrained regression model.

As a result, the numerical size of the Wald test statistic is always larger than the likelihood ratio statistic, which is also larger than the Lagrangian multiplier statistic (WT $\geq$LRT $\geq$LMT). Therefore, the p-values are always lowest for the Wald test, and highest for the Lagrangian multiplier test with the likelihood ratio test in between **((Berndt and Savin (1977) and Shanken (1985)).**

Though, Green (2000) explains that the choice among the three is a matter of ease of computation (rather than superiority of one over the others), yet due to the subtle computational differences, these three tests do not lead to the same conclusion. Thus when applied in the test of mean-variance spanning it is seen that circumstances in which the Wald test rejects, the Lagrangian multiplier test may accept the null hypothesis of spanning and the likelihood ratio can swing either way.

In this context using the three, at the same time, on the same data set can provide more meaningful result than using any one of them or the F-test alone in the mean-variance spanning framework for the purpose of examining the benefits from international diversification. The next sections discuss the derivation of the statistic for each of these three further tests.

5.6.1 The Likelihood Ratio Test of Mean-variance Spanning

This section explains the derivation of the likelihood ratio test statistic for mean-variance spanning as the first alternative procedure to be used to consolidate the findings from the F-test. Assuming the absence of a riskless asset, **Kandel (1984)** derives a likelihood ratio test statistic for mean-variance efficiency of a portfolio.

Following similar steps, HK (1986 and 1987) derive the F-test and separated it into mean-variance spanning and mean-variance intersection. By revisiting the likelihood ratio test, Kan and Zhou (2001) derive (from it) a test statistic on similar line as HK's F-test to investigate the mean-variance equivalence of a subset of assets to the whole or complete set (i.e. likelihood ratio version of the test of mean-variance spanning).

In general, likelihood ratio tests compare two alternative nested models; the likelihood functions under the null and the alternative hypotheses and thus involve estimating the model twice: first without restriction imposed on the parameters, giving the unrestricted likelihood estimator $\hat{B}$ and second with the null hypothesis imposed, giving the restricted maximum likelihood estimator $\tilde{B}$ (see the F-test).

The estimation of the model under both restricted and unrestricted regressions also end up with two sets of regression residuals, restricted and unrestricted residuals and the likelihood ratio test of spanning can be derived as the ratio of the determinants of these residuals similar to the derivation of HK's F-test. Thus the estimates of the regression parameters are the same as under the F-Test in the sense of HK (1987).

This provides the determinants of the residuals as $\hat{\Sigma}$ for the restricted model and $\tilde{\Sigma}$ for the unrestricted regression model. The Likelihood estimate of U is thus $|\hat{\Sigma}| / |\tilde{\Sigma}|$ and the likelihood ratio test of mean-variance spanning can be conveniently written as: $-T\ln(U)$ with T representing the length of time series. The test simply becomes the number of time series observations, T, multiplied by the natural logarithm of the ratio of the determinants of the regression residuals, ln (U).

The problem with this approach as with the F-Test is the cumbersome process in the calculation of the determinants of regression residuals with large number of test assets (emerging market assets). Unfortunately, and perhaps because of the logarithmic properties, the likelihood ratio test does not have geometrical interpretation.

The direction taken by Kan and Zhou (2001) is to use only the unrestricted model and estimates the likelihood ratio statistic for mean-variance spanning as the sum of the natural logarithms of one (1) plus each of two eigenvalues computed by defining a set of matrices using the efficient set constants derived for the returns on the benchmark assets and the returns on the expanded portfolio. This approach is followed here.

Based on the efficient set constants for the developed market portfolio the matrix G is defined as $G = \begin{bmatrix} 1+a_D & b_D \\ b_D & c_D \end{bmatrix}$ where, a_D, b_D and c_D are the same as the efficient set constants for the developed market assets derived under the F-test.

Following Jobson and Korkie (1989), let $\Delta \hat{a} = a_{DE} - a_D$, $\Delta \hat{b} = b_{DE} - b_D$ and $\Delta \hat{c} = c_{DE} - c_D$ denote the marginal contribution of the emerging market (test) assets to the efficient set constants of the developed market (benchmark) assets. Using this, the matrix H can be defined as $H = \begin{bmatrix} \Delta a & \Delta b \\ \Delta b & \Delta c \end{bmatrix} = \begin{bmatrix} a_{DE} - a_D & b_{DE} - b_D \\ b_{DE} - b_D & c_{DE} - c_D \end{bmatrix}$ (9)

Thus matrix H (the *marginal information matrix*) can be said to summarise the difference between the constants that define the shape of the efficient frontier for the expanded portfolio and the shape of the efficient frontier for the developed market portfolio and therefore shows how far the efficient frontier for the expanded asset set differs from the efficient frontier for the developed market portfolio.

Using the information contained in the two matrices, G and H, the likelihood ratio test statistic for mean-variance spanning derives from two eigenvalues denoted as λ_1 and λ_2 obtained by multiplying matrix H by the inverse matrix of G, thus HG^{-1} where $\lambda_1 \geq \lambda_2 \geq 0$ and $(1+\lambda_1)(1+\lambda_2) = \frac{1}{U}$.

From this the likelihood ratio statistic for mean-variance spanning then becomes:

$$T\sum_{i=1}^{2} \ln(1+\lambda_i) = T[\ln(1+\lambda_1) + \ln(1+\lambda_2)] \quad \chi^2_{2E} \tag{10}$$

Further details of the likelihood ratio test may be found in Kan and Zhou (2001). This approach is used because of its ability to accommodate a large number of test assets.

5.6.2 The Wald Test of Mean-variance Spanning

The Wald test of mean-variance spanning is presented as the next alternative to the F-test. Derivation of the test statistic follows the procedure in DeRoon and Nijman

(2001) and Kan and Zhou (2001). The general formulation of the Wald test as shown in most econometric literature, for example Verbeek (2002) is:

$$W = (Rb - q)'[Var(RVR)]'(Rb - q) \tag{11}$$

and the interest in the test centres on the *discrepancy* vector $Rb - q$ and how far it deviates from zero (0).

In the mean-variance spanning test, however, the focus of the Wald test lies in investigating the extent to which the regression intercept is closed to zero and the sum of the slope coefficients to unity. Following DeRoon and Nijman (2001) and Kan and Zhou (2001) the Wald test of mean-variance spanning, like the F-test, also has a nice geometrical interpretation and can thus be viewed as a sum of two quantities.

The first is the change in the Sharpe ratio (excess return per unit of risk) of the benchmark portfolio resulting from the addition of the test assets and the second is the change in the global minimum-variance of the benchmark portfolio again due to the presence of the test assets. To this end, the derivation of the Wald statistic of spanning demands computing the Sharpe ratio and the global minimum-variance of the portfolio of the developed market assets and the expanded asset set.

Let η_D denote the expected return on the global minimum variance portfolio of R_D with the variance of this portfolio given by $(\sigma_D)^2$, while $(\sigma_{DE})^2$ denote the global minimum variance of R_{DE}, and $\hat{\theta}_{DE}(\eta_{DE})$ and $\hat{\theta}_D(\eta_D)$ respectively represent the maximum attainable squared Sharpe ratios achievable from the portfolio combining the developed and the emerging markets and the portfolio of only the developed market assets.

Using the efficient set constants derived for the F-test, these notations may be summarised as follows:

$\eta_D = \frac{b_D}{c_D}$ = return on global minimum variance portfolio of the benchmark assets

$\sigma_D^2 = c_D$ = variance of the global minimum variance portfolio of the benchmark assets

$\sigma_{DE}^2 = c_{DE}$ = variance of the global minimum variance portfolio of the expanded asset set

$\hat{\theta}_{DE}(\eta_D) = a_{DE} - 2b_{DE}\eta_D + c_{DE}\eta_D^2$ = Maximum squared Sharpe ratio of expanded asset set

$\hat{\theta}_D(\eta_D) = a_D - 2b_D\eta_D + c_D\eta_D^2$ = Maximum squared Sharpe ratio of benchmark assets

It is important to point out that the Sharpe ratios are for a zero-beta rate equal to the (in-sample) expected return on the global minimum-variance portfolio of the benchmark assets, and therefore are the slopes of the asymptotes of the mean-variance frontier (De Roon and Nijman 2001) of the benchmark and of the expanded asset sets.

Thus the test statistic as to whether the returns on the benchmark assets span the frontier of the returns of both the benchmark and the test assets can be estimated with the Wald test, as sum of the two quantities, based on the following formula.

$$W_{Span} = T\left(\frac{1+\hat{\theta}_{DE}\left(\hat{\eta}_D\right)^2}{1+\hat{\theta}_D\left(\hat{\eta}_D\right)^2}-1\right)+T\left(\frac{\left(\hat{\sigma}_D\right)^2}{\left(\hat{\sigma}_{DE}\right)^2}-1\right) \cong \chi_{2E}^2 \qquad (12)$$

From Jobson and Korkie (1989) the variance of a mean-variance portfolio is given by $\sigma_P^2 = \left[a - 2b\mu + c\mu^2\right] / \left[ac - b^2\right]$ where μ represent the zero-beta rate. It is well known that the numerator of this equation represents the maximum Sharpe ratio obtainable from any combination of the assets in a portfolio. Using this same process the Wald test formula above may be written in a more explanatory format as:

$$W_{Span} \Rightarrow T\left[\frac{1+\left[a_{DE} - 2b_{DE}\eta_D + c_{DE}\eta_D^2\right]^2}{1+\left[a_D - 2b_D\eta_D + c_D\eta_D^2\right]^2} - 1\right] + T\left[\frac{(c_D)}{(c_{DE})} - 1\right] \cong \chi_{2E}^2 \qquad (13)$$

From the formula, it is clear that the first part of the Wald test statistic measures whether the frontiers for the two portfolios intersect (as determined by the change in the maximum attainable squared Sharpe ratios). The numerator measures the squared Sharpe ratio for the developed market assets plus the emerging market assets while the denominator measures the squared Sharpe ratio for the developed market only.

Since the upper limb of the efficient frontier is simply the negative of the lower limb, the squared Sharpe ratios for those two extremes are the same. Therefore, the first portion of the statistic can be interpreted as measuring whether there is intersection at the extreme ends of the efficient frontier (i.e. whether there is a limiting form of the intersection by going sufficiently far up or down the efficient frontier).

The second term of the statistic is also determined by the change in the global minimum variance of the portfolios, and measures whether the point most to the left on the frontier for the developed markets equities changes or not as a result of the inclusion of the emerging market equities. Stated differently, the first term measures whether there is intersection for a mean-variance investor with a very small risk aversion ($\gamma = 0$), while the second term measures whether there is intersection for a mean-variance investor with a very high (almost infinite) risk aversion ($\gamma = \infty$).

It is important to point out that the second term has the global minimum variance of the developed market portfolio as the numerator and the global minimum variance of the expanded asset portfolio as denominator. This is to reflect the fact that the variance of a portfolio can only decrease as more assets are added to the portfolio.

For this reason, each term of the statistic is always greater than or equal to one (1). Therefore, the closer the result of each term is to one, the greater the possibility of equality between the two sets of assets (i.e. the smaller the Wald statistic) and the greater the chances of accepting the null hypothesis of mean-variance spanning.

Conversely, the further away the result of each term is from one the greater the size of the Wald test statistic and the lesser the chance of accepting the null hypothesis of mean-variance spanning (or equality between the two efficient frontiers) which in turn implies the adding the test assets to the benchmark assets leads to a significant shift in the efficient frontier for the benchmark assets (a signal for diversification benefits).

5.6.3 The Lagrangian Multiplier Test of Mean-variance Spanning

The Lagrangian multiplier test of mean-variance spanning is implemented as the last alternative test that provides further evidence on the findings from the F-test. The procedure for calculating the test statistic follows Kan and Zhou (2001). They offer both statistical and geometrical interpretation to this version of the test of spanning.

Using the statistical interpretation the Lagrangian multiplier test statistic can be derived as a sum of two ratios obtained from two eigenvalues calculated by imposing the spanning restrictions on the regression parameters. The test statistic derives from:

$$T\left[\left(\frac{\lambda_1}{1+\lambda_1}\right)+\left(\frac{\lambda_2}{1+\lambda_2}\right)\right] \cong \chi^2_{2E} \qquad (14)$$

where, λ_1 and λ_2 are the two eigenvalues derived from the regression parameters (using the procedure as used for the likelihood ratio test of mean-variance spanning).

However, it is preferable to employ the geometric interpretation of the test in order to avoid the lengthy (econometric) processes required for the statistical interpretation. When interpreted geometrically, the Lagrangian multiplier test of mean-variance spanning measures the *intersection* of two separate portions of the frontiers for the benchmark assets and for the expanded asset set.

The test can thus be viewed as a sum of two quantities where the first measures the closeness of the *ex post* global minimum-variance portfolio of the expanded asset set to the *ex post* global minimum-variance portfolio of the benchmark assets and the second measures the closeness of the tangency portfolios of the expanded asset set and the benchmark assets.

Using the same symbols as in the Wald test, let η_D denote the expected return on the global minimum variance portfolio of R_D with the variance of this portfolio given by $(\sigma_D)^2$, while $(\sigma_{DE})^2$ denote the global minimum variance of R_{DE}, and $\hat{\theta}_{DE}(\eta_{DE})$ and $\hat{\theta}_D(\eta_D)$ respectively represents the maximum Sharpe ratios achievable from the portfolio combining the benchmark and the test assets and the benchmark assets only.

Using the efficient set constants derived for the F-test, these mathematical notations may be summarised as follows:

$\eta_{DE} = \frac{b_{DE}}{c_{DE}}$ = return on global minimum variance portfolio of the expanded asset set

$\sigma_D^2 = c_D$ = variance of the global minimum variance portfolio of the benchmark assets

$\sigma_{DE}^2 = c_{DE}$ = variance of the global minimum variance portfolio of the expanded asset set

$\hat{\theta}_{DE}(\eta_D) = a_{DE} - 2b_{DE}\eta_D + c_{DE}\eta_D^2$ = Maximum Sharpe ratio of expanded asset set

$\hat{\theta}_D(\eta_D) = a_D - 2b_D\eta_D + c_D\eta_D^2$ = Maximum Sharpe ratio of benchmark assets

From this the Lagrangian multiplier test statistic for the hypothesis that the frontier generated from the returns on the developed market equities spans the frontier for both the developed and the emerging market equities can be estimated from the two quantities using the formula:

$$LM_{Span} = T\left(1 - \frac{1+\hat{\theta}_D\left(\hat{\eta}_{DE}\right)^2}{1+\hat{\theta}_{DE}\left(\hat{\eta}_{DE}\right)^2}\right) + T\left(1 - \frac{\left(\hat{\sigma}_D\right)^2}{\left(\hat{\sigma}_{DE}\right)^2}\right) \cong \chi^2_{2E} \qquad (15)$$

In a more explanatory format, the formula can be re-written as:

$$LM_{Span} \Rightarrow T\left[1-\frac{1+\left[a_D - 2b_D\eta_{DE} + c_D\eta_{DE}^2\right]^2}{1+\left[a_{DE} - 2b_{DE}\eta_{DE} + c_{DE}\eta_{DE}^2\right]^2}\right] + T\left[1-\frac{(c_D)}{(c_{DE})}\right] \cong \chi_{2E}^2 \qquad (16)$$

The first (left hand side) quantity of the statistic measures whether the frontiers of the two portfolios intersect as indicated by the change in the Sharpe ratios of the expanded portfolio compared to the Sharpe ratio of a portfolio of only the developed market equities. The numerator measures the Sharpe ratio for the developed market while the denominator measures the Sharpe ratio of the expanded opportunity set using a zero-beta rate equivalent to the in-sample expected return on the global minimum-variance portfolio of the expanded asset set (See Kan and Zhou (2001)).

The second (right hand side) quantity measures the closeness of the minimum-variance portfolios of the benchmark assets and the expanded asset set as measured by the ratio of their variances. Evidently, there is a direct link between the Lagrangian multiplier test and the Wald test.

The Wald test examines the increase in the variance (risk) as one moves from a variance of zero (0) to a variance of one (1) in a mean-variance space. The Lagrangian multiplier test measures the reduction in the variance resulting from a movement from a variance of one (1) backwards to a variance of zero (0) (an opposite direction). The Wald test examines the increase in risk as one adds the emerging markets to the developed markets while the Lagrangian multiplier test examines the reduction in risk from reducing the expanded set by the emerging markets.

Also for the Wald test the return on the minimum-variance portfolio of the benchmark assets is the reference point in measuring the closeness of the frontier for the expanded assets set to the frontier of the benchmark assets but for the Lagrangian multiplier test the reference point is the return on the minimum-variance portfolio of the expanded asset set. Therefore both tests do not yield the same result.

5.7 Small Sample Distribution of Spanning Tests

Having explained the spanning tests, it is important to also discuss the small sample properties of the test statistics. BU(1996) present simulation results which indicate that the size and power of spanning tests are adversely affected by an increase in the number of benchmark and test assets conditional on a given sample size. They show that for a given number of benchmark (test) assets the size and the power of the test deteriorate as the number of either the benchmark or test assets increases.

Rowland and Tessar (2004) find that as the number of test assets increases the size of the test increases and the power of the test decreases. The problem emanating from this for the analysis in this thesis is that though the number of (5) benchmark assets is relatively small, the number of test assets to be added ranges from 2 to 14. This can have wide implications on both the power and size of the test and on the conclusion.

This concern is made more serious by the fact that the tests described above and that to be discussed in Chapter Six are based on asymptotic distribution. That is, it has been assumed that the return observations are infinitely large. Given that, in this study, sample sizes as small as 69 observations are used (particularly in Chapter Six), it could be expected that the result would be affected by the choice of sample size, the number of test assets and benchmark assets to be included in the analysis.

In the literature two approaches have been used to mitigate this problem. Some authors employ Monte Carlo techniques to simulate the small sample distribution of the test, the result of which becomes the basis for the accept/reject decision[20]. The alternative is to base the accept/reject decision by comparing the result with the simulation result of another study using similar sample size. For instance, Errunza, Hogan and Hung (1999) derive the conclusion from their test results by comparing their result with the simulation results in BU (1996). This approach is used in this study. The problem, however, is finding a study that uses similar sample size.

[20] See Bekaert and Urias (1996 and 1999) , Harvey (1995) and Rowland and Tessar (2004)

BU (1996) uses a sample of 152 observations which is near the sample of 139 used in this study. However, they use weekly returns as opposed to monthly returns use in this research. Besides, BU (1996) employ a test of spanning based on the SDF model while this study uses the regression-based model. Their results do not form the appropriate yardstick for comparison. Kan and Zhou (2001) employ the regression-based test of spanning and present Monte Carlo simulation results for different sample sizes, number of test assets and benchmark assets. They provide result for test assets ranging from 2 to 25, combined with benchmark assets ranging from 2 to 10 for varying number of monthly return observations, i.e. 60, 120 and 240 observations.

Because this study uses the regression-base test their result could serve as the closest approximation to the result obtained in this section. The problem, however, is that they study portfolio diversification among developed equity markets. Harvey (1995) provides simulation results on a study involving emerging markets, but the number of assets and the sample size far exceeds that used in this study. However, as no other study is available, it was found expedient to make comparison with these studies which serve as approximation to the methodology and the sample used in this study.

Throughout this study it is maintained that a set of emerging market (test assets) returns provides diversification benefits relative to a set of developed market asset (benchmark) returns if adding that set of emerging markets to the developed market returns leads to a significant leftward shift in the mean-standard deviation frontier.

5.8 Data and Application of Tests of Mean-variance Spanning

This section applies the procedures discussed in the previous sections in investigating the benefits from including the emerging markets in optimal portfolios of the developed market assets. For this purpose, the emerging markets are grouped, first as a standalone asset class, and second as regional assets based on geographical location.

Following from Chapter 3, it is noted that there are variations in the length of return series for the markets in this study. Therefore, adding all the emerging markets to the developed market portfolio simultaneously would require reducing the returns on those markets with long data. This would result in substantial loss of data and may obscure the diversification potentials of those markets whose returns may be reduced.

To avoid such a problem, the emerging markets (as one asset class) are formed into three time-based portfolios. Portfolio One combines the first 10 emerging markets; South Korea, Malaysia, Thailand, Indonesia, South Africa, Zimbabwe, Hungary, Turkey, Chile and Mexico, that have data from August 1991 to February 2003 (139 monthly returns) into one emerging market portfolio for inclusion in the optimal portfolio of the developed market returns from August 1991 to February 2003.

Portfolio Two adds two more emerging markets from January 1994 to February 2003. This is achieved by reducing the returns on the markets in Portfolio One to 110 months to enable the next two emerging markets, Argentina and the Czech Republic, with 110 monthly returns to be added, thus making 12 emerging markets combined in one portfolio to be included in the optimal portfolio of the developed market assets.

The same process is followed in forming Portfolio Three which contains all the 14 emerging markets in this study consisting of the 12 emerging markets in Portfolio Two plus Brazil and Romania from February 1997 to February 2003 (73 monthly return observations). Again the return series for the 12 markets in Portfolio Two were reduced to 73 monthly observations to allow for the inclusion of Romania and Brazil with the shortest length of data in order to form one emerging market portfolio.

As a next stage, the emerging markets are included in the developed market portfolio as geographical assets, grouped into South East Asia, Latin America, Eastern Europe and Southern Africa over different time periods. Once more, since the markets in the various geographical regions have different length of data, for each region, the returns are reduced to level up with the market (in the region) with the shortest data series.

The returns on the South East Asian and Southern African emerging markets are included in the developed market portfolio from August 1991 to February 2003 (139 observations). Because Romania has short data series (February 1997 to February 2003) the Eastern European markets are added to the developed market portfolio from February 1997 to February 2003 (73 observations). Similarly, the Latin American markets are included in the developed market portfolio from September 1994 to February 2003 (102 observations) in line with the length of the data series for Brazil.

The analyses are conducted in a Microsoft Excel environment using matrix algebra. The algorithms used in computing the statistics are outlined in appendices D to G.

5.8.1 Investigation of Diversification Benefit: Portfolio One

This section is the first to apply the four tests of mean-variance spanning in investigating the benefits of adding the emerging markets as a standalone asset to the developed market portfolio. The analysis covers the period from August 1991 to February 2003 and combines the 5 developed markets with the first 10 emerging markets; South Korea, Malaysia, Indonesia, Thailand, Hungary, Turkey, Chile, Mexico, South Africa and Zimbabwe that have relatively longer return series.

The focus is to determine whether the frontier derived from the developed market portfolio shifts significantly from the frontier generated after adding the emerging markets. As a foundation to the statistical analysis, diagram 5.1 provides the graphical demonstration of the extent to which the efficient frontier for the developed market portfolio has shifted following the inclusion of the emerging market returns.

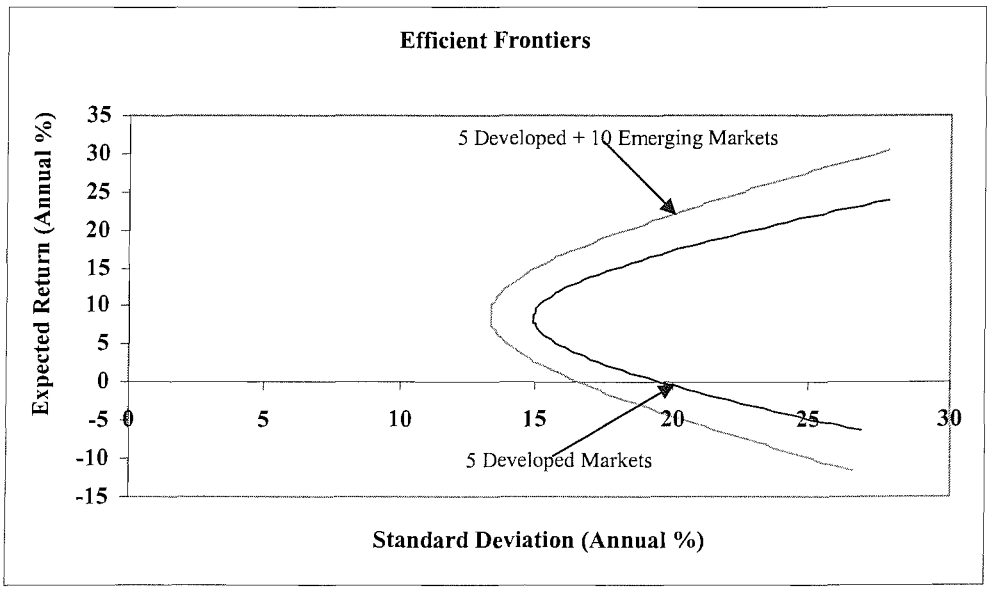

Diagram 5.1

As could be seen from diagram 5.1, at the global minimum-variance portfolio, the annualised standard deviation of the developed market assets is 14.90%. By adding the emerging market returns, the standard deviation falls by 10.81% to 13.29%. This appears to suggest that the addition of the emerging markets leads to a significant shift in the frontier for the developed market portfolio. This provides an initial indication that diversification to the emerging markets could be beneficial.

However, while this graphical analysis provides important clues, it does not provide evidence as to the statistical significance of the shift in the frontier. The test results in Table 5.1 extend the analysis beyond the graphical representation to provide the statistics measuring the significance, in mean-variance sense, of the differences between the frontier for the developed market and that for the expanded asset set.

Table 5.1 Mean-variance Spanning Test Results for Portfolio One

Test Procedures	Test Period	Number of Observations	Test Statistics {p-value}
F-Test	August 1991 – February 2003	139	1.691 {0.035}
Likelihood Ratio	August 1991 – February 2003	139	35.547 {0.017}
Wald Test	August 1991 – February 2003	139	39.518 {0.000}
Lagrangian Multiplier	August 1991 – February 2003	139	32.130 {0.042}

The statistics in Table 5.1 are for the joint test of the hypothesis that the frontier derived from the developed market portfolio spans the frontier derived by adding the emerging markets to the developed market assets. The last column shows the spanning test statistics together with the corresponding p-value (in bracket) at 5% level of significance. From a simple observation, it is obvious that all four tests have low p-values (below 5%), evidence of a rejection of the hypothesis of spanning.

Starting with the F-test, the statistic of 1.691 (p-value of 0.035) exceeds the critical value at 5% level of significance, indicating significant shift in the frontier for the developed market portfolio (resulting from the addition of the emerging markets). This implies that the emerging market returns are not spanned by the returns on the developed market assets. As a result, including the emerging market returns in the developed markets portfolio significantly improves the portfolio's risk-return profile.

In order to provide confirmatory information, the result from the other three tests of spanning need to be discussed. At a glance, it is clear that this does not alter the evidence. The likelihood ratio test statistic of 35.547 (p-value 0.017) and the Wald test statistic of 39.518 (p-value 0.00) as well as the Lagrangian multiplier test of 32.130 (p-value 0.042) all exceed the critical value at 5% significance level, implying evidence of significant shift in the frontier for the developed market portfolio.

Considered together, all four spanning tests suggest significant diversification benefits to a UK investor from diversifying the equity portfolio of developed market assets to the 10 emerging markets. The benefit may be attributed mainly to the low average correlation between the emerging market returns and the returns on the developed market assets and the fact that the emerging markets provide higher expected returns.

The table of portfolio weights (see appendix A) shows that of the ten emerging markets only Malaysia, Chile and Zimbabwe have positive weights in the expanded portfolio. This indicates that for an investor interested in the global minimum-variance portfolio, the imposition of short-sale constraints may eliminate investment in the seven remaining emerging markets. By comparing the portfolio volatility after constraining the weights for all the markets in the expanded portfolio to be positive to when negative values are allowed a huge change in the portfolio risk is noticed.

With short sale constraint imposed, the standard deviation for the expanded portfolio rises to 14.51%, from 9.74% (which is the standard deviation without the imposition of short- sale constraints). In comparison with the standard deviation of 14.90% for the portfolio of only the developed markets assets, it could be noticed that when short sale constraints are imposed the opportunities for diversification become minimal.

Therefore, without taking a short position, the improvement in the mean-variance performance of the developed market portfolio arising from the presence of the 10 emerging markets becomes traceable to only three. As a result, for the full diversification benefits presented by the 10 emerging markets to be attainable, constraint on short-selling should be absent in seven of the 10 emerging markets (these are; Korea, Thailand, Indonesia, South Africa, Turkey, Hungary and Mexico)

5.8.2 Investigation of Diversification Benefit: Portfolio Two

This section provides continuation to the analysis in the preceding section. In this section two more emerging markets; Argentina and the Czech Republic are added to the markets examined in Portfolio One (making 12 emerging markets). Again the aim is to investigate whether benefits could be achieved by adding these markets to the developed market portfolio over the period from January 1994 to February 2003.

Diagram 5.2 provides the graphical representation of the shift in the frontier for the developed market portfolio due to the inclusion of the emerging market assets. As in the preceding section, a wide difference can be observed between the efficient frontier for the developed markets and for the expanded opportunity set, measured by the distance between the standard deviations at the global minimum-variance portfolios.

Noting from diagram 5.2, the standard deviation for the developed market assets at the global minimum-variance portfolio is 14.72%. This decreases to 11.85%, which is 19.5% lower, due to the inclusion of the emerging market assets. This exceeds the extent of risk reduction observed in Portfolio One. However, this is reasonable since by having relatively larger number of (12) emerging markets the diversification gains to be expected from this portfolio should, most likely, exceeds that of Portfolio One.

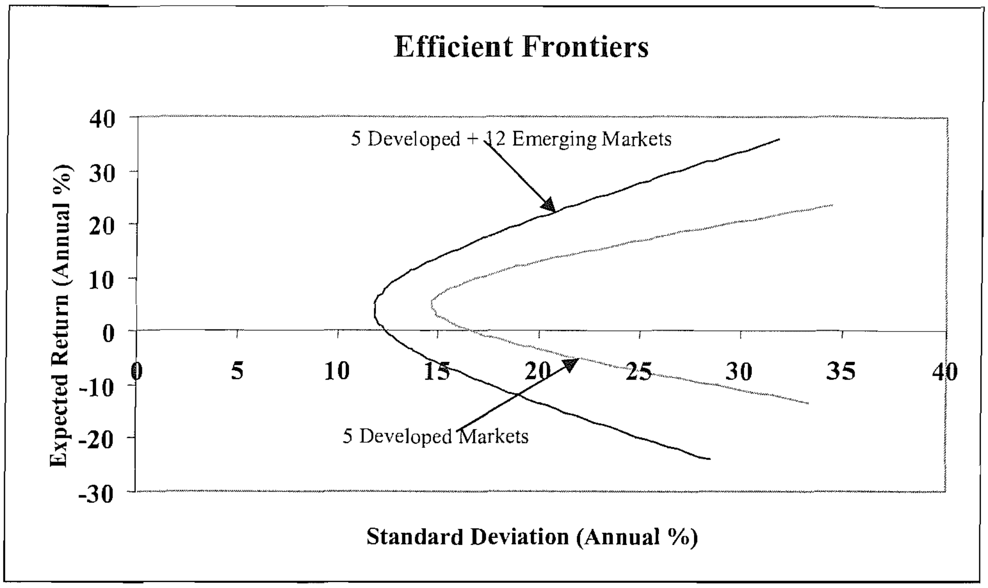

Diagram 5.2

The reduction in standard deviation can be interpreted as evidence of significant shift in the efficient frontier for the developed market portfolio resulting from the presence of the12 emerging market assets. However, following a similar argument as in the preceding section, using the graphical analysis alone provides insufficient evidence as to the significance of the shift in the frontier; hence stronger evidence is required.

Table 5.2 extends the analysis further by reporting the results of the four statistical tests that present evidence demonstrating the significance of the shift in the frontier for the developed market portfolio after adding the12 emerging market assets.

Table 5.2 Mean-variance Spanning Test Results for Portfolio Two

Test Procedures	Test Period	Number of Observations	Test Statistics {p-value}
F-Test	January 1994 – February 2003	110	2.155 {0.002}
Likelihood Ratio	January 1994 – February 2003	110	53.974 {0.000}
Wald Test	January 1994 – February 2003	110	65.950 {0.000}
Lagrangian Multiplier	January 1994 – February 2003	110	44.938 {0.006}

In the same trend as the evidence derived in the preceding section, all the four tests of spanning suggest significant shift in the developed market frontier. As could be observed from Table 5.2, the F-test statistic of 2.155 (p-value 0.002) exceeds the critical value at 5% level of significance. This indicates that the null hypothesis of spanning is rejected and that the emerging markets significantly shift the efficient frontier generated from the developed markets, evidence of diversification benefit.

The three remaining tests only serve to confirm this evidence. The likelihood ratio test statistic of 53.974 (p-value 0.000) compared to the critical value (of 31.15) rejects spanning at 5% significance level, so are the Wald test statistic of 65.950 (p-value 0.000) and the Lagrangian multiplier test of 44.938 (p-value 0.006) both of which fail to accept the null hypothesis that the emerging markets are spanned by the developed markets. Thus, all four tests again point to significant improvement in the risk-return profile of the developed market portfolio when the emerging markets are added.

Compared to the previous section, the evidence in favour of diversification benefits seems stronger, judging from the p-values and the percentage reduction in standard deviation at the global minimum-variance portfolios. This may have resulted from having a relatively larger number of emerging markets in Portfolio Two, than in Portfolio One. Overall, however, the benefits results primarily from the low average correlation of the emerging market assets with the developed market returns.

Taking the analysis further by constraining the portfolio holdings to take only positive values, only 4 of the 12 emerging markets; Malaysia, Turkey, Chile and Zimbabwe have positive weights in the expanded portfolio (see appendix A). In the absence of short-sale constraints the standard deviation at the global minimum-variance portfolio for the expanded asset set is11.85%. With the imposition of short-selling restrictions the standard deviation rises to14.60%, (an increase of 23.21%). By comparison to the risk level of 14.72% for the developed market assets the evidence seems to show again that with short-sale constraints the benefit from diversification may be minimal.

5.8.3 Investigation of Diversification Benefit: Portfolio Three

Building on the analyses in the previous two sections, this section adds Brazil and Romania, the two emerging markets with the shortest return data in this study, to the 12 emerging markets examined in the preceding section (making 14 emerging markets) from February 1997 to February 2003. As previously, the objective is to investigate the improvement in the mean-variance characteristics of the developed market portfolio that would result from the addition of all 14 emerging markets.

Following a similar pattern of analysis, diagram 5.3 provides, as a starting point, the graphical illustration of the effect on the efficient frontier for the developed market portfolio upon adding the emerging market assets. From diagram 5.3, there appears to be considerable difference between the efficient frontier for the developed market portfolio and the frontier after the addition of the returns on the 14 emerging markets.

The developed market assets have a standard deviation of 16% at the global minimum-variance portfolio. The standard deviation decreases by 40% to 9.60% with the addition of the emerging market returns. This provides the initial indication of the extent to which the emerging markets can improve the investment opportunity set.

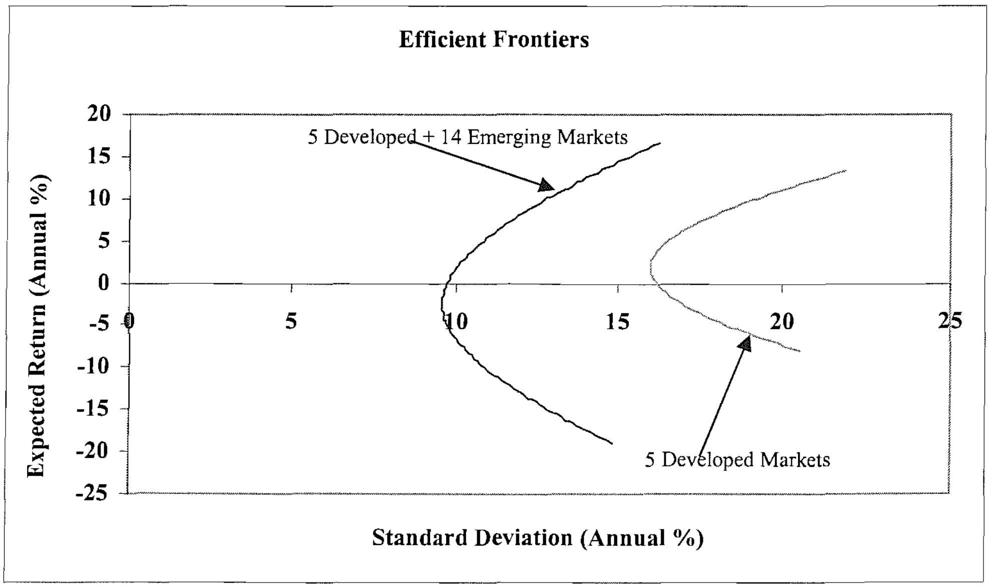

Diagram 5.3

As further evidence, Table 5.3 presents the result of the four tests of spanning. From a simple observation, it could be seen that all four tests suggest significant improvement in the developed market portfolio. The F statistic of 2.947 (p-value 0.000) exceeds the critical value at all levels of significance, evidence that the null hypothesis of spanning cannot be accepted. This signals that adding the emerging markets significantly shifts the frontier for the developed market portfolio.

Table 5.3 Mean-variance Spanning Test Results for Portfolio Three

Test Procedures	Test Period	Number of Observations	Test Statistics {p-value}
F-Test	February 1997 – February 2003	73	2.947 {0.000}
Likelihood Ratio	February 1997 – February 2003	73	82.871 {0.000}
Wald Test	February 1997 – February 2003	73	139.377 {0.000}
Lagrangian Multiplier	February 1997 – February 2003	73	54.294 {0.002}

The three further tests again lead to the same conclusion as the F-test. As shown in Table 5.3, the likelihood ratio test statistic of 82.871 (p-value 0.000) immensely departs from the critical values, and strongly rejects spanning, at all significance levels. The Wald statistic of 139.377 (p-value 0.000) and the Lagrangian multiplier statistic of 54.294 (p-value 0.002) also reject spanning at all significance level.

The discussion so far shows that adding the emerging markets can lead to substantial improvement in the mean-variance performance of the developed market portfolio. Essentially, with more emerging markets in this than in the preceding two portfolios the evidence of diversification benefits seems much stronger, judging on the basis of the extremely low p-values of the test statistics and the large percentage (40%) reduction in the standard deviation at the global minimum-variance portfolios.

On the whole, the benefit could be attributed to the low average correlation between the developed market returns and the returns on the emerging markets considered as standalone asset class. However, out of the 14 emerging markets in the portfolio, only

4; Romania, Chile, Indonesia, and Zimbabwe seem to be significant in the expanded opportunity set (see appendix A). The remaining 10 markets all have negative weight, suggesting that without permitting short-selling the benefits may not be realised.

To verify this, comparison is made of the standard deviations at the global minimum variance portfolio of the expanded investment opportunity set with and without short-sale constraints imposed. When the portfolio weights are not constrained to take on only positive values the standard deviation is 9.74%. But, with short-sale constraints imposed the standard deviation increases by about 62% to 15.76%. Thus, relative to the standard deviation of 16% for the developed market portfolio, it becomes obvious that short selling would need to be permitted for the entire benefits to be achieved else the extent of improvement in portfolio volatility would tend be insignificant.

5.8.4 Implications of the Findings from the Three Portfolios

The analyses so far have aimed at investigating the gains from diversifying developed markets portfolio to emerging markets, considered a standalone asset class, using four versions of the test of mean-variance spanning. Three different portfolios have been examined with each adding the emerging markets to the developed market returns in a different time period and with two more emerging markets added each time period.

The results from all four tests show, for each time period, that emerging markets, as a standalone asset class, are not spanned by returns on developed market assets. To this effect, including emerging markets in a mean-variance efficient portfolio of the developed markets can significantly reduce the portfolio volatility as demonstrated by both the graphical and the statistical analyses. This result accords with that reported by Harvey (1995) for US investors using only the F-test of mean-variance spanning.

Other essential pieces of evidence can be deduced from the analysis. The reason that emerging markets significantly shift the minimum-variance frontier of developed market returns derives from the characteristics of emerging markets assets that distinguish them from developed market assets. As noted in chapter 4, emerging markets are volatile, but present higher expected returns than developed markets. In addition, they have lower correlations with themselves and with returns on developed markets assets. This makes their addition to the developed market portfolio profitable.

Also of crucial importance is the observation that while each of the four tests procedures employed has different power in accepting or rejecting the null hypothesis, all have suggested significant shift in the frontier for the developed market portfolios following the addition of each set of emerging market returns. The unanimity in the conclusions from all four tests highlights the significance of the shifts in the developed market frontier and the extent of the benefits achievable by a UK investor. The evidence corroborates one another in a way that is not achievable using one test.

It is also important to point out that the benefits provided by emerging markets are enormous when short selling is not constrained. With the imposition of restrictions on short selling the opportunity for reducing portfolio risk with diversification to emerging markets is paramount in few emerging markets, particularly Chile and Zimbabwe. Thus not all emerging markets provide diversification benefits. This also confirms the evidence in Errunza, Hogan and Hung (1999) who find Zimbabwe, Chile, (India, Thailand and Greece) more beneficial than other emerging markets.

In this sense, it may be submitted that, viewed from the standpoint of a UK with a developed market portfolio, the absence of short sale constraints would be necessary in order to realise the benefits from diversification to emerging financial markets. Or the investor would have to select some specific emerging markets to achieve benefits.

5.9 Diversification Benefits from Regional Emerging Markets

In furtherance to the analysis of emerging markets investment, this section takes a different direction to the classification of the emerging markets. The focus is to examine the diversification potential when the emerging markets are considered regional assets classified on the basis of the geographical location (or region).

Studies that have examined South East Asian or Latin American markets from the viewpoint of US investors find evidence of diversification gains. Since similar specific emphasis appears not to have been laid on the emerging markets in Africa and Eastern Europe, and most essentially from the standpoint of investors from other developed countries, there are gaps remaining in the literature that need to be filled.

The analysis being pursued in this section therefore attempts to provide a more comprehensive evidence by investigating the gains from diversification to emerging markets in South East Asia, Latin America, Eastern Europe and Southern Africa as in DNW (2001)[21] but with four versions of the regression-based test of spanning.

5.9.1 Diversification to South East Asian Emerging Markets

Using only the Wald test of mean-variance spanning, without imposing short sale constraints, DNW (2001) report evidence of diversification gains for a US investor expanding developed market portfolio to South East Asian emerging markets. However, there is no evidence whether UK investors with optimal portfolio of developed market returns can also benefit from diversification to South East Asian emerging markets. This section seeks to expand the literature in that direction.

The interest of this section lies in examining the shift in the minimum-variance frontier for the developed market portfolio resulting from the inclusion of four East Asian markets; South Korea, Malaysia, Indonesia and Thailand over the period from August 1991 to February 2003 using the four mean-variance spanning tests. As a first stage, diagram 5.4 indicates the extent to which the frontier for the developed (Western European) market portfolio shifts upon adding the Asian emerging markets.

From diagram 5.4, the developed market portfolio has a standard deviation of 14.90% at the global minimum-variance portfolio. This reduces just slightly by 5.4% to 14.10% with the inclusion of the Asian emerging markets. From the graphical evidence, there seems to be only a minimal reduction in the level of volatility of the

[21] They grouped the emerging markets in their sample into Asia, Latin America and Other which consisted of Greece, Jordan, Zimbabwe and Nigeria. Eastern Europe and African markets were not specifically isolated for analysis.

developed market portfolio even after adding the Asian emerging markets. This, however, does not negate the importance of these markets in the portfolio.

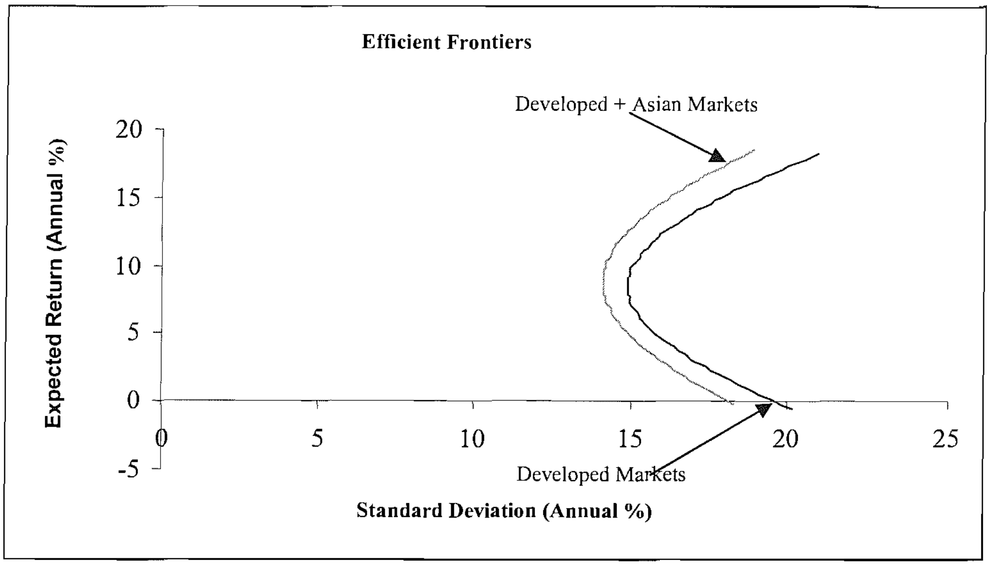

Diagram 5.4

The question of whether the graphical evidence is statistically significant to support the inclusion or exclusion of the Asian markets in the developed market portfolio is answered by the results in Table 5.4. Table 5.4 presents the statistics for the joint test of the hypothesis that the efficient frontier for the developed market portfolio is the same as the efficient frontier derived after adding the South East Asian markets.

Two forms of results (for the joint and for individual markets) are reported in Table 5.4. That is, the second column presents the result for the joint test of adding the four South East Asian markets to the developed market returns. The third column presents the test result for adding the returns on only the South Korean equities to the developed market portfolio and similar results are reported for the equity returns for Malaysia, Indonesia and Thailand in the fourth, fifth and sixth columns respectively.

The tests in Table 5.4 provide interesting evidence. In spite of the fact that the graphical analysis shows only 5.4% reduction in the standard deviation, the result from all the four spanning tests suggest significant shift in the efficient frontier for the developed market asset. The F-test statistic of 2.076 (p-value 0.0384) exceeds the critical value at 5% significance level, likewise the likelihood ratio statistic of 17.221 (p-value 0.0279), the Wald test of 18.133 (p-value 0.0203) as well as the Lagrangian multiplier test of 16.374 (p-value 0.0373) reject spanning at the 5% significance level.

Table 5.4

Spanning Test Results for South East Asian Markets (August 1991 to February 2003)

Test Procedures	Southeast Asia	South Korea	Malaysia	Indonesia	Thailand
F-test p-value	2.076 {0.0384}	1.5158 {0.2234}	1.0259 {0.3613}	0.3557 {0.7013}	0.7240 {0.4867}
Wald Test p-value	17.221 {0.0279}	6.4090 {0.0406}	4.3219 {0.1152}	1.4909 {0.4745}	3.0430 {0.2184}
Likelihood Ratio Test p-value	18.133 {0.0203}	6.2656 {0.0436}	4.2561 {0.1191}	1.4830 {0.4764}	3.0101 {0.2220}
Lagrangian Multiplier p-value	16.374 {0.0373}	6.1265 {0.0467}	4.1916 {0.1230}	1.4751 {0.4783}	2.9778 {0.2256}

The implication of this is that the returns on the South East Asian markets are not spanned by the developed market returns hence, a UK investor with optimal portfolio of the developed market equities can benefit substantially from the inclusion of the equity market returns on the four Asian emerging markets. This conclusion therefore corroborates the findings in DNW (2001) when there are no short sale constraints.

However, a critical analysis of individual Asian market reveals another picture. South Korea, Indonesia and Thailand have negative weights in the portfolio of the expanded opportunity set without the imposition of short-sale constraints (see appendix B). If short selling is disallowed the diversification opportunities in Korean, Indonesian or Thailand may likely be non-existent. Therefore the investor would need to sell short in all except the Malaysian equity market to be able to realise the benefits observed.

The reason for this may be traced to the preliminary analysis in chapter 4 which shows Korea and Thailand as having higher correlation with the developed markets compared to Indonesia and Malaysia. The average correlation of the returns on the Korean and the Thai markets with the developed markets are respectively 42% and 41% while Malaysia and Indonesia have average correlations of 25% and 35% with the developed markets. Added to this, Indonesia has both negative expected return and high return volatility. This wipes out any opportunity for improvement in either the risk level or the expected return of the developed market portfolio.

In the case of South Korea and Thailand, being highly correlated with the developed markets, the expected returns have to be higher or the risk much lower for diversification to be gainful. From Chapter 4, it is shown that Thailand has high volatility but relatively low expected return. While Korea exhibits both high volatility and higher correlation with the developed market assets, these are compensated for by higher expected return. Because of this, (see Table 5.4), when examined individually it is noticed that all four tests accept spanning for Malaysia, Thailand and Indonesia.

However, with the exception of the F-test, the three remaining tests reject spanning for Korea at 5% level of significance. This suggests that relative to the other Asian markets the Korean equities present greater diversification opportunities on individual basis. These have important implications. When investing in individual Asian markets the analysis show that South Korea could provide greater diversification gains than the other (South East Asian) markets in this sample. Furthermore, to benefit from investing in a group of Asian markets the investor would need to take a short position.

These evidences are in consonant with the conclusions in DNW (2001) that the benefits from diversifying developed market portfolios to emerging markets in South East Asia seem to disappear when short sale constraints are imposed. Moreover, the evidence appears to suggest that diversification to individual South East Asian markets could be more profitable than diversification to all the Asian markets.

5.9.2 Diversification to Latin American Emerging Markets

Following the argument in section 5.8.1, this section also examines whether a UK investor can improve his/her investment opportunity set by adding Latin American emerging markets to the developed market portfolio. As with the South East Asian emerging markets, most studies taking the standpoint of US investors document immense gains from diversification to emerging markets in Latin America.

Without short sale constraints, DNW (2001) report evidence of diversification gains to US investors expanding portfolios to Latin America by employing the Wald test of spanning. Similarly, **Susmel (2001)** using safety-first principle of **Roy (1952)** finds significant gains to US investors from diversification to four Latin American markets; Argentina, Brazil, Chile and Mexico, but Meric, Leal, Ratner and Meric (2001) find a weak evidence of diversification gains to US investors from these markets. This is due to increased co-movement of US returns with returns on Latin American assets.

Viewed in another context, there is scanty evidence in the literature as to whether benefits can accrue to investors from other developed countries, especially the UK, from extending developed market portfolios to emerging markets in Latin America. The objective in this section is to extend the literature in that dimension by employing four different versions of the test of mean-variance spanning to examine the gains to UK investors from adding Latin American equities to developed market portfolios.

Four markets; Argentina, Brazil, Chile and Mexico are being investigated for their diversification potentials over the period from September 1994 to February 2003. To set the pace for the statistical analysis, diagram 5.5 presents the graph demonstrating the extent to which the minimum-variance frontier generated from the returns on the developed market assets shifts in the mean-standard deviation plane from the efficient frontier after incorporating the Latin American emerging market returns.

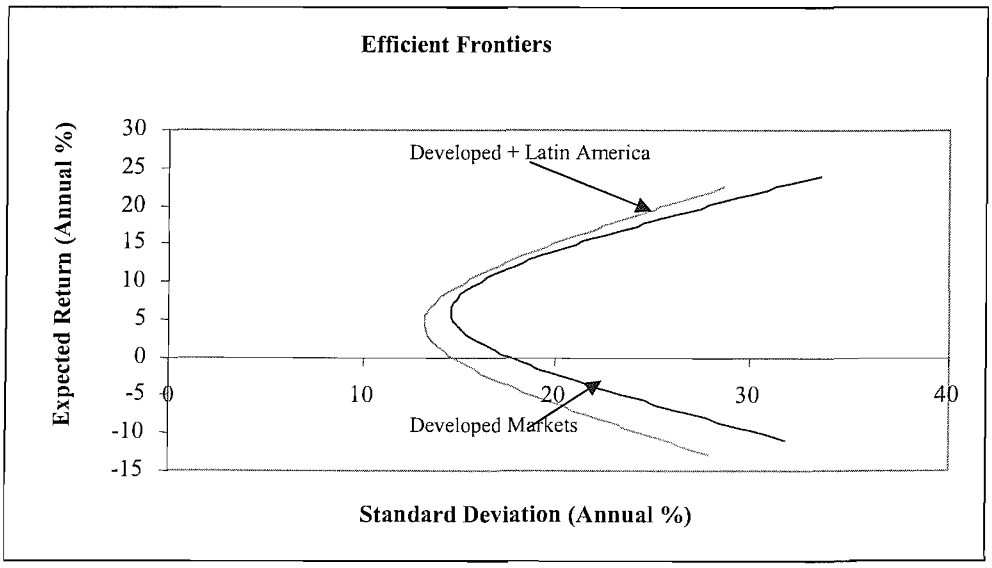

Diagram 5.5

At the global minimum-variance portfolio, the standard deviation for the developed markets of 15% reduces by 10% to 13.5% with the returns on the Latin American emerging markets in the portfolio. As in all cases, the question of whether this reduction is significant to require the addition of the Latin American markets to the developed market portfolio cannot be answered using the graphical analysis.

For further evidence, Table 5.5 provides the result of the four tests of statistical significance of the shift in the frontier for the developed market portfolio upon the addition of the returns on the four Latin American emerging market equities. Five different results are provided. The second column presents the test result for all four Latin American markets jointly. The third, fourth, fifth and sixth columns present the results for adding individual Latin American markets to the developed market returns.

Table 5.5

Spanning Test Results for Latin America Emerging Markets (September 1994 to February 2003)

Test Procedures	Latin America	Argentina	Brazil	Chile	Mexico
F-test p-value	2.553 {0.012}	0.2044 {0.8153}	1.5895 {0.2067}	0.5672 {0.5681}	0.8653 {0.4226}
Wald Test p-value	21.251 {0.007}	0.8706 {0.6471}	6.872 {0.0323}	2.4248 {0.2975}	3.7106 {0.1564}
Likelihood Ratio Test p-value	23.459 {0.013}	0.8669 {0.6483}	6.6459 {0.0360}	2.3964 {0.3017}	3.6447 {0.1616}
Lagrangian Multiplier p-value	19.321 {0.013}	0.8632 {0.6495}	6.4340 {0.0401}	2.3685 {0.3060}	3.5804 {0.1669}

In direct confirmation to the graphical evidence, all four tests reject spanning at 5%. The F test shows a statistic of 1.938 (p-value of 0.054) which is far in excess of the critical value at 5% significance level, indicating that spanning is not accepted. Buttressing this, the likelihood ratio statistic of 21.251 (p-value of 0.007) as well as the Wald and the Lagrangian multiplier test statistics of 23.459 (p-value of 0.013) and 19.321(p-value 0.013) respectively also reject the null hypothesis of spanning at 5%.

Therefore, it could be explained that a UK investor with optimal portfolio of the developed market assets can improve the mean-variance performance of the portfolio through the addition of the equity returns on the four Latin American emerging markets. The benefits derive primarily from the low average correlation between the developed market returns and the returns on the Latin American equities.

As in the case with the Asian markets, this analysis does not recognise the effects of short-sale limitations hence negative portfolio holdings have been allowed. The table of portfolio weights (presented in appendix B) shows that Argentina and Chile have positive holdings while Brazil and Mexico have negative weights. By implication the investor has to sell short in Brazil and Mexico in order to obtain the diversification benefits. The reason for this lies in the analysis of correlations.

As revealed in Chapter 4, among the emerging markets, Brazil has the highest average correlation (56%) with the developed markets and Mexico with 46% is in the next category of markets with high average correlation. Thus, compared to Argentina and Chile with lower average correlation of 39% and 38% respectively with the developed markets, the expected returns on the Brazilian and Mexican equities would need to be much higher or the standard deviation much lower than on the developed markets for these markets to offer improvement to the developed market portfolio.

Though Table 4.2 shows Brazil to provide lower expected returns than Chile and Mexico measured according to the time of availability of data, when measured in the same time frame (September 1994 to February 2003), Argentina, Chile and Mexico provide negative expected returns. Only the Brazilian equities presents positive expected return (results are not shown). This overshadows its high correlation with the developed markets and reflected in Table 5.5, with all four tests suggesting evidence that Argentina, Chile and Mexico, are spanned by the developed markets.

In the case of Brazil, spanning is accepted only by the F-test. The Wald test, the likelihood ratio and the Lagrangian multiplier tests all exceed their critical values at 5% significance level. By implication, when examined individually over the period from September 1994 to February 2003, Brazil presents more opportunities for diversification than the rest of the Latin American markets. But when the portfolio holdings are constrained to be positive Argentina, Brazil and Mexico receive zero allocations leaving only Chile with a portion in the expanded portfolio.

It can thus be explained that if short selling is not allowed Chile may offer significant diversification gains among the four Latin American markets considered as a group. In the absence of short selling, however, Brazil appears to present stronger evidence of diversification opportunities among the Latin American markets. Thus contrary to the evidence in DNW(2001) this study seems to demonstrate that investing in a combined portfolio of all the Latin American markets provides better diversification opportunities than investing in individual emerging markets in Latin America.

5.9.3 Diversification to Eastern European Emerging Markets

In contrast with the Asian and Latin American emerging markets, there is very little evidence on the benefits from diversifying developed market portfolios specifically to emerging equity markets in East and Central Europe. Most of the Eastern European markets may have been discussed as part of a larger set of emerging markets but studies isolating Eastern European markets for detailed scrutiny appear scanty.

This leaves a big question, as well as a gap, in the literature as to whether, from the standpoint of developed market investors, there are benefits from diversifying equity investments to Eastern European emerging markets. From the perspective of US investors **Gilmore and McManus (2002)** reports that since Eastern European markets (Hungary, Poland and the Czech Republic) are not cointegrated with the US market, the relatively low correlations between the US returns and returns on these markets are indications of diversification benefits for both short- and long-term investors.

This section attempts to verify this assertion by evaluating whether a UK investor can also improve his/her investment opportunity set with the addition of the returns on four Eastern European markets; Hungary, Czech Republic, Romania and Turkey to a developed (Western European) market portfolio over a 73-month period; February 1997 to February 2003 using four regression-based test of mean-variance spanning.

Diagram 5.6 compares the efficient frontier generated from the developed market returns to the frontier after adding the returns on the Eastern European markets to the developed markets. From diagram 5.6, the estimated annualised standard deviation at the global minimum-variance portfolio for the developed market returns is 16%. With the addition of the returns on the Eastern European markets, the standard deviation falls by 16.63% to 13.5%, an indication of improvement in the level of portfolio risk.

As in all cases, the observed shift in the frontier as demonstrated by the diagram does not necessarily suggest the mean-variance difference between the two portfolios is significant to warrant the inclusion of the Eastern European markets in the investment opportunity set for the UK investor. It is thus essential to extend the analysis beyond the evidence provided by the graph. This is presented by the test results in Table 5.7.

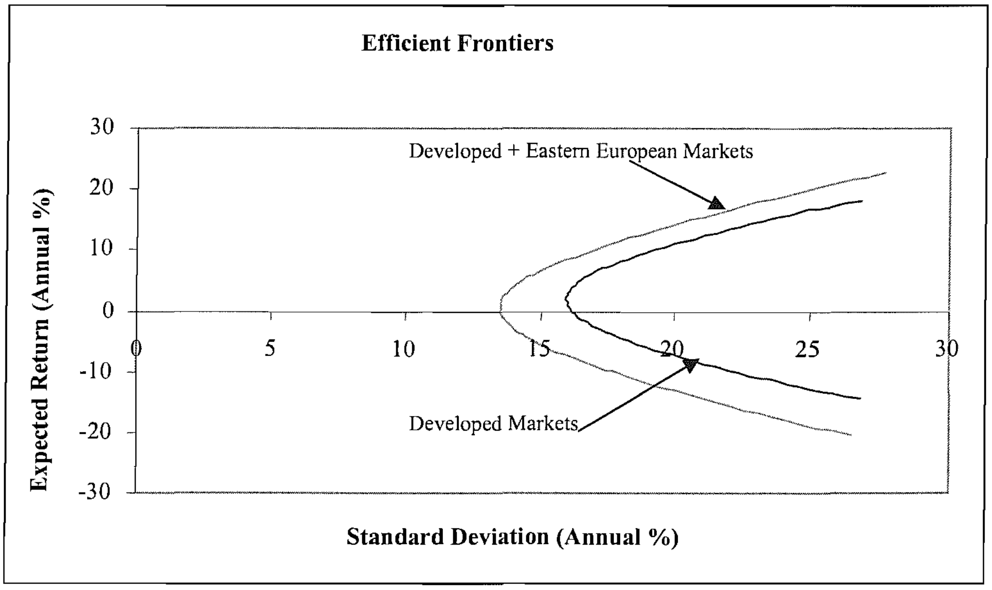

Diagram 5.6

The test result in Table 5.6 are for the joint test of the hypothesis that the frontier generated with the returns on the developed markets coincides with the frontier that could be generated by adding the Eastern European markets (jointly) or individually. The second column presents the results for the joint test of all the four Eastern European markets while the third, fourth, fifth and sixth columns provide the results of the tests for Hungary, Romania, Turkey and the Czech Republic respectively.

Table 5.6

Spanning Test Results for Eastern European Markets (February 1997 to February 2003)

Test Procedures	Eastern Europe	Hungary	Romania	Turkey	Czech Republic
F-test p-value	3.128 {0.003}	0.8376 {0.4350}	0.5809 {0.5608}	1.2958 {0.2771}	1.2799 {0.2814}
Wald Test p-value	26.067 {0.001}	3.6963 {0.1575}	2.5537 {0.2789}	5.7567 {0.0562}	5.6844 {0.0583}
Likelihood Ratio Test p-value	30.751 {0.000}	3.6057 {0.1648}	2.5101 {0.2851}	5.5410 {0.0626}	5.4740 {0.0648}
Lagrangian Multiplier p-value	22.324 {0.004}	3.5181 {0.1722}	2.4644 {0.2912}	5.3359 {0.0694}	5.2738 {0.0716}

The statistical tests confirm the assertion in Gilmore and McManus (2002). All four test procedures suggest evidence of no spanning for the Eastern European markets combined. The F test statistic of 3.128 (p-value of 0.003) rejects spanning at both 5% and 10% significance levels. Along the same line, likelihood ratio statistic of 26.067 (p-value 0.001) also rejects spanning at both 5% and 10% levels of significance.

This is confirmed by the Wald statistic of 30.751 (p-value 0.000) and the Lagrangian multiplier statistic of 22.324(p-value 0.004) both of which exceed the critical values and thus reject the null hypothesis of spanning at both 5% and 10% significance levels, an evidence of considerable left-ward shift in the efficient frontier.

On the basis of this evidence, the Eastern European emerging markets can be argued to significantly improve the investment opportunity set for a UK investor in the same way as has been suggested for US investors by Gilmore and McManus (2002). The benefit could be seen to result primarily from the low average correlation between the returns on the developed and the Eastern European emerging markets.

In Chapter 4, it is shown that the combined average correlation between the returns on the developed markets and the Eastern European markets is roughly 28%. This, coupled with the high expected return on the Eastern European markets, are the main contributory factors to the diversification benefits being revealed by this analysis.

However from a closer consideration, it may be submitted that not all the Eastern European markets offer diversification benefits. Hungary, for instance has relatively low risk and low expected return but at the same time has high average correlation of 46% with the developed market returns. Similarly, while Turkey has high expected return it also has very high return volatility. Thus the correlation with the developed markets has to be very low for Turkey to offer significant diversification benefits.

In this sense the average correlation of 26% between the Turkish equity returns and developed market returns may be considered substantially high for the Turkish equities to offer valuable opportunities for diversification. By comparison, Romania with high expected return and high volatility has a very low average correlation of 11% with the developed markets returns which provides avenue for diversification.

For the Czech Republic the relatively high average correlation of 29% with the developed markets (as compared to Turkey's 26%) is also associated with lower expected return and higher risk compared to the developed markets leading to lesser diversification opportunities. Among the four Eastern European markets the Czech Republic presents lower correlation with the developed markets, lower risk and lower expected return which suggests evidence of possible diversification opportunities.

As shown in appendix C, Hungary has negative holding while Romania and Turkey have extremely low (near-zero) holding in the expanded portfolio. Thus it may prove impossible to make portfolio allocations to Hungary and Turkey when short sale constraints are imposed. Therefore without permitting short selling, common feature in most emerging markets, only the Czech Republic and Romania may be able to offer opportunities for diversification among the four Eastern European markets.

As shown by the individual tests in Table 5.6, all four spanning tests suggest the equity returns on each of the four Eastern European markets are spanned by the returns on the developed markets. By implication, even in the absence of short-sale constraints, it may be less profitable to diversify the developed market portfolio to individual Eastern European markets in spite of the fact that there is evidence of substantial benefits from diversification to all the four Eastern European markets.

5.9.4 Diversification to Southern African Emerging Markets

This section is the last of the discussion in this Chapter by examining the gains from diversification to the Southern African emerging markets. Similar to the case of the Eastern European emerging markets, there are virtually no studies isolating African emerging markets for detailed examination. Several studies, such as DNW(2001) and Harvey (1995) that examine diversification to emerging markets as a standalone asset including African markets find substantial benefits, from US investors' perspective.

Erb, Harvey and Viskanta (1996) employing hypothetical data to project the potential gains from investing in African equities find African assets to have low average correlation with developed markets and conclude that if most of the African markets actually existed and were available to international investors, they would be very good portfolio diversification opportunities (to developed market investors). This observation is further confirmed by **Hassan, Maroney, El-Sady and Telfah (2003)**

Unfortunately, in searching through the literature, a paper by **Ayogu and Mohammed (1992)**, examining the gains from diversification to African equity markets from the standpoint of US investors seems to be the only available study dedicated specifically to African emerging markets. However, they employed simple calculation and comparisons of the means and variances of returns in a format akin to the graphical analysis in this study, following the work of Levy and Sarnat (1970).

The findings are insufficient since simple estimation and comparison of mean and variances of portfolio provides less evidence of improvement in the investment opportunity set. For this reason, it can be argued that it remains unknown whether the inclusion of African markets in developed market portfolios significantly shifts the portfolio frontier and most importantly from the perspective of a UK investor.

This section attempts to provide the bridge in the literature by examining the benefits from adding two African markets, South Africa and Zimbabwe, to the developed market portfolio over the period from February 1991 to February 2003. Diagram 5.7

provides the initial illustration of the impact on the efficient frontier for the developed market returns resulting from the inclusion of the two Southern African markets.

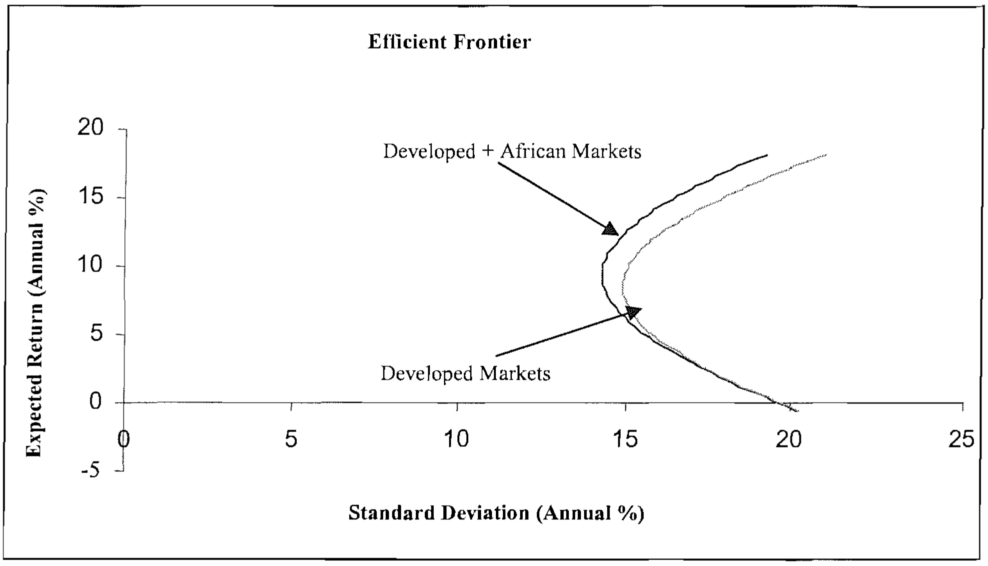

Diagram 5.7

From diagram 5.6, the global minimum-variance portfolio of the developed market equities has an annualised standard deviation of 14.57%. With the addition of the Southern African market returns, the standard deviation of the expanded asset set reduces by only 9.40% to 13.20%. Thus, similar to the Asian markets, only minimal reduction in the standard deviation is experienced from adding the African markets.

While the analysis show that the frontier for the developed market returns has shifted only slight due to the presence of the African markets, as in the previous cases, this does not indicate whether the shift is statistically insignificant. Considered closely, there appears to be an overlap at the lower limb of the frontiers, suggesting some evidence of spanning. However, because this occurs at the inefficient portion of the frontiers, more substantive evidence would be required for further verification.

Table 5.7 provides the result for four tests of the joint hypothesis that the frontier for the developed market equity returns coincides with the frontier for the portfolio combining the returns on both the developed and the Southern African emerging markets over the period from August1991 to February 2003. The second column presents the result for the joint test for the two African markets while the third and the fourth columns provide the results for South Africa and Zimbabwe respectively.

Table 5.7: Spanning Test Results for African Markets (August 1991 to February 2003)

Test Procedures	Southern Africa	South Africa	Zimbabwe
F-test p-value	6.089 {0.0004}	0.0742 {0.9285}	2.6858 {0.0719}
Wald Test p-value	12.770 {0.0125}	0.3103 {0.8563}	11.4547 {0.0033}
Likelihood Ratio Test p-value	12.2202 {0.0158}	0.3100 {0.8564}	11.0072 {0.0041}
Lagrangian Multiplier Test p-value	11.7013 {0.0197}	0.3096 {0.8566}	10.5826 {0.0050}

In spite of the overlap identified in diagram 5.6, all four tests indicate no evidence of spanning at 5% level of significance for joint tests of the Southern African markets. The F statistic of 6.089 (p-value 0.0004) rejects the null hypothesis of spanning at 5%. By employing the likelihood ratio, the Wald and the Lagrangian multiplier tests the evidence is not altered. The likelihood ratiot statistic of 12.22.2 (p-value 0.0158), together with the statistics of 12.7703 (p-value 0.0125) and 11.7013 (p-value 0.0197) for the Wald and the Lagrangian multiplier tests rejects spanning at 5%.

The implication of this is that returns on the African markets are not spanned by the developed market returns. This shows that including the African markets in the developed market portfolio significantly shifts the portfolio's efficient frontier such that to the UK investor the African markets provide significant diversification benefit. This confirms the forecast on African equities by Erb, Harvey and Viskanta (1998).

In particular, the benefits documented stems mainly from the low average correlation of 28% between the returns on the two African emerging markets and the five developed equity markets. This aside, it is important to point out that comparing the African markets; South Africa has a high average correlation of 51% with the developed markets while Zimbabwe has a very low average correlation of 5%.

Moreover, from Table 4.3 in Chapter 4 it can be noticed that South Africa ranks below four of the developed markets; Switzerland, Netherlands, UK and France in terms of expected return and below all the developed markets in terms of standard deviation (risk level) implying that it has lower expected return than the four developed markets but has higher risk level than all the developed markets. Therefore, given the relatively high average correlation the diversification benefits obtainable from the South African equity market could be expected to be minimal.

This has reflected as a negative portfolio holding for South Africa in the expanded portfolio (see appendix C). As a result, short selling has to be allowed for the benefits offered by the South African market to be realised. In this context, while there appears to be substantial gains from diversification to Southern Africa, the benefits seem to derive largely from diversification to Zimbabwe. This is due to its relatively low average correlation with the developed markets and higher expected return.

This is evident when the markets are tested individually. Each of the four spanning tests suggests the returns on the South African equities are spanned by the developed market returns. Thus, there is less evidence of benefits from diversification to South Africa. On the contrary, spanning is rejected by all four tests employed for Zimbabwe. Each of the four test statistics exceeds the critical vale at 5% significance level. Therefore, while diversification to Southern Africa seems beneficial, the benefits emanate from Zimbabwe only, except short-selling is allowed.

5.9.5 Implications of the Findings from Regional Portfolios

From the analyses in the last four sections it is clear that returns on the equity markets in the four geographical regions of South East Asia, Latin America, Eastern Europe or Southern Africa are not spanned by returns on developed equity markets and thus adding these regional emerging market assets to developed market portfolios can significantly improve the investment opportunity set for a UK investor.

For the South East Asian and Latin American markets, these findings have provided valuable confirmation to the evidence already documented for US investors. But of most significance is the fact that the results for the African and Eastern European markets suggest vital expansion to the range of diversification opportunities available to mean-variance investors in developed markets seeking global risk diversification.

As would be expected, considered as regional, rather than individual markets a very low average correlation is observed between the returns on the developed markets and the returns on the emerging markets. This added to the relatively high expected returns means that diversification to these regional markets can be beneficial in spite of the fact that diversification to some individual markets appear less beneficial.

Considered individually, there seems to be significant variations in the diversification opportunities provided by the emerging markets within each geographic region. Thus, in a way, the benefits documented on a regional basis are traceable to specific markets within each geographical region, except when no short-sale limitations are imposed. Therefore without taking a short position it will be possible to invest only in Malaysia among the Asian markets and Chile in the case of Latin American markets, the Czech Republic for the Eastern European markets and Zimbabwe for the African markets.

In the absence of short sale constraints, investing in individual Eastern European markets is less beneficial. Among the Latin American markets Brazil provides the greatest opportunity in such circumstance, among the South East Asian markets Korea present more diversification benefits and Zimbabwe is better than South Africa in the case of the Southern African markets. It can thus be submitted that for a UK investor to achieve the benefits of emerging market investment, first short selling would have to be permitted or second, a selection would have to be made of individual markets in each of the three geographical regions of South East Asia, Africa and Latin America.

BU(1999) posit that as emerging markets mature and become integrated into the world financial markets most of the investment restrictions (which most likely include short selling restrictions) may be removed. In that context, short sale constraints may not present a significant barrier to international investment in the near future which would make diversification gains available in emerging markets attainable. On this basis, it may be suggested that diversification to all the emerging markets in each of the four regions provides gains irrespective of the version of spanning test employed.

5.10 Summary and Conclusions from Chapter Five

Chapter 5 has examined the benefits of diversification to emerging markets by applying four versions of the regression-based test of mean-variance spanning; the F-test, the likelihood ratio test, the Wald test and the Lagrangian multiplier test. The application has concentrated mainly on investigating whether adding emerging markets significantly shifts the efficient frontier of developed market assets.

The analysis has proceeded by first considering all the emerging markets in this study as a standalone asset class resulting in three time-based portfolios containing 10, 12 and 14 emerging markets for the period August 1991 to February 2003, January 1994 to February 2003 and February 1997 to February 2003 respectively. Again the same markets were grouped into four; Asia, Latin America, Eastern Europe and Africa.

Using four tests of mean-variance spanning with different accept-reject decisions, it would be expected that different conclusions would have emanated as to the existence of gains from diversifying the developed market portfolio to the emerging markets. As the analysis has indicated, irrespective of the test procedure employed, emerging markets are not spanned by developed market returns hence UK investors can achieve significant improvement in portfolio performance by adding emerging market assets.

Compared to similar researches, from US investors' viewpoint based on single test procedures, this study , using four different tests provides a stronger evidence on the benefits of diversification to UK investors, which firmly supports the result documented in studies such BU(1999) and Harvey (1995) for US investors.

Viewed closely, the benefits are seen to result from individual markets within each region, suggesting that the benefits documented so far may be less phenomenal when the markets are considered individually. While this finding appears to be in line with the findings in DNW (2001), the evidence in this study differs in that while DNW

(2001) find individual emerging markets in Asia and Latin America to provide better benefit than the combination of all the emerging markets in each region, this study finds the combination of all the markets beneficial than individual markets. This finding supports Markowitz (1952 and 1959) as the combination of more assets in a portfolio reduces volatility than individual assets.

Furthermore, studies such as Harvey (1995), BU (1996 and 1999) that find emerging markets to provide substantial benefits may have come to that conclusions because they examine a number of emerging markets as a single asset class where the good performance of some markets may have overshadowed the poor performance of others. As shown in Chapter 4, emerging markets differ in the level of expected return and risk, as well as the degree to which they correlate with returns on developed market assets hence there are variations in diversification opportunities they offer.

Diversification to markets such as Argentina, Mexico, Thailand, Indonesia, South Africa, Hungary and Turkey appears to be less beneficial compared to Zimbabwe, Brazil, South Korea, Malaysia, Chile, the Czech Republic and Romania. This results from the variation in the degree of correlation with returns on the developed markets, the level of expected returns and return volatility presented by the different markets. In a sense, investors would need to be selective in the choice of emerging markets as investment destinations (BU (1999)) in order to achieve significant benefits

6.0 Sub-Period and GMM Test of Diversification Benefits

6.1 Introduction

This chapter marks the second phase of the empirical analysis. Chapter 5 has provided useful evidence suggesting significant shift in the efficient frontier for the developed market portfolio as a consequence of including the emerging markets, whether as a standalone asset class or as different geographic regional assets.

The investigations were based on two assumptions. First, the correlations among developed and emerging market returns were assumed to remain constant over the period of the analyses, and second, each of the four test procedures employed was based on the assumption that equity returns follow multivariate normal distribution.

The objective in this chapter is to examine the consequences of departures from these assumptions on the benefits from international diversification reported in Chapter 5. The analyses commence with recognition of the effects of instability in correlations. This involves dividing the returns into two sub-periods (in section 6.2) and examining whether the evidence of diversification benefits differs between the two sub-periods.

In section 6.3, the evidence reported in all the preceding sections beginning from the three portfolios in Chapter 5 to the two sub-periods in section 6.2 of this chapter are re-examined using GMM Wald test of spanning. Because the GMM does not require assumptions about the distribution of asset returns, it can provide "distribution-free" evidence on the diversification benefits documented in all the preceding sections.

The importance of this chapter derives from the fact that the application of GMM Wald test extends the objective of this study by bringing to five the number of tests being employed in investigating the gains from diversification to emerging markets. The results from this chapter adds to those obtained in chapter 5 to present the most comprehensive analysis, as far as test procedures are concerned, of the benefits from expanding developed market portfolios to emerging equity markets.

6.2 Analysis of Diversification Benefits in Sub-Periods

This section continues from Chapter 5 by re-investigating whether the benefits reported from incorporating the emerging markets as a standalone asset in the developed market portfolio over the period from August 1991 to February 2003 are persistent or vary significantly in two sub-periods within the period of 139 months.

The tests in chapter 5 assumed constancy for the correlations among the returns on developed and emerging markets as a means to simplify the analysis. But, as shown by the test of stability in Chapter 4, the correlations among the developed markets and some of the emerging markets in this study have not been stable over the 139 months.

Departure from the assumption of constant correlation can be a signal for time-variation in the gains from diversification. It is thus important to assess the impacts of unstable correlations among the returns on the gains already reported. Performing this investigation requires return series long enough for division into sub-periods. However, the returns series for most of the markets are extremely short for this purpose. It is, therefore, not possible to include all the markets in this investigation.

While all the developed markets have sufficient data for division into two periods, out of the 14 emerging markets only 10 have return data that are long enough to enable the division into sub-periods. These are; South Korea, Malaysia, Indonesia, Thailand, Hungary, Turkey, Chile, Mexico, South Africa and Zimbabwe. As a result, four emerging markets; Argentina, Brazil, the Czech Republic and Romania, had to by excluded for not having return data that meet the purpose of this analysis.

It could be seen that the markets being examined are the same as those examined in Portfolio One in Chapter 5, hence the analysis simply reduces to re-examination of the benefits reported for the 139 months from August 1991 to February 2003 in two sub-periods .The first 69 months from August 1991 to April 1997 form the first sub-period while the next 70 months from May 1997 to February 2003 form the second sub-period, the same as the sub-periods in chapter 4 for the test of parameter stability.

6.2.1 Diversification Benefit from August 1991 to April 1997

This section considers the diversification potentials of the emerging market assets over the 69 month-period from August 1991 to April 1997 as the first of two analyses required to verify whether there are persistence in the diversification gains reported for Portfolio One in Chapter 5. To begin the analysis, diagram 6.1 provides graphical demonstration of the shift in the efficient frontier for the developed market portfolio following the addition of the emerging market assets over the 69 months.

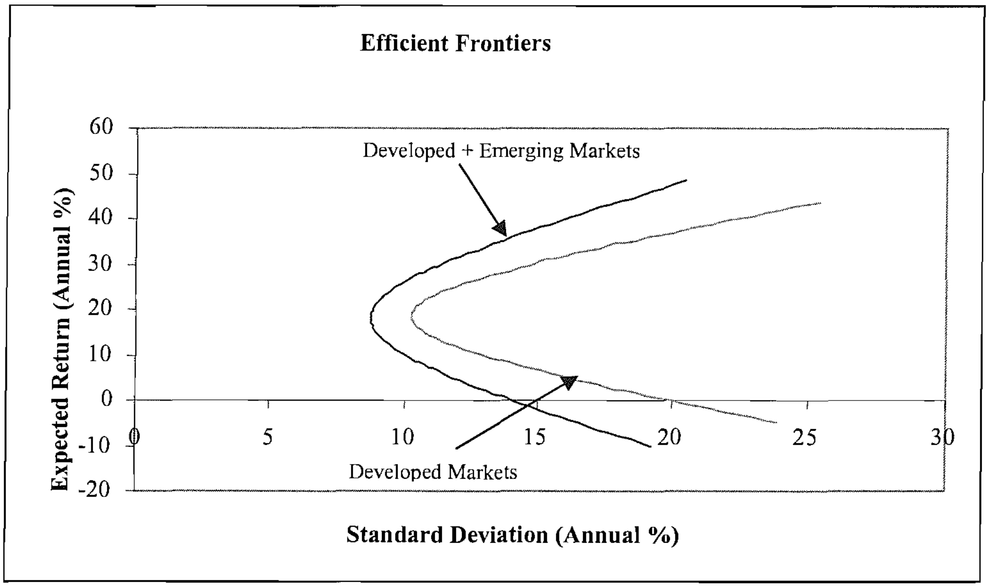

Diagram 6.1

As shown in diagram 6.1 the developed market portfolio has a standard deviation of 10.24% at the global minimum-variance portfolio. With the inclusion of the emerging markets, the annualised standard deviation for the global minimum-variance portfolio of the expanded asset set is 8.74%, which is14.65% lower than the standard deviation at the global minimum-variance of the portfolio formed from the developed markets.

This represents the initial signal as to the extent of the change in the developed market frontier. At first sight there appears to be a significant shift in the portfolio frontier with the inclusion of the emerging market returns, judging from the distance between the frontiers in diagram 6.1. Further evidence is presented in Table 6.1 that provides information on the statistical significance of the difference between the frontiers.

Table 6.1 Mean-variance Spanning Test Results for First Sub-Period

Test Procedures	Test Period	Number of Observations	Test Statistics {p-value}
F-Test	August 1991 – April 1997	69	1.279 {0.2089}
Likelihood Ratio	August 1991 – April 1997	69	29.336 {0.0814}
Wald Test	August 1991 – April 1997	69	33.618 {0.0288}
Lagrangian Multiplier	August 1991 – April 1997	69	25.820 {0.1718}

Given that spanning is rejected by all four tests for the longer period from August 1991 to February 2003, it would have been expected that similar evidence would emerge from the tests result of this first sub-sample period. On the contrary, the evidence is mixed. The Wald test provides indications of significant shift in the developed market frontier. The Wald statistic of 33.618 (p-value 2.88%) exceeds the critical value at 5% significance level, which indicates a rejection of spanning.

On the other hand, each of the three remaining test procedures accepts spanning at 5%. The F-test shows a statistic of 1.279 (p-value of 20.89%) which is lower than the critical value at 5% significance level, an indication that the shift in the frontier for the developed market portfolio is not significant. Similarly, the likelihood ratio statistic of 29.336 (p-value 8.14%) and the Lagrangian multiplier statistic of 25.820 (p-value 17.18%) are both lower than the critical values at 5%, also suggesting that the emerging market returns are spanned by the developed market returns.

The implication of the above analysis is obvious. Based on only the Wald test of spanning, a UK investor can achieve significant improvement in the mean-variance characteristics of the developed market portfolio with the addition of the emerging market assets. On the other hand, using the likelihood ratio test, the F-test or the

Lagrangian multiplier test of spanning, a UK investor does not achieve any improvement in the investment opportunity set by expanding to emerging markets.

This is an interesting revelation considering that there is evidence of significant diversification gains from all four test procedures in the longer period from August 1991 to February 2003. It is thus surprising that the test for the first sub-period within the longer period suggest the emerging markets are redundant in the developed market portfolio. As explained earlier in this study, the Wald test has higher tendency to reject spanning than the other tests due to the larger numerical size of the statistic.

In this context, it quite probable that studies such as DNW (2001) that employ only the Wald test of spanning would more likely reject spanning, that is report evidence of gains from diversification even when the gains are not substantial according to the other versions of the mean-variance spanning test. However, this conclusion remains premature until the economic significance of the benefits suggested by the Wald test is quantified (using the change in incremental Sharpe ratio) subsequently in chapter 7.

6.2.2 Diversification Benefit from May 1997 to February 2003

As a continuation to the result in the preceding section, this section investigates the diversification benefits over the second sub-period covering the 70 months from April 1997 to February 2003 in an attempt to establish reasons for the variation in the test results for the longer period (August 1991 to February 2003) and the first sub-period.

The possibilities are that the shift in the developed market frontier for the longer period stems from a significant difference between the risk and return on the developed and the emerging markets over this second sub-period. If that is the case, it can be established that the benefits reported in the longer period (of 139 months) derive largely from the returns in the period from May 1997 to February 2003.

As an initial test, diagram 6.2 provides the graphical illustration of the extent to which the frontier for the developed market portfolio has shifted following the addition of the emerging market assets. It is observed from diagram 6.2 that the standard deviation for the developed market assets at the global minimum-variance portfolio has decreased from 16.25% to 12.23% (a percentage difference of 24.74%) with the presence of the emerging market returns.

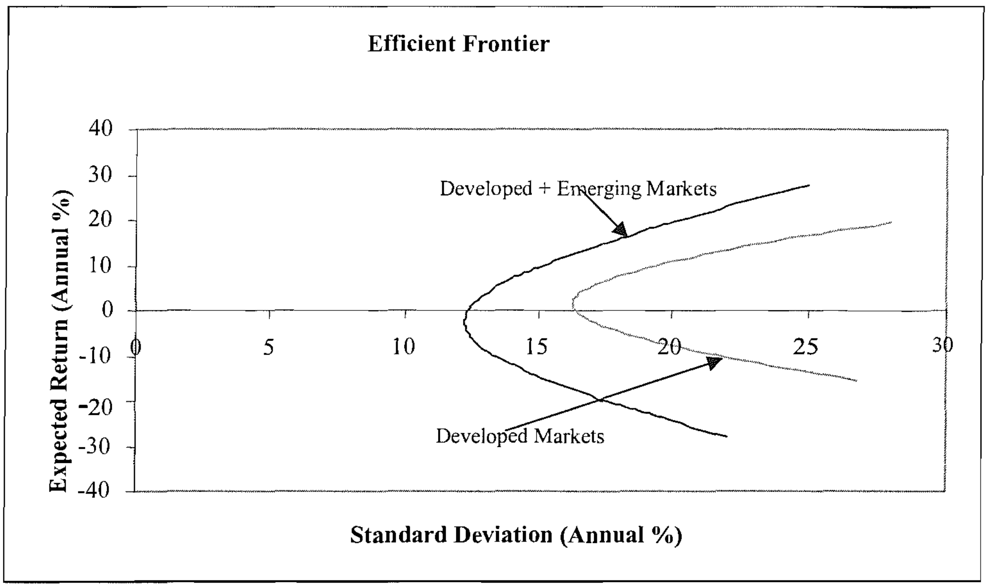

Diagram 6.2

Comparing the changes in the minimum standard deviations shown in diagram 6.1 and diagram 6.2 for the first sub-period and the second sub-period respectively, there is a clear evidence that the extent to which the developed market frontier shifts in the second sub-period as indicated by the standard deviation appears considerably greater than the shift observed for the developed market frontier in the first sub-period. Table 6.2 provides the statistical tests that determine whether the shift is significant

Table 6.2 Mean-variance Spanning Test Results for Second Sub-Period

Test Procedures	Test Period	Number of Observations	Test Statistics {p-value}
F-Test	May 1997 – February 2003	70	2.169 {0.0059}
Likelihood Ratio	May 1997 – February 2003	70	46.546 {0.0000}
Wald Test	May 1997 – February 2003	70	61.236 {0.0000}
Lagrangian Multiplier	May 1997 – February 2003	70	36.503 {0.0134}

In contrast to the findings in the first sub-period, all four test procedures reject spanning at 5% significance level (in this second sub-period). Employing the F-test of spanning produces a test statistic of 2.169 (p-value of 0.0059), which in addition to the likelihood ratio test statistic of 46.546 (p-value 0.0) rejects spanning at 5% level of significance. Similarly, both the Wald test statistic of 61.236 (p-value 0.00) and Lagrangian multiplier statistic of 36.503 (p-value 0.0134) reject spanning at 5%.

These results simply suggest that over the period from May 1997 to February 2003 including the emerging markets in the developed market portfolio leads to significant shift in the portfolio's mean-variance frontier. Therefore, a UK investor with optimal portfolio of the developed market assets can significantly improve upon the mean-variance characteristics through diversification to emerging equity markets.

This contradicts the results obtained for the first sub-period from August 1991 to April 1997 where diversification benefits are documented only under the Wald test. Given the fact that the tests result for the entire period from August 1991 to February 2003 show evidence of significant diversification benefit, these results are conflicting. The next section presents the implication and the reasons for the contradicting results.

6.2.3 Implications of the Findings from Sub-Period Analysis

The preceding two sections have examined whether the benefits observed for the period from August 1991 to February 2003 in Chapter 5 are persistent or have changed over the entire 139 months. The test suggests insignificant diversification benefits in the first sub-period from August 1991 to February 2003 while there are substantial benefits in the second sub-period from May 1997 to February 2003.

This is due to the changes in the correlations among the developed and emerging market returns and among the developed market themselves. The test of constancy of correlation in Chapter 4 indicates that among the 14 emerging markets only Malaysia has experienced a fall in the correlation with the returns on the developed markets in the second than in the first sub-period. The remaining emerging markets have either had a stable or increased correlation with the developed markets over the 139 months.

However, the correlation among the developed markets increased substantially from May 1997 to February 2003 (than from August 1991 to February 2003) compared to their correlation with the emerging markets from May 1997 to February 2003. This may have led to the evidence of significant diversification benefits in the period from May 1997 to February 2003 and a weak evidence of diversification benefits from August 1991 to February 2003. This underlines the essence of recognising the impact of short term changes in correlation among asset returns on diversification gains.

Moreover, of crucial significance is the implications of the conflict in the results for the Wald test and the three other test procedures; the F-test, the likelihood ratio and the Lagrangian multiplier test for the first sub-period. This highlights the essence of implementing more than one statistical method at a time. The evidence demonstrates the limitations of studies that rely on one spanning test, for example DNW (2001) and Harvey (1995), in examining the benefits of diversification to emerging markets.

6.3 Diversification Benefits with GMM Wald Test of Spanning

Until this stage, all the tests implemented have assumed asset returns are multivariate normally distributed. The assumption that asset returns follow multivariate normal distribution allowed the test procedures to be employed using ordinary least square (OLS) regression based on a set of (Gauss-Markov) assumptions, enumerated follows:

(i) the expected value of the regression error term is zero, implying that, on average the regression line plotting the independent variable against the dependent variable should be correct. Thus: $E\{\varepsilon_t\} = 0, \qquad i = 1,........, N$

(ii) the regression error term and the explanatory variables are independent. $\{\varepsilon_1,.........., \varepsilon_N\}$ and $\{x_1,..................., x_N\}$ are independent.

(iii) all error terms have the same variance. That is they are *homoskedastic.* $V\{\varepsilon_i\} = \sigma^2, \qquad i = 1,.........., N$

(iv) there is zero correlation between different error terms. This excludes any form of *autocorrelation.* $Cov\{\varepsilon_i, \varepsilon_j\} = 0 \qquad i, j = 1,............, N \quad i \neq j$.

According to Gibbons, Shanken and Ross (1989) the assumption of normality helps provide 'a good working approximation' to the distribution of monthly equity returns. In this study, assuming multivariate normality in the return distribution serves as a useful starting point for the empirical investigation so that further tests under different assumptions would provide corroborative evidence to the results obtained so far.

From Table 4.4 in Chapter 4, the JB test rejects normality for all the markets except for Malaysia, where some evidence of normality appears to exist. Furthermore, the coefficients of skewness and excess kurtosis show signs of fat tails and peakedness in the returns, confirming that normality cannot be accepted. The fact that normality can be rejected for the returns has significant implications for the results obtained and conclusions drawn on the basis of the four spanning tests that assume normality.

It may be that the regression error term ε_i exhibit conditional heteroskedasticity, in which case, the statistics computed up to this stage would no longer have asymptotic chi-square distribution under the null hypothesis of spanning. In this context, the test results derived may have been engendered by sampling error. It is therefore important to proceed further to determine whether the shifts in the efficient frontiers observed so far are genuine and not the consequences of sampling variation (Harvey (1995)).

Hansen's (1982) GMM constitutes a viable procedure for re-estimation of the test statistics where doubt exists about the distribution of asset returns. This is used in this section to provide alternative evidence on the diversification benefits reported in the preceding sections. This section is organised as follows: subsection 6.3.1 discusses the GMM Wald test procedure and subsections 6.3.2 to 6.3.4 discuss the results obtained by applying the GMM Wald test to re-investigate the gains from diversification. The last subsection, 6.4, examines the implications of the results.

6.3.1 Brief Discussion of the GMM Wald Test of Spanning

Hansen (1982) developed the GMM as a *distribution-free* alternative that overcomes the limitations of the OLS enumerated above. Unlike the OLS, the GMM utilises the moment conditions in the estimation of the regression parameters in a way that avoid the assumptions about the error term and the nature of distribution of the return series.

Thus, employing GMM in the spanning framework can serve as a useful addition to the collection of statistical tests used in the analysis in all the preceding sections. All the three alternative tests; the likelihood ratio, the Lagrangian multiplier and the Wald test have GMM versions. Moreover, as already explained, for the spanning tests both the restrictions and regression model being estimated are linear, which implies that they can (but not necessarily) have the same weighting matrix, in a GMM model, a condition that can be exploited to facilitate the calculation of the test statistics.

Because of the relationship between the three tests in the GMM, **Newey and West (1987)** show that the GMM version of the likelihood ratio test and the Lagrangian multiplier test have exactly the same form as the GMM version of the Wald test in spite of the fact that one needs the restricted estimates of the regression parameters (β) to compute the likelihood ratio and the Lagrangian multiplier test statistics.

Accordingly, the GMM versions of all three tests can have identical numerical values, and may lead to the same conclusion, when the same weighting matrix is used in estimating the test statistics. In practice, different weighting matrices are used which leads to different values for test statistics and hence different accept-reject decisions.

In this study only the Wald version of the GMM test of mean-variance spanning is implemented as it is sufficient to provide *distribution-free* confirmation to the evidence of diversification benefits recorded up to this point. Most essentially, the GMM version of the Wald test, unlike the others, does not require pre-specification of a weighting matrix and the number of iterations. This makes the estimation of the statistic for the GMM Wald test of spanning simpler compared to the others.

The next few paragraphs present a brief explanation of the procedure in deriving the test statistic for the GMM Wald test of spanning. This follows the approaches in **Ferson, Foerster and Keim (1993)** and Kan and Zhou (2001). Detailed and elaborate explanation of the GMM test for spanning can be obtained from these two studies.

In order to apply the GMM test, the vector of returns for the benchmark (developed market) assets are defined as $R_D = \lfloor 1, R_{D(t+1)} \rfloor '$, and the vector of returns of the test (emerging market) assets defined as $R_E = R_{E(t+1)}$. Therefore, the regression residuals may be expressed as $\varepsilon_{t+1} = R_E - \beta' R_D$ where β represent the matrix of slope and intercept coefficients that results from the regression of R_E on R_D.

Thus the population moment conditions used in the GMM estimation of β are :

$$E[gt] = E[R_D \otimes \varepsilon_t] = 0_{(D+1)E}, \tag{18}$$

and the sample moment conditions given by

$$\bar{g}T = [\beta] = \frac{1}{T}\sum_{t=1}^{T} R_D \otimes \left(R_E - \beta' R_D\right) \tag{19}$$

From this the GMM estimate of β is obtained by minimising the quadratic form of the equation: $\bar{g}T(\beta)' S_T^{-1} \bar{g}T(\beta)$, where S_T is a consistent estimate of $S_0 = E\left[g_t g_t'\right]$ $= (R_D R'_D) \otimes (\varepsilon_t \varepsilon'_t)$ assuming that g_t are serially uncorrelated. Again the Wald test needs to be set up for incorporation into the GMM framework. For this purpose, three matrices A, C and Θ are defined on the matrix of regression parameters β where:

$$\mathrm{A} = \begin{bmatrix} 1 & 0_D' \\ 0 & -1_D' \end{bmatrix}, \quad \mathrm{C} = \begin{bmatrix} 0_E' \\ -1_E' \end{bmatrix} \text{ and } \Theta = \mathrm{A}\hat{\beta} - \mathrm{C} \tag{20}$$

The system (19) is exactly identified in that the number of parameters to be estimated is the same as the number of moment conditions. Therefore, the unconstrained estimates of β and hence Θ do not depend on S_T and remain the same as their OLS estimates. With these estimates and following Kan and Zhou (2001) the GMM version of the Wald test of mean-variance spanning may be conveniently written as:

$$W_{GMM} = T vec(\Theta')' \left[(A_T \otimes I_E) S_T (A_T' \otimes I_E\right]^{-1} vec(\Theta')' \cong \chi^2_{2E} \tag{21}$$

Where the symbol, $\otimes$, implies kronecker product and

$$A_T = \begin{bmatrix} 1 + a_D & -\mu_D \Sigma_D^{-1} \\ b_D & -\iota_D' \Sigma_D^{-1} \end{bmatrix} = \left[\frac{1}{T} \left[\begin{pmatrix} 1, & R_D' \end{pmatrix} \begin{pmatrix} 1, & R_D' \end{pmatrix} \right] \right]^{-1} \times \begin{bmatrix} 1 & 0_D' \\ 0 & -1_D' \end{bmatrix} \qquad (22)$$

The test is approximately chi-square distributed with degrees of freedom equal twice the number of test assets (emerging markets) to be added to the benchmark portfolio (the developed markets assets). Following the pattern laid down in chapter 5; this analysis is also conducted in a Microsoft Excel environment. Outline of the routines and algorithms used in calculating the test statistics are presented in appendix H.

The rest of this section applies the GMM Wald test in examining the benefits from diversifying the developed market portfolios to the emerging markets.

6.3.2 GMM Wald Test: Portfolios One, Two and Three

The objective in this section is to extend the analyses in sections 5.8.1, 5.8.2 and 5.8.3 of Chapter 5 with the GMM Wald test of spanning to re-examine the diversification benefits for the three portfolios (One, Two and Three) by way of verifying whether the shifts in the developed market frontiers are genuine or derives from wrong assumption about the distribution of asset returns. Table 6.3 presents the results.

Table 6.3 GMM Wald Test Results for Portfolios One, Two and Three

Portfolios	Test Period	Number of Observations	Test Statistics {p-value}
Portfolio One	August 1991 – February 2003	139	42.279 {0.003}
Portfolio Two	January 1994 – February 2003	110	53.555 {0.000}
Portfolio Three	February 1997 – February 2003	73	94.067 {0.000}

From Table 6.3, the GMM tests for all three portfolios provide evidence similar to that derived from the tests under assumption of normal distribution. The statistic of 42.279 (p-value 0.003), for Portfolio One, strongly rejects the null hypothesis of spanning at both 5% and 10% levels of significance. Similarly, the GMM statistics of 53.555 (p-value 0.000) and 94.067 (p-value 0.000), for Portfolios Two and Three respectively, both reject the null hypothesis of spanning at all significance levels.

These results show that the emerging markets significantly shift the developed market frontier in all three time periods. Therefore, the shifts in the efficient frontiers for the developed market portfolio in diagrams 5.1, 5.2 and 5.3 can be said to be genuine indications of the benefits achievable from diversification to the emerging markets and not driven by sampling error or wrong assumption about the return distribution.

In this sense, the GMM tests has consolidated the findings in Chapter 5 by further highlighting the extent to which a UK investor can improve the mean-variance profile of his/her developed market portfolio by including returns on emerging market assets.

6.3.3 GMM Wald Test: Emerging Market Regional Portfolios

Following the same line of argument as in section 6.3.3, the analyses in this section are meant to complement the evidence in section 5.9.1 to 5.9.4 in chapter 5. The GMM Wald test is employed in this section to re-investigate the results obtained for the emerging market regional portfolios. The results are presented in Table 6.4.

Table 6.4 GMM Wald Test Results for Emerging Market Regional Portfolios

Emerging Market	Test Period	Number of Observations	Test Statistics {p-value}
South East Asia	August 1991 – February 2003	139	19.458 {0.0126}
Latin America	September 1994 – February 2003	102	17.174 {0.028}
Eastern Europe	February 1997 – February 2003	73	20.626 {0.008}
Southern Africa	August 1991– February 2003	139	14.685 {0.0054}

It is evident from Table 6.4, that the tests reject spanning for each emerging market regional asset. In the case of the South East Asian emerging markets, the GMM statistic of 19.456 (p-value 0.0126) rejects spanning at 5%. Similarly, the GMM statistic of 17.174 (p-value 0.028) for the Latin American markets, 20.626 (p-value 0.008) for the Eastern European markets and 14.685 (p-value 0.0054) for the Southern African markets all reject spanning at 5% significance level.

Given the results from the GMM test, it can be shown that each emerging market regional asset significantly shifts the frontier for the developed market portfolio. Most importantly the shift symbolises genuine improvement in the mean-variance characteristics of the (developed market) portfolio resulting from the presence of these regional assets rather than an artefact of sampling variation (Harvey (1995)).

This substantiates the evidence derived from the four tests under normal distribution. Therefore combining the two (GMM and the previous test results) there is a strong reason to believe that the addition of each of the four emerging market regional assets can significantly improve the investment opportunity set for a mean-variance UK investor with developed (Western European) market portfolio (granted short selling).

6.3.4 GMM Wald Test: Sub-Period Portfolios

As a follow-up to the conclusions drawn in sections 6.1.1 and 6.1.2 of this chapter, this section re-examines the test results in the two sub-periods in a GMM framework. The objective is to provide additional evidence to the findings derived from the four test procedures. Table 6.5 provides the result for the GMM Wald test for the two sub-periods; August 1991 to April 1997 and from May 1997 to February 2003.

Table 6.5 GMM Wald Test Results for Sub-Period Portfolios

Test Procedures	Test Period	Number of Observations	Test Statistics {p-value}
Sub-Period One	August 1991 – April 1997	69	81.154 {0.000}
Sub-Period Two	May 1997 – February 2003	70	42.978 {0.0021}

As in the preceding section, the GMM test for each sub-period portfolio rejects the null hypothesis of mean-variance spanning. For the first sub-period, the statistic of 81.154 (p-value 0.000) exceeds the critical value at all significance levels. Similarly the statistic of 42.978 (p-value 0.021) for the second sub-period also exceeds the critical value at all levels of significance, implying that spanning cannot be accepted.

In both sub-periods the GMM test provides evidence of significant shift in the frontier for the developed market portfolio as depicted in diagram 6.3.1 and 6.3.2. For the second sub-period, the GMM result serves to consolidate the evidence derived with the four tests in section 6.3.2 and thus confirms that significant diversification benefits could be achieved by a UK investor with developed market portfolio by diversifying to emerging markets in the 70-months period from May 1997 to February 2003.

In the case of the first sub-period, while the GMM test leads to two conclusions. First, it corroborates the traditional Wald test in section 6.1.1 to suggest that the presence of the emerging markets significantly improves the mean-variance performance of the developed market portfolio. Secondly, it reinforces the contradiction between the result from the traditional Wald test and the other tests employed in section 6.3.1.

6.4 Summary and Conclusions from Chapter Six

The basic purpose of this chapter has been to consolidate the findings in Chapter 5 in two main dimensions. The first dimension has been to find evidence on the impact of instability in the co-movements among developed market and emerging market returns on the gains from international diversification as documented in Chapter 5.

The second dimension has also been to examine whether the gains reported in chapter 5 emanate from genuine improvement in the developed market portfolio due to the presence of the emerging markets or are just the result of sampling error arising from wrong assumptions about the distribution of asset returns. This chapter has provided valuable clues about the estimation of the benefits from international diversification.

First, there appears to be time-variation in the benefits from diversifying developed portfolios to emerging markets. This analysis has shown a stronger evidence of significant gains from diversification to emerging markets from May 1997 to February 2003, than from August 1991 to April 1997. This seems to be driven by time-variation in the correlation between the developed and the emerging markets.

As shown in Chapter 4, aftermath of various economic events across the emerging economies in the second half of the 1990s to the early 2000s had significantly impacted on the extent to which returns on developed markets correlate with the returns on emerging markets. While the developed markets have experienced increased correlation with one another[22], their correlation with the emerging markets reduced from 1997 to early 2003. This has had positive effects on the benefits to developed market investors from diversification to emerging equity markets.

Moreover, this analysis has shown that examining the benefits from international diversification on the basis of a single statistical procedure can be misleading. This is highlighted in the conflict between the result from the traditional and the GMM Wald tests, on one hand, and the results obtained from the F, the likelihood ratio and the Lagrangian multiplier tests on another hand for the first sub-period. Thus the essence of employing more statistical tests at a time is seen to be revealed in this analysis.

Finally, the GMM Wald test has served to clarify the evidence in chapter 5 by demonstrating that all the benefits observed so far derive from genuine shifts in the frontiers for the developed market portfolios and not the result of sampling variation or wrong assumption about the distribution of asset returns. To this end, it can be concluded that while some individual emerging markets seem not to provide diversification benefits, a number of emerging markets examined together can improve the mean-variance characteristics of developed market portfolios.

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[22] It may be argued that the introduction of the European single currency, the Euro may have accounted for this rise in correlation while at the same time the correlation with most emerging markets in that period perhaps due to investor response to a number of crises in emerging markets.

7.0 Economic Significance of Diversification Benefits

7.1 Introduction

This chapter is the last of three chapters dedicated to the empirical analysis. The preceding chapters have provided evidence suggesting that, statistically, emerging markets significantly shift the frontier for developed market portfolios. The objective in this chapter is to provide economic meaning to the shift in the frontier following BU (1996), Rowland and Tessar (2004) and Errunza, Hogan and Hung (1999).

As explained in chapter 5, the principle behind the test of mean-variance spanning is simply to examine whether the frontier for the benchmark assets intersects the frontier for both the benchmark and the test assets at two points in the mean-standard deviation space. From the two-fund separation theorem, intersection at two points implies intersection at all points (i.e. the two efficient frontiers are the same)

Thus when the hypothesis of spanning is rejected it signifies that the two frontiers are different and that the test assets are not redundant in the benchmark portfolio. This is normally based on two of the array of portfolios depicted by the efficient frontiers. To this end, merely rejecting spanning may not be adequate in forming conclusions as to whether the test assets provide significant diversification gains. It is thus relevant to ask whether the portfolios at which intersection is tested are also realistic (BU, 1999).

This invariably requires employing a portfolio performance measure to examine, in practical terms, how the performance of the benchmark portfolio has improved as a result of the presence of the test assets (quantify or test the economic significance of the diversification benefits). The literature employs two main methods for achieving this purpose. The first is the use of Sharpe (1966 and 1994), "reward-to-risk" ratio. The second and perhaps the most recent is the percentage change in lifetime utility.

While both methods are explained in this thesis, only the Sharpe ratio is employed to investigate the extent of the improvement in the performance of the developed market portfolios resulting from the inclusion of the returns on the emerging market assets.

Section 7.2 discusses the use of the percentage change in the lifetime utility while section 7.3 explains the use of Sharpe ratios as a measure of portfolio performance. Section 7.4 presents the Sharpe ratios for all the portfolios examined in Chapters 5 and 6. This chapter ends in section 7.5 with summary of the findings and conclusions.

By measuring the economic significance of the shift in the developed market frontier, this chapter provides a more practical analysis of the relevance of the emerging markets in the developed market portfolio in a way not achievable by using only the tests of statistical significance in the preceding chapters. Thus, this chapter adds to the statistical analyses to present a detailed evaluation of the benefits from diversification to emerging markets than is provided in the literature on emerging market investment.

7.2 Changes in Lifetime Utility as Test of Economic Significance

Cole and Obstfeld (1991) and Lewis (2000) employ the change in lifetime utility or permanent consumption to examine international risk-sharing. The focus of these studies was to find explanations for the investor bias towards home assets. Recently, Rowland and Tessar (2004) have applied this metric to quantify the benefits from (i.e. test the economic significance of) expanding portfolios to international markets.

Using this metric, the test of economic significance is derived as the percentage reduction in permanent consumption that makes the investor indifferent between the optimal portfolio comprising of the assets in the expanded investment opportunity set and the optimal portfolio comprising of returns on the benchmark assets only.

By letting C_t denote the permanent consumption at time **t** of an investor holding the optimal portfolio of the benchmark assets and C_t* denoting the lifetime utility or permanent consumption at time **t** of an investor holding the optimal portfolio of the expanded asset set, the measure of utility gain from holding a portfolio, δ, is given by the relationship:

$$U_0(C_0) = U_0\left(C_0^*(1-\delta)\right) \qquad (23)$$

Using the Epstein-Zin-Weil specification for utility (see Epstein and Zin, 1990), which allows the risk-aversion parameter, γ, to differ from the inverse of the elasticity of intertemporal substitution parameter, θ, the utility function can be specified as:

$$U_t = \left[c_t^{(1-\theta)} + \beta\left[E_t\left(U_{t+1}^{1-\gamma}\right)\right]^{(1-\theta)/(1-\gamma)}\right]^{1/(1-\theta)} \quad \text{for all } \gamma,\theta > 0, \gamma,\theta \neq 1 \tag{24}$$

The utility maximizing portfolio is thus obtained by maximizing the utility function given in equation (24) subject to the efficient frontier of the portfolio of all assets available to the investor. Within the utility framework portfolio returns are assumed to be jointly log-normally distributed such that $\ln(R_{D,t}) \sim N(\mu_D - (1/2)\sigma_D^2, \sigma_D^2)$ and $\ln(R_{DE,t}) \sim N(\mu_{DE} - (1/2)\sigma_{DE}^2, \sigma_{DE}^2)$, where $R_{D,t}$ and $R_{DE,t}$ are the vectors of the gross returns on the portfolio of the benchmark and the expanded asset set respectively.

Following from the above, the expected utility of consumption for an investor holding the optimal benchmark portfolio can be written as:

$$E_t U(C_t) = W_t\left\{1 - \beta \exp\left[(1-\theta)\left(\mu_D - \frac{1}{2}\gamma\sigma_D^2\right)\right]\right\}^{-(1/(1-\theta))} \tag{25}$$

Similarly, the expected utility of consumption for an investor holding the optimal portfolio of the expanded asset set may be written as:

$$E_t U(C_t) = W_t\left\{1 - \beta \exp\left[(1-\theta)\left(\mu_{DE} - \frac{1}{2}\gamma\sigma_{DE}^2\right)\right]\right\}^{-(1/(1-\theta))} \tag{26}$$

W_t is equal to the investor's wealth at time t and is assumed to be exogenous.

Without the test assets the investor maximizes utility subject to the portfolio frontier of the benchmark assets. The optimal portfolio is obtained at the point of tangency between the efficient frontier for the benchmark assets and the utility curve. By expanding the set of available assets to include both the benchmark assets and the test assets, the investor now increases utility by choosing the optimal portfolio which is given by the point of tangency between the efficient frontier for the expanded asset set and the utility curve. In this way, the investor gains utility by switching from the portfolio of only the benchmark assets to the portfolio of the expanded asset set (the diagram illustrating this is provided in the work of Rowland and Tessar (2004)).

This implies that, by limiting his/her investment to only the benchmark portfolio, the investor experiences opportunity cost measured by the loss in utility resulting from investing in the portfolio comprising of only the benchmark assets or forgoes the improvement in utility resulting from expanding the investment opportunity set to include the test assets. Building on this premise, Rowland and Tessar (2004) derive the means for quantifying the gains from international diversification.

This is achieved by measuring the percentage reduction in the investor's utility (or permanent consumption) that makes him/her indifferent between the optimal portfolio at the point of tangency between the benchmark frontier and the utility curve and the portfolio at the tangency between the expanded frontier and the utility curve.

Their test could simply be explained to mean that an investor would consider expanding portfolios to international markets when the extent of lifetime utility loss resulting from investing in only the portfolio of home assets (i.e. the benchmark portfolio) is such that it would be imprudent to exclude the returns on foreign assets (i.e. the test assets). In the mean-variance spanning context this suggests that the test assets are not redundant in the benchmark portfolio or that their presence in the portfolio could lead to significant leftward shift in the portfolio efficient frontier. The portfolio selection decision is made on the basis of the risk and returns on the assets.

This is evident in equations (25) and (26) as the inner brackets in both equations indicate that utility maximisation involves a trade-off between the mean return of the portfolio and its variance. However, in the case of the above utility functions, Lewis (2000) shows that the portfolio allocation decision depends only on the coefficient of risk aversion, γ, and no other preference parameters. This suggests that the derivation of the optimal portfolio is dependent on the degree of risk aversion of the investor while the computation of utility gain is dependent on the optimal portfolio weight.

Rowland and Tessar (2004) compute the utility gain in three steps. Firstly, they solve numerically for the optimal portfolio weights given the set of benchmark assets and test assets. Secondly, they use equation (25) and (26) to compute the utility levels associated with the two portfolios, given the portfolio weights, and thirdly they compute the welfare gain using equation (24). It can be seen from equation (25) and (26) that computing the expected utility demands the value for the discount factor β which also depends on the values for risk aversion and elasticity of intertemporal substitution parameters.

The approach used by Rowland and Tessar (2004) to compute β is to restrict the admissible combination of the measure of risk aversion, γ, and the elasticity of substitution, θ, such that the discount factor, β, is less than one and given by:

$$\beta^{-1} > \exp\left[(1-\theta)\left(\mu - \frac{1}{2}\gamma\sigma^2\right)\right] \tag{27}$$

In their study, they consider the utility gain from diversification for risk aversion parameter γ equal to 2 and an elasticity of intertemporal substitution parameter θ of 5.

A number of problems emanate from using this utility-based approach to quantify the gains from diversification. There is little consensus in the literature about the "true" magnitudes of the parameters for risk aversion (γ) and intertemporal substitution (θ). The choice of these values (in Rowland and Tessar (2004)) is arbitrary. Lewis (2000) suggests that the value for the relative risk aversion parameter could range from 1 to 10.

Though Rowland and Tessar (2004) concede that their choice of the values for these parameters is to make their result comparable to similar studies using the utility gain to measure diversification benefit, the arbitrariness in the choice of the values for the two parameters suggests that the result and hence the conclusion depend on these values. Thus different studies using this methodology but arbitrarily choosing different degree of risk aversion and intertemporal substitution parameters would arrive at different results even if they use the same dataset. This makes the utility gain approach problematic.

Furthermore, the test seems to be dependent on the measure of utility and thus the specification of the consumption function. Rowland and Tessar (2004) employ the Epstein-Zin specification of consumption function, which is the exact form of the consumption function. However, since there are different specifications of consumption functions, the result and hence the evidence to be derived from the test could be driven by the specification of consumption function. That is, different specifications may provide different results as to the benefits from diversification.

In order to avoid these limitations the change in lifetime utility is not used in this study. It was considered important to restrict the test of economic significance to only the change in the Sharpe ratio. The next section provides explanation for the use of Sharpe ratio as a test of economic significance of diversification benefits.

7.3 Sharpe Ratio as a Portfolio Performance Measure

Sharpe (1966) developed this ratio for evaluating the performance of mutual funds. Comparing two mean-variance portfolios based on the absolute values of their Sharpe ratios provides clues as to which portfolio is to be preferred to the other. For a single portfolio, the Sharpe ratio is calculated simply as the expected return of the portfolio in excess of the risk free rate divided by the portfolio's standard deviation.

Sharpe (1994) has formalised a generalised version of the ratio as an alternative for performance measurement in a multi-index world. Instead of the difference between the expected return on a portfolio and the riskless rate to the standard deviation, the generalised ratio uses the ratio of the difference between the average return on the portfolio and a benchmark portfolio to the standard deviation of the difference. If the benchmark portfolio is identified via time series analysis of a multi-index model, the ratio becomes Jensen alpha divided by standard deviation (Elton and Gruber (1997)).

However, for the purpose of this study, it was deemed convenient to conduct the computations following DeRoon and Nijman (2001), similar to the approach used in Errunza, Hogan and Hung (1999). This produces similar result as in Sharpe (1994) but most essential (for this study) the information required for computing the ratio in this format are already provided through the process of calculating the statistics for the various tests of mean-variance spanning employed in the preceding chapters.

From DeRoon and Nijman (2001), for a given expected return or standard deviation of a portfolio, the maximum attainable Sharpe ratio (by definition) is the Sharpe ratio of the minimum-variance efficient portfolio. Also for a minimum-variance efficient portfolio of assets with return R_{t+1}, given a risk free rate of R_f, or in the absence of it, a zero-beta rate, ŋ, the Sharpe ratio is equal to the slope of the line tangent to the efficient frontier and originating at $(0, R_f)$ or (0, ŋ) in the mean-variance space.

In the spirit of Jobson and Korkie (1989), the slope of this tangent line, which is the Sharpe ratio, can be estimated from the efficient set constants that define the shape of the efficient frontier for the portfolio. For this reason, the efficient set constants derived for the developed market portfolio and for the expanded asset set in Chapter 5 can be employed with slight modification, in terms of the risk-free rate, to calculate the Sharpe ratios for both the developed market assets and the expanded portfolio.

Referring to chapter 5, the efficient set constants for the developed market assets are: a_D, b_D, and c_D and for the expanded asset sets are: a_{DE}, b_{DE} and c_{DE}. With these efficient set constants and given a risk free rate, R_f, the maximum Sharpe ratio for the developed market assets becomes; $\theta_D(R_f) = (a_D - 2b_D R_f + c_D R_f^2)^{1/2}$. On the other hand, the maximum Sharpe ratio obtainable from the portfolio of both the developed and the emerging market asset is: $\theta_{DE}(R_f) = (a_{DE} - 2b_{DE} R_f + c_{DE} R_f^2)^{1/2}$.

7.4 Data and Application of Sharpe Ratio

Equipped with these formulae, the next task involves slotting in the relevant values for the efficient set constants to derive the maximum Sharpe ratios for the portfolios. In doing so a decision had to be taken on the risk-free rate of return to be used. In order to make this analysis comparable to other studies using reward-to-risk ratios for quantifying the performance of international portfolios the mean of the one-month UK London Interbank Offer Rate (LIBOR) is used as proxy for the risk-free rate[23].

The application of the Sharpe ratio (in this study) involves the following steps. First the Sharpe ratio is calculated for the developed market portfolio and again for the portfolio combining the developed market and the emerging markets. Secondly, the incremental Sharpe ratios are computed as the difference between the Sharpe ratio for the expanded portfolio and the Sharpe ratio for the developed market portfolio. This is then expressed as a percentage of the Sharpe ratio for the developed market portfolio.

The difficulty in using Sharpe ratio for this purpose is the lack of precedence in the literature that can be followed in determining how much change in the ratio is significant. This stems from the reason that it is difficulty to test whether changes in the Sharpe ratios for a set of portfolios are statistically significant as the sample distribution of Sharpe ratios are unknown. To mitigate this difficulty, BU (1996) employed Monte Carlo simulation analysis to investigate the small sample distribution of the Sharpe ratios in their study. This procedure is not attempted here.

With the Monte Carlo technique BU (1996) find that changes in the absolute Sharpe ratios of less than 0.057 are not (statistically) significant. In a different step, and also because the incremental Sharpe ratios (in this study) are expressed as percentage of the Sharpe ratio for the developed market assets, it is decided that an increase of at least 4.75% in the Sharpe ratio for a developed market portfolio attributable to a set of emerging markets constitutes economically significant shift in the portfolio frontier.

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[23] Errunza, Hogan and Hung (1999), Tessar and Rowland (1999) and Bekaert and Urias (1996) all used the LIBOR rate as proxy for the riskless asset.

The choice of 4.75% is meant to compare the percentage incremental Sharpe ratio to a value closer to the Bank of England interest rate of 4.75% (announced at the time of this analysis) and slightly below the LIBOR rate used in this study. Most importantly, in this study, absolute incremental Sharpe ratios closer to 0.057 are also below the 4.75% minimum target (in percentage terms). Therefore the yardstick chosen may be argued to provide a good approximation to that used by BU (1996). The next sections present the Sharpe ratios for all the portfolios examined in Chapters 5 and 6.

7.4.1 Economic Significance for Portfolios One, Two and Three

This section builds on the analyses of the three portfolios; One, Two and Three discussed in Chapters 5 by investigating whether the shifts in the frontiers in diagram 5.1, 5.2 and 5.3 for the developed market portfolios observed in that chapter represent significant improvement in the excess return per unit of risk of each portfolio. For each of the three portfolios all the tests of statistical significance have suggested immense diversification gains derive from the presence of the emerging markets.

In chapter 5, Portfolio Three containing 14 emerging markets was found to have stronger statistical evidence of diversification benefits than Portfolio Two with 12 emerging markets, the evidence for which was also found to be stronger than that for Portfolio One which contains the smallest number of (10) emerging market assets.

This analysis extends the results further by introducing a new variable, the LIBOR, in calculating the reward-to-risk ratios for the portfolios. This is meant to present a more practical measure of portfolio performance that substantiates the conclusions drawn from the statistical tests. That is, by examining the increase in the Sharpe ratio it is expected that more evidence would emerge which enable the assessment of whether the benefits noted using the statistical tests reflect gains which are realisable.

Table 7.1 provides both absolute and percentage increase in the Sharpe ratios of the three developed markets portfolios emanating from the emerging market assets.

Table 7.1 Incremental Sharpe Ratios for Portfolio One, Two and Three

Portfolios	Sharpe Ratio Developed Plus Emerging Markets	Sharpe Ratio Developed Markets	Absolute Change in Maximum Sharpe Ratios	Percentage Change in Maximum Sharpe Ratios
	a	b	c = a-b	d = [(a-b)/b]*100
Portfolio One	1.482	1.323	0.159	12.00%
Portfolio Two	1.630	1.286	0.344	26.71%
Portfolio Three	2.171	1.222	0.949	77.66%

For each portfolio, the second column (a) of the table shows the Sharpe ratio for the portfolio of both the developed and emerging market assets. The third column (b) indicates the Sharpe ratio derived from the developed market portfolio only while the fourth column (c) shows the absolute change in the Sharpe ratios. The last column (d) expresses the change in the Sharpe ratios (c) as a percentage of the Sharpe ratio for the developed market portfolios (b) which are then compared to the target of 4.75%.

As the results shows, there is clear evidence of significant incremental Sharpe ratios for all three portfolios. Comparing the results for all three portfolios, there seems to be a pattern that conforms to the evidence observed for these same portfolios under the tests of statistical significance (mean-variance spanning) in Chapters 5 and 6.

For Portfolio One, the inclusion of the emerging markets leads to a 12% increase in the Shape ratio which is higher than the 4.75% minimum target. The evidence is stronger for Portfolio Two as the rejection of mean-variance spanning in section 5.2 is associated with 26.71% increase in the Sharpe ratio. For Portfolio Three the evidence is much stronger. Rejection of the spanning hypothesis is associated with an increase in excess return per unit of risk that is 77.66% over that for the developed markets.

Relating this to the tests of statistical significance, a pattern appears to emerge. Portfolio Three with 14 emerging markets provides the highest percentage incremental Sharpe ratio (and the strongest statistical evidence for the shift in the developed market frontier). This is followed by Portfolio Two with 12 emerging markets, leaving Portfolio One with only 10 emerging markets to provide the lowest percentage incremental Sharpe ratio and relatively less strong statistical evidence.

Even though the null hypothesis of spanning is rejected for each portfolio, there are differences in the extent to which the excess return per unit of risk for the developed market portfolio improves following the addition of the different set of emerging markets. This signifies that statistical significance does not imply economic significance. It is for this reason that BU (1999) and Rowland and Tessar (2004) suggest extending further than the rejection of spanning to examine the economic importance of the test (emerging market) assets in the (developed market) portfolio.

More essentially, the evidence from the percentage incremental Sharpe ratios has buttressed both the graphical evidence and the statistical tests to suggest that the shifts in the frontiers in diagrams 5.1, 5.2 and 5.3 symbolise actual improvements in the risk- return characteristics of the developed market portfolios above the LIBOR.

7.4.2 Economic Significance: Emerging Market by Regions

Relating to the analysis in the preceding section, this section also provides another dimension to the discussion of emerging markets as regional assets (began in chapter 5). For each regional assets; South East Asia, Latin America, Eastern Europe and Southern Africa, the tests of statistical significance implemented in Chapters 5 and 6, reject the null hypothesis of mean-variance spanning, which implied substantial benefits from diversifying developed market portfolios to these emerging markets.

However, as demonstrated for the three emerging market time-based portfolios, the statistical evidence alone cannot be conclusive justification for including emerging markets assets in developed market portfolios. Table 7.2 presents the percentage increase in the reward-to-risk ratio for the developed market portfolio associated with the rejection of mean-variance spanning for each of the four regional assets.

Table 7.2 Incremental Sharpe Ratios for Emerging Market Regions

Portfolios	Sharpe Ratio Developed Plus Emerging Markets	Sharpe Ratio Developed Markets	Absolute Change in Maximum Sharpe Ratios	Percentage Change in Sharpe Ratios
	a	b	c = a-b	d = [(a-b)/b]*100
South-East Asia	1.484	1.425	0.072	5.45%
Latin America	1.450	1.282	0.166	13.00%
Eastern Europe	1.474	1.222	0.252	20.62%
Southern Africa	1.363	1.323	0.040	3.00%

From a simple glance at the percentage incremental Sharpe ratios in column (d) the importance of examining the economic significance of diversification benefits becomes evident. Though spanning is rejected for each set of emerging market regional asset, differences can be noticed in the extent to which each regional asset improves the excess return per unit of risk of the developed market portfolio.

Respectively, for the Latin American and Eastern European emerging markets the rejection of spanning is associated with13% and 20.62% percentage increase in the expected excess return per unit of risk over and above that obtainable from investing only in the developed market portfolio. Relative to the 4.75% minimum target, this is indicative of significant improvement in the reward-to-risk ratio of the developed market portfolio resulting from the Latin American and Eastern European markets.

On the contrary, the maximum Sharpe ratio for the developed market portfolio rises by only 5.45% with the inclusion of the Asian emerging markets and by 3.00% when the Southern African markets are added to the portfolio. In percentage terms these are not much different from the targeted of 4.75% and in absolute terms, slightly higher or lower than 0.057 suggested by BU (1996).Therefore, while the shift in the frontiers in diagrams 5.6 and 5.7 is statistically significant, it has less economic significance.

The implication of this apparently conflicting result is obvious as it stems from the emphasis of the tests of economic and statistical significance. It could be recalled from chapter 5 that the test of mean-variance spanning basically consists of two quantities. The first is the distance between the (standard deviations of the) global minimum-variance portfolios, and the second is the distance between the tangency portfolios of the benchmark assets and the expanded opportunity set.

Despite this, the primary determinant of the power of the spanning test is mostly the distance between the standard deviations of the global minimum-variance portfolios. In a sense, while the distance between the tangency portfolios is seen to be part of the test, it is relatively unimportant in determining the strength (or power) of the test.

This is expected because the test of mean-variance spanning is a joint test of $\alpha = 0_E$ and $1_E - \beta 1_D = 0_E$ and it weighs the estimates of α and $1_E - \beta 1_D$ according to their statistical accuracy (Kan and Zhou 2001). Because the calculation of $1_E - \beta 1_D$ does not involve the sample mean returns, μ, it can be estimated a lot more accurately (Jorion 1985). The spanning test inevitably places more weight on $1_E - \beta 1_D = 0_E$, (a measure of risk reduction) and little weight on $\alpha = 0_E$ (return improvement).

From the statistical point of view this practice is natural and may be justified, yet, as $\alpha = 0_E$ relates to the tangency portfolio, which is of economic importance, the spanning test could be seen to ignore the economic significance of departures from the null hypothesis. Because of that, it is possible for the small difference in the standard deviation at the global minimum-variance portfolios of 5.4% caused by the South East Asian and 3% by the Southern Africa emerging markets to be statistically significant while, as shown by the Sharpe ratio, they have little economic importance.

Thus, unlike the Latin American and the Eastern European markets, the reason that the South East Asian and Southern African markets significantly shift the developed market frontier may be argued to derive predominantly from the slight reduction in volatility. To this end, whether or not the diversification benefits offered by the South East Asian and Southern African emerging markets are seen to be substantial to justify their addition to the developed market portfolio may depend on whether UK investors would be content with the slight reduction in portfolio volatility they offer.

Li, Sankar and Wang (2003) quote from an article in the Wall Street Journal that "*the main reason to invest abroad isn't to replicate the global market or to boost returns". Instead, what we're trying to do by adding foreign stocks is to reduce volatility*" and **Elton and Gruber** (1995, chapter 12) also argue that:

"*since there is no evidence to support international CAPM, risk-averse investors with no ability to forecast expected return might seek to minimise the variance(standard deviation) of their portfolios*".

From these quotes it may be reasonable to suggest that the Asian and African markets are not necessarily redundant in the developed market portfolio. However, by noting the difference between the statistical and the economic significance the essence of using both (economic and statistical significance) together in evaluating the gains from international diversification, particularly to emerging equity markets, is clear.

7.4.3 Economic Significance: Sub-Period Analysis

This section constitutes the final phase of the empirical investigation by examining the economic significance of the shift in the efficient frontiers for the developed market portfolios in the two periods; from August 1991 to April 1997 and from May 1997 to February 2003 examined in Chapter 6. As noticed in Chapter 6, all five tests of statistical significance reject spanning for the developed market portfolio in the period from May 1997 to February 2003.

For the first sub-period; August 1991 to April 1997, the traditional and the GMM Wald tests reject spanning while the F-test, the likelihood ratio and the Lagrangian multiplier tests could not reject the hypothesis of spanning for the developed market portfolio. It is expected that the test results in Table 7.3 measuring the increase in the excess expected return per unit of risk generated by adding the emerging markets to the developed market portfolio will provide evidence that resolves the conflict.

Table 7.3 Incremental Sharpe Ratios for Sub-Period Portfolios

Portfolios	Sharpe Ratio Developed Plus Emerging Markets	Sharpe Ratio Developed Markets	Absolute Change in Maximum Sharpe Ratio	Percentage Change in Sharpe Ratios
	a	b	c = a-b	d = [(a-b)/b]*100
Sub-Period One	2.232	1.875	0.357	19.04%
Sub-Period Two	1.715	1.206	0.509	42.15%

The result in Table 7.3 substantiates the statistical evidence for the second sub-period. The rejection of spanning for the developed market portfolio in the period; May 1997 to February 2003 represents a percentage increase of 42.15% in the excess expected return per unit of risk achievable from investing only in the developed market assets. Relative to the target of 4.75%, there is evidence that the emerging market returns considerably improve the risk-return profile of the developed market portfolio.

Surprisingly, there is evidence of significant increase in the reward-to-risk ratio for the first sub-period. The rejection of spanning under the two Wald tests is associated with an increase of 19.04% in the Sharpe ratio for the developed market portfolio. Given the minimum target of 4.75%, this indicates a remarkable improvement in the portfolio's risk-return characteristics. Thus, notwithstanding the fact that three statistical tests accept spanning this result seems to demonstrate otherwise.

BU (1996) suggest that, ideally, the incremental Sharpe ratio for a portfolio that is statistically insignificant should be zero (because the risk return characteristics of the benchmark portfolio does not change from the addition of the test assets to that portfolio). For this reason Rowland and Tessar (2004) do not compute the Sharpe ratio at all for such portfolios as from their perspective the results may be irrelevant.

The advantage in this study is that, while these studies use only one statistical test, this study uses five tests with only three out of the five suggesting statistically insignificant diversification benefits. Thus based on the results from the two tests suggesting significant shift in the frontier for the benchmark portfolio, computation of economic significance is reasonable and this is confirmed by the result (19%) above.

The contradiction in the result may be explained by a number of reasons. First the focus of the two measures, as explained earlier. The reason that the Sharpe ratio has increased for a portfolio that three statistical tests suggest offers no diversification gains can be explained by the fact that this portfolio provides increase in expected return than reduction in volatility which is the key power of the statistical tests.

Moreover, it could be that because the Wald test statistic is always numerically bigger than the statistics for the likelihood and the Lagrangian multiplier tests, there is higher tendency for it to reject the null hypothesis than these tests ((Kan and Zhou 2001, Gibson, Ross and Shanken (1989)). On the other hand, it may be argued that there are benefits which the other three tests have failed to detect because they accept spanning too often than the Wald test. By implication the likelihood ratio, Lagrangian multiplier or F-test may inadvertently accept spanning even where there are gains.

A further interpretation may be given following BU (1996). They assert that while the incremental Sharpe ratios should be zero under the null hypothesis of spanning, mean-variance mathematics implies that this number (the incremental reward-to-risk ratio) would be (normally) upwardly biased. Using Monte Carlo simulation they find this upward bias to be severe. Although it is difficult to discern this, it may be argued that upward bias can be the reason for the increase in the Sharpe ratio for this portfolio.

Whatever explanation that is provided this analysis has demonstrated that without measuring the economic significance, additional (test) assets that contribute more to improvement in expected returns than to reduction in portfolio volatility may be accidentally rejected (or deemed redundant) on the basis of evidence from the three other tests. Therefore measurement of both statistical and economic significance of diversification benefits is important in order to draw meaningful conclusions.

7.5 Summary and Conclusions from Chapter Seven

The objective in this chapter has been to provide a yardstick against which the results from the preceding two chapters could be measured as a means of providing further evidence on the contribution of the emerging markets to the improvement in the risk-return characteristics of the developed market portfolio. The results have shown that a statistically significant shift in the efficient frontier of a portfolio does not necessarily imply, at the same time, an economically significant shift in the efficient frontier.

Li, Sankar and Wang (2003) argue that since portfolio performance depends on expected return and volatility, tests of diversification benefits should encompass both. By laying emphasis mainly on the reduction in portfolio risk, the test of mean-variance spanning appears lop-sided in this respect. In this sense, the test of economic significance that incorporates both risk and expected returns seem to bring into the analysis what investors may look for when diversifying portfolios internationally.

Applying only the tests of statistical significance, the Southern African and the East Asian emerging markets would have been deemed to offer substantial diversification gains to the UK investor. But as the incremental Sharpe ratio shows the resulting improvement in portfolio return per unit of risk is very minimal. Similarly, without the test of economic significance, the emerging markets as a standalone asset examined in the first sub-period would have been seen not to offer diversification benefits, while in actual fact the portfolios expected return improves substantially.

On these notes, the evidence from the Sharpe ratios have highlighted the flaws in over-reliance on only statistical significance in drawing conclusions on the effects of the emerging markets in the developed market portfolio. This is also pointed out by BU (1996) Errunza, Hogan and Hung (1999) and Tessar and Rowland (2002).

For this reason, studies using only statistical measures, for example Harvey (1995) and DNW (2001), may have found emerging markets to be beneficial because the analyses were based only on tests of statistical significance. Consideration of the economic significance of the portfolios examined could have provided additional evidence that could have made their conclusions perhaps much more convincing.

8.0 Summary, Conclusions and Recommendations

8.1 Summary of the Study

This study has employed five regression-based tests of mean-variance spanning to investigate whether a UK investor with developed market returns can significantly improve the investment opportunity set with diversification to emerging markets.

The analyses have been conducted on the premise that the investor has portfolios generated from the sterling returns of five developed markets; France, Germany, Netherlands, Switzerland and UK and is considering the gains from the addition of fourteen emerging markets; Argentina, Brazil, Chile, Czech Republic, Hungary, Indonesia, Malaysia, Mexico, Romania, South Korea, South Africa, Thailand, Turkey and Zimbabwe (as one asset or as four geographic regional assets) to the portfolio.

The case for international diversification of portfolio risk was first established by Grubel (1968) who employed Markowitz's (1952) mean-variance portfolio analysis to measure the improvement in the risk-return characteristics of portfolios resulting from the inclusion of returns on international assets. Later studies by Levy and Sarnat (1970) and others confirm the risk-reduction benefits of international diversification by concentrating primarily on diversification among developed financial markets.

Due to increased co-movements among international asset returns the benefits from diversifying portfolios across the developed markets have reduced. This, among other factors, have compelled investors to balance the allocation of investment funds in favour of investment in domestic assets with less in international portfolios, creating home-asset bias (French and Porteba 1991). The alternative for investors to improve portfolio performance has been the inclusion of returns on emerging market assets

The proponents of emerging market investment; Speidell and Sarpenfield (1992), Harvey (1995) and Bekaert and Urias (1999), argue on the basis of two reasons, which are also buttressed by the preliminary tests in Chapter 4 of this study. That is, emerging markets are highly volatile, but present higher expected returns. Moreover, returns on emerging market assets are lowly correlated with returns on developed market assets and with returns on other emerging markets, hence adding emerging markets to developed market portfolios should significantly reduce portfolio risk.

In response, several studies, as noted from Chapter 2, have examined the gains from diversifying developed market portfolios to emerging markets. The majority employ the test of mean-variance spanning developed by Huberman and Kandel (1987). In the mean-variance spanning framework, a set of test assets (emerging market returns) is deemed to offer diversification benefits when the inclusion of that asset sets (returns on emerging markets) in a benchmark portfolio (of developed market returns) results in a significant leftward shift in the (developed market) portfolio frontier.

With increased application, other tests of the spanning hypothesis have evolved. Kan and Zhou (2001) and DeRoon and Nijman (2001) have developed the Wald test of spanning while Kan and Zhou (2001) add the likelihood ratio and the Lagrangian multiplier tests of the spanning hypothesis. DeSantis (1993) and BU (1996) recasts the mean-variance spanning test in the SDF model of Hansen and Jagannathan (1991). Ferson, Foerster and Keim (1993) and Kan and Zhou (2001) present a GMM Wald test of spanning which is suitable for all forms of asset return distribution.

However, while all the tests of mean-variance spanning basically examine the equivalence of two efficient frontiers, the evidence produce from using more than one spanning tests simultaneously are not necessarily equivalent. This gives reasons to believe that using several spanning tests on the same returns data may provide more meaningful conclusion on the benefits of diversification than employing only one. On this basis, Chapter 5 of this study has employed four tests of spanning; the F-test, the Wald test, the likelihood ratio and the Lagrangian Multiplier tests, to examine the benefits from adding the emerging market returns to the developed market portfolios.

For this purpose, the emerging markets were added to the developed markets, first as three portfolios. Portfolio One consists of the first 10 emerging markets; Chile, Hungary, Indonesia, Malaysia, Mexico, South Korea, South Africa, Thailand, Turkey and Zimbabwe with data from August 1991 to February 2003. Portfolio Two adds 12 emerging markets by adding Argentina and the Czech Republic to the markets in

Portfolio One from January 1994 to February 2003. Portfolio Three combines the14 emerging markets in this study over the period from February 1997 to February 2003.

Secondly, in Chapter 5, the emerging markets are included in the developed market portfolio as four regional assets classified on the basis of geographical location into South East Asia, Latin America, Eastern Europe and Southern Africa. In each case the time period covered in the analysis is based on the returns series of the market (within the region) with the shortest length of return observations. Several useful lessons can be derived from these analyses (of emerging markets investment).

Chapter 5 shows that, irrespective of the version of the test of spanning employed, due to lower average correlation and higher expected returns, emerging markets returns are not spanned by returns on developed market assets. The inclusions of emerging markets, classified as one asset, in optimal portfolios of developed market returns provides substantial benefits to a UK investor in all the three time periods examined. This corroborates Harvey's (1995) conclusion for US investors.

However, while Harvey (1995) finds short sale constraints to have no impact on the benefits reported in his study, the benefits reported in this study seem to be sensitive to the imposition of limitations on short selling. It is seen that without short selling the gains from diversification to many of the emerging markets may be less, especially for markets such as Argentina, South Africa, Mexico and Thailand.

Moreover, it is inferred from Chapter 5 that when grouped as regional assets emerging markets still provide significant improvement in the risk and return of developed market portfolios. Particularly, Eastern European and Latin American markets are seen to demonstrate evidence of more benefits than Asian and Southern African emerging markets, granted that investors can sell short in each market.

However, when tested individually, each of the Eastern European markets are spanned by the returns on the developed markets, in spite of the fact that as a group Eastern European markets provide stronger evidence of diversification benefits than each of the three other emerging market regions. Among the Latin American markets Brazil seems to offer the greatest diversification benefit, while South Korea stands out among the Asian markets. Also Zimbabwe provides more benefit than South Africa.

In summary, Chapter 5 shows that the benefits provided by emerging market investment derive from the opportunities available in some individual markets which tend to overshadow the lack of opportunities in other emerging markets. When examined jointly the indication of diversification benefits is seen to depend on the magnitude of the benefits available in the profitable markets and the extent to which this may be neutralised by the poor performance of the other markets in the portfolio.

This observation is similar but contrasts the evidence in DNW (2001). They find that individual East Asian and Latin American markets offer benefits while less evidence of benefits is observed when the markets are examined jointly. On the contrary this study finds that when examined jointly the emerging markets are not spanned by the developed market returns but when examined individually there is less evidence of diversification benefits for a number of the emerging markets. In a sense, there are variations in the diversification opportunities offered by different emerging markets.

Chapter 6 extends the evidence in Chapter 5 in two dimensions by examining the consequences of departures from the assumptions of constant correlation and multivariate normality in the return distribution. This proceeds with examination of the benefits reported in Chapter 5 in two sub-periods; August 1991 to April 1997 and from May 1997 to February 2003 and again by introducing GMM version of the Wald test which does not require any assumption about the distribution of returns.

Three important evidences derive from Chapter 6. The GMM tests for all portfolios examined confirm that whichever way emerging markets are classified (regional or standalone assets) their inclusion in developed market portfolios leads to significant shift in the developed market frontier. From this analysis there are reasons to believe that the evidence of diversification benefits derived from Chapter 5 emanate from genuine shifts in the frontiers and not from sampling variations (error) (Harvey 1995).

Furthermore, Chapter 6 shows evidence of time-varying benefits from diversification.

In particular, stronger evidence of diversification benefits is noticed over the period from May 1997 to February 2003 than from August 1991 to April 1997. This is explained by the fact that the correlation between the emerging and the developed markets was higher from August 1991 to April 1997 than from May 1997 to February 2003. Besides, the correlations among the developed markets also appear to have fallen between May 1997 and February 2003 following a number of world events.

Most essentially, Chapter 6 reveals variation in the results from different tests of mean-variance spanning for the sub-period from August 1991 to April 1997. Using the traditional and the GMM Wald tests there is evidence of significant shift in the frontier for the developed market portfolio, while at the same time results derived from the F-test, the likelihood ratio test and the Lagrangian multiplier tests suggest the developed market frontier shifts only insignificantly (i.e. no diversification gains). This highlights the necessity to employ more than one statistical test at a time.

As Chapters 5 and 6 provide evidence of statistical significance, Chapter 7 follows BU (1996), Errunza, Hogan and Hung (1999) and Rowland and Tessar (2004) to examine the economic significance of the shifts in the frontiers in those two chapters, using percentage changes in Sharpe's (1966 and 1994) reward-to-risk ratio. This was meant to present more practical measurement of the improvement in the risk-return characteristics of the developed market portfolio resulting from the emerging markets.

The main finding from Chapter 7 is that statistically significant shift in a portfolio frontier does not necessarily denote economically significant shift. Using the tests of statistical significance the Southern African and South East Asian emerging markets are seen to present immense diversification benefits. But the evidence from Chapter 7 suggests the benefits are economically insignificant. Conversely, the emerging market combined portfolio in the first sub-period is seen to present weak evidence of statistically significant benefit yet the benefit is seen to be economically significant.

8.2 Summary of the Findings

From the discussions so far the findings of the study may be summarised as follows:

The benefits offered by emerging markets depend on whether the markets are considered individually or as a group. Some individual markets are the drivers of the much-vaunted diversification benefits that emerging markets as a standalone asset or as regional assets are deemed to offer. In this study, Zimbabwe, Brazil, South Korea, Malaysia, the Czech Republic and Chile seem to present more benefits than the other emerging markets investigated.

Moreover, whether there is indication of diversification benefit depends on the test procedure employed in the investigation. This study finds that the Wald test of mean-variance spanning appears more likely to reject the null hypothesis of spanning and provide indications of significant benefits from diversification to emerging markets than the likelihood ratio test, the Lagrangian multiplier test or the F-test of spanning.

In addition, evidence of diversification benefits appears to depend again on the time period of the investigation. In this study the evidence of diversification benefits are stronger in the period from May 1997 to February 2003 than from August 1991 to April 1997. This is explained by the fact that there was increased correlation among the developed markets which coincided with a fall in the correlation among the developed and the emerging markets in the period from May 1997 to February 2003.

Finally, for most emerging markets, the benefits depend significantly on whether or not short selling is permitted. In the presence of constraints on short selling the benefits provided by some individual emerging markets seem to be absent. Thus to realise the full diversification gains from emerging market investment short sale constraints need to be absent. This requires the relaxation of investment barriers.

8.3 Conclusions from the Study

From the findings in the preceding section a number of conclusions emerge:

First, because the benefits from emerging market investment derive from few markets, in the presence of short selling constraints, in practice, investors may have difficulties in realising the benefits in a number of emerging markets. This coupled with the increasing correlation among some emerging markets and the developed markets suggest investors have to be selective in their choice of emerging markets.

Secondly, while benefits of international diversification can be detected, it might be difficult for investors to select optimal investment strategies in advance because the correlation structure among international markets seems to be unstable over time. As a result it may be difficult to realise the benefit in practice because the evidence that there are gains seems to depend also on the time period of the investigation.

Most essentially, it would be important to implement more than one test of mean-variance spanning in examining the benefits from emerging market investment. Thus the circumstances in which studies such as Harvey (1995) report evidence of significant gains from emerging markets using the F-test, it is probable that other tests may have suggested insignificant gains that would have called for more investigation.

Finally, this study confirms that it is important to extend beyond the mere rejection of the mean-variance spanning hypothesis to investigate the economic significance of the portfolios at which spanning is rejected. Thus using Sharpe ratios to quantify the benefits has presented strong evidence surpassing that derived from implementing only the statistical tests of mean-variance spanning. This supports BU (1996) and Rowland and Tessar (2004) to highlight the essence of employing both measures.

8.4 Recommendations for Future Research

This study provides valuable new insights into emerging market investment, yet the issues discussed are not exhaustive. In future work this data will be used to explore a number of other issues relating to the benefits of international diversification and the test of mean-variance spanning which continue to be unresolved in the literature.

First, all the tests of spanning used in this study assume the absence of short sale constraints. DeRoon, Nijman and Werker (2001) attempted to account for the effect of short sale constraints and transaction costs in the Wald test of spanning. Similar attempts with the other versions of the mean-variance spanning test would be most valuable. Such a test would be helpful in determining whether an investor subject to reasonable constraints on portfolio allocation can benefit from emerging markets.

Secondly, the results in this study are based on ex post sample returns. However, in reality, investors are mostly interested in making ex ante portfolio selection decisions. Future research in this direction would be to examine the spanning hypothesis within a framework that takes into account investors' uncertainty about future returns. Such a study would be more valuable in investor portfolio choice than using past returns.

Furthermore, while there seems to be consensus that emerging markets differ in the diversification opportunities they offer such that some markets are more profitable than others, there is no framework for segregating ex ante which emerging market (s) would be the most profitable investment destinations. Future research that provides such a measurement criteria will be useful for international diversification decisions.

Moreover, further studies are required that examine the small sample (or the exact) distribution of the change in the Sharpe ratios. While a study in this direction would seem to be more of statistics than finance it would significantly enhance the quality of evidence derived from test of economic significance and enhance the assessment of the impact on the risk-return profile of portfolios caused by the addition of new assets.

Finally, this study and, to the best of my knowledge, the other studies employing the test of mean-variance spanning fail to incorporate hedging strategies in examining the gains from diversification. Future studies employing the spanning test that use hedged returns may be most useful. The diversification benefits observed in such a study, being free from the impact of currency fluctuation, are likely to be more realisable than the benefits documented in this and the existing studies using tests of spanning.

Appendices

Appendix A: Portfolio Holdings for Portfolios One, Two and Three

Country	Portfolio One		Portfolio Two		Portfolio Three	
	No Short Sale Constraint Imposed	With Short Sale Constraint Imposed	No Short Sale Constraint Imposed	With Short Sale Constraint Imposed	No Short Sale Constraint Imposed	With Short Sale Constraint Imposed
UK	87.96%	65.77%	112.10%	72.34%	112.20%	75.00%
Netherlands	25.81%	19.00%	18.87%	9.06%	14.05%	0.00%
Switzerland	-15.15%	0.00%	-30.15%	0.00%	-16.71%	0.00%
France	-22.27%	0.00%	-26.68%	0.00%	-23.77%	0.00%
Germany	20.86%	0.00%	23.20%	0.00%	10.72%	0.00%
South Korea	-5.22%	0.00%	-7.68%	0.00%	-8.26%	0.00%
Malaysia	6.52%	3.82%	2.40%	3.30%	-0.66%	2.70%
Indonesia	-0.90%	0.00%	0.77%	0.00%	2.44%	0.00%
Thailand	-5.82%	0.00%	-2.85%	0.00%	-0.87%	0.00%
Hungary	-5.36%	0.00%	-15.26%	0.00%	-19.45%	0.00%
Romania	----	----	----	----	1.11%	6.26%
Turkey	-0.55%	0.00%	15.39%	1.81%	-3.02%	0.00%
Czech Rep	----	----	-2.83%	0.00%	26.17%	8.74%
Argentina	----	----	5.34%	0.77%	7.00%	6.40%
Brazil	----	----	----	-----	-16.93%	0.00%
Chile	11.83%	3.56%	11.18%	5.77%	21.10%	2.37%
Mexico	-7.18%	0.00%	-5.36%	0.00%	-3.00%	0.00%
South Africa	2.02%	0.00%	-6.16%	0.00%	-11.04%	0.00%
Zimbabwe	7.66%	8.00%	7.81%	7.70%	8.88%	9.03%

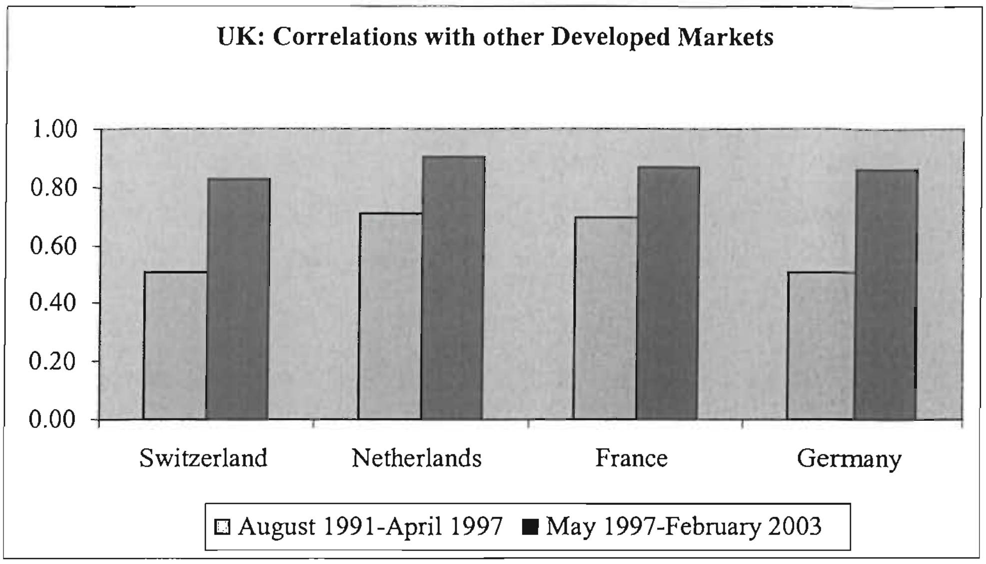
Appendix B: Portfolio Holdings for South East Asia and Latin America

Country	South East Asia		Country	Latin America	
	No Short Sale Constraint Imposed	With Short Sale Constraint Imposed		No Short Sale Constraint Imposed	With Short Sale Constraint Imposed
UK	93.83%	70.87%	UK	125.02%	87.35%
Netherlands	34.06%	22.13%	Netherlands	2.06%	1.59%
Switzerland	-22.36%	0.00%	Switzerland	-17.23%	0.00%
France	-23.55%	0.00%	France	18.71%	0.00%
Germany	19.63%	0.00%	Germany	4.96%	0.00%
South Korea	-5.75%	0.00%	Argentina	3.13%	0.00%
Malaysia	11.03%	7.00%	Brazil	-16.85%	0.00%
Indonesia	-1.46%	0.00%	Chile	25.72%	11.06%
Thailand	-5.44%	0.00%	Mexico	-8.10%	0.00%

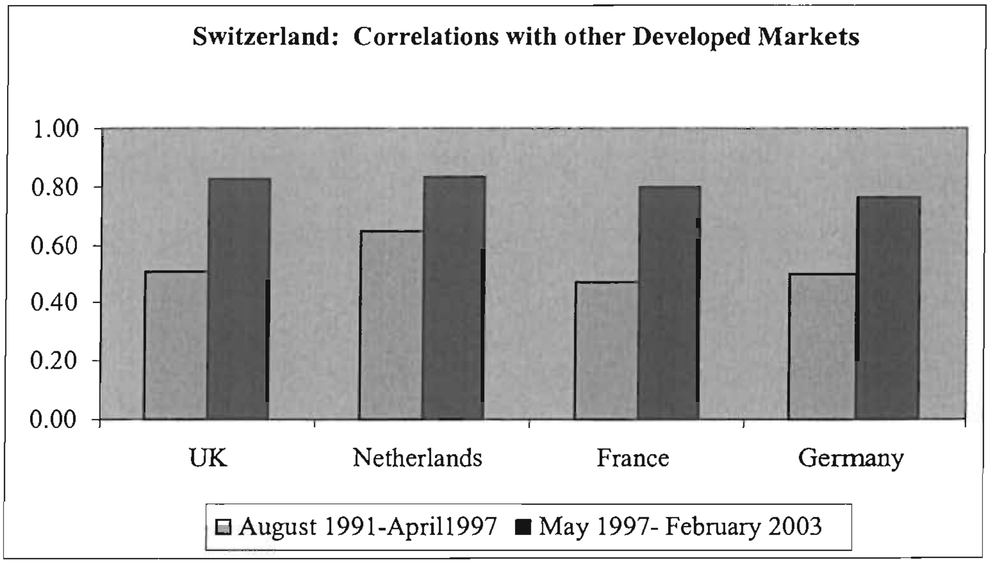
Appendix C: Portfolio Holdings for Eastern Europe and Latin America

Country	Eastern Europe		Country	Southern Africa	
	Without Short Sale Constraint Imposed	With Short Sale Constraint Imposed		Without Short Sale Constraint Imposed	With Short Sale Constraint Imposed
UK	127.23%	85.41%	UK	88.18%	69.50%
Netherlands	24.48%	0.00%	Netherlands	25.91%	18.43%
Switzerland	-34.78%	0.00%	Switzerland	-19.90%	0.00%
France	-30.14%	0.00%	France	-26.37%	0.00%
Germany	9.51%	0.00%	Germany	28.79%	3.33%
Hungary	-24.72%	0.00%	South Africa	-5.97%	0.00%
Romania	2.82%	2.64%	Zimbabwe	9.36%	8.75%
Turkey	3.29%	0.00%			
Czech Republic	28.90%	11.95%			

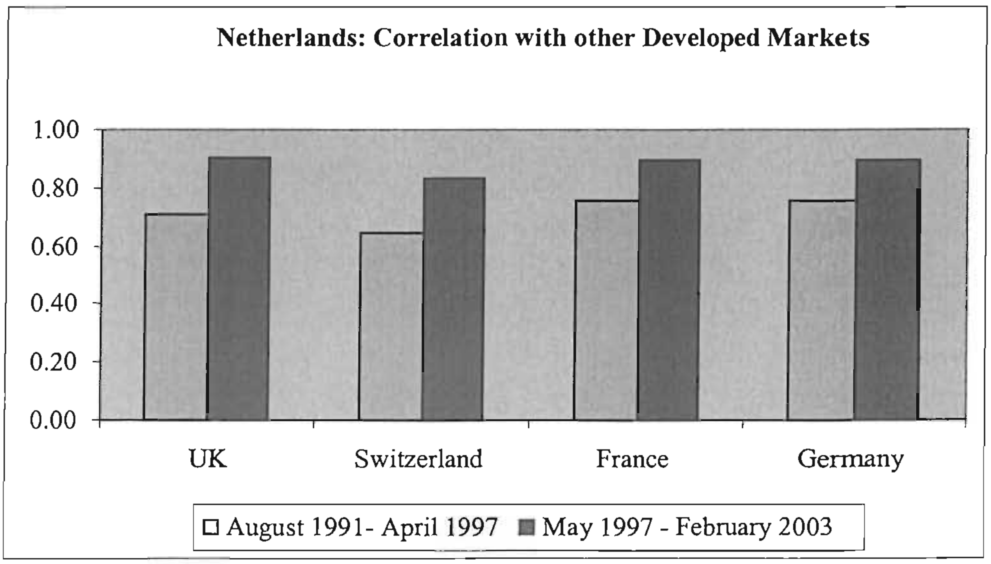
Appendix D



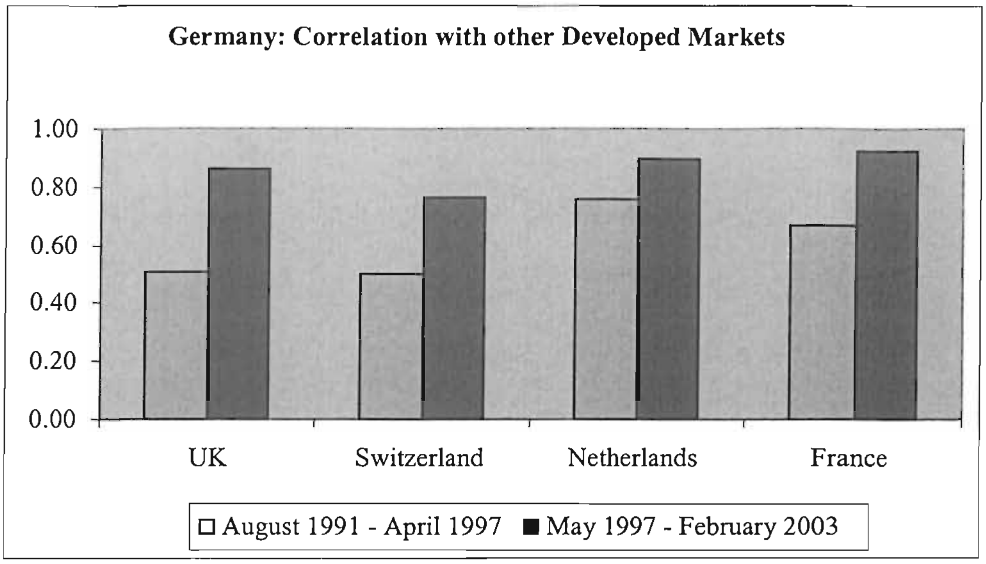
Appendix E



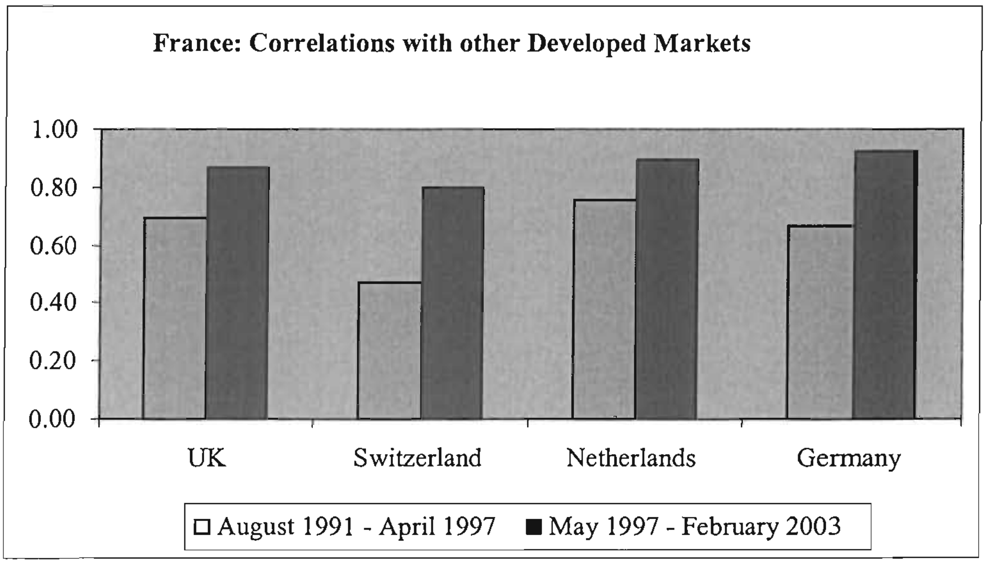
Appendix F



Appendix G



Appendix H



Appendix I: F-Test Statistic for Spanning

Step 1 Expanded Asset Set

Calculation of Variance-covariance matrix V_{DE}

D85:V103 $\Rightarrow$ {=MMULT (TRANSPOSE (Z4:AR76), Z4:AR76)}

$\Rightarrow$ Multiply the transpose matrix of the return deviations by itself and load the result in the square space D85:V103.

C108:V128 $\Rightarrow$ {= (D85:V103)/73}

$\Rightarrow$ Divide the matrix of sum of squared deviations by the number of observations in the square space C108:V128 to form the variance-covariance matrix.

Inverse of the Variance-Covariance Matrix V_{DE}^{-1}

C138:V158$\Rightarrow$ {=MINIVERSE (C108:V128)}

$\Rightarrow$Calculate the inverse matrix of the variance-covariance matrix in cells (C108:V128) in cells (C138:V158).

Step 2 Benchmark Assets

Calculation of Variance-covariance matrix V_D

Z85:AD89 $\Rightarrow$ {=MMULT (TRANSPOSE (Z4:AD76), Z4:A76)}

$\Rightarrow$ Multiply the transpose matrix of the return deviations by itself and load the result in the square space Z85:AD89.

Z96:AD100 $\Rightarrow$ {= (Z85:AD89)/73}

$\Rightarrow$Divide the matrix of sum of squared deviations by the number of observations in the square space Z96:AD89 to form the variance-covariance matrix.

Inverse of the Variance-Covariance Matrix V_D^{-1}

Z104:AD109$\Rightarrow$ {=MINIVERSE (Z96:AD100)}

$\Rightarrow$Calculate the inverse matrix of the variance-covariance matrix in cells (Z96:AD100) in cells (Z104:AD109).

Step 3: Calculation of Efficient Set Constants

This demands first setting up the column vector of the mean returns and a corresponding vector of ones for both the expanded asset set and the benchmark assets.

The Row Vector of mean returns calculated in Row79 in cells F79: X79 are now transposed into two Column Vectors, one for the expanded asset set in cells (AB170:AB189) and another for the benchmark assets in cells (AF104:AF109). At the same time column vectors of ones corresponding to the mean returns are set up in AD170:AD189 for the expanded asset set and in AH104:AH109 for the benchmark assets:

Appendix I (Continued)

AB170:AB189 ⇒ {=TRANPSOSE (F79: X79)} → AD170:AD189

⇒ Transpose Row Vector of mean returns in cells F79 toX79 to a Column Vector in cells AB170:AB189

AF104:AF109 ⇒ {=TRANSPOSE (F79:J79)} → AH104:AH109

⇒ Transpose Row Vector of mean returns in cells F79 toJ79 to a Column Vector in cells AF104:AF109

Efficient Set Constant (a)

Expanded Asset Set →→ $a_{DE} = \mu'_{DE} V_{DE}^{-1} \mu_{DE}$,

D218 ⇒ {=MMULT (MMULT (TRANSPOSE (AB170:AB189), C138:V158), AB170:AB189)}

⇒Pre- and post-multiply the vector of mean returns in cells (AB170:AB189) by the inverse matrix of the variance-covariance matrix, resulting in a single value in cell D218.

Benchmark Assets →→ $a_D = \mu'_D V_D^{-1} \mu_D$
I218 ⇒ {=MMULT (MMULT (TRANSPOSE (AF104:AF109), Z104:AD109), AF104:AF109)}

⇒Pre- and post-multiply the vector of mean returns in cells (Z104:AD109) by the inverse matrix of the variance-covariance matrix, resulting in a single value in cell I218.

Efficient Set Constant b
Expanded Asset Set →→ $b_{DE} = \mu'_{DE} V_{DE}^{-1} \iota_{DE}$

D220 ⇒ {=MMULT (MMULT (TRANSPOSE (AB170:AB189), C138:C158), AD170:AD189)}

⇒Pre-multiply the inverse of the variance-covariance matrix by the vector of mean returns in cells (AB170:AB189) and post-multiply multiply the same by their corresponding vector of ones (1s) in cells (AD170:AB189) resulting in a single value in cell D220.

Benchmark Asset $b_D = \mu'_D V_D^{-1} \iota_D$
I220 ⇒ {=MMULT (MMULT (TRANSPOSE (AF104:AD109), Z104:AD109), AH104:AH109)}

⇒Pre-multiply the inverse of the variance-covariance matrix by the vector of mean returns in cells (AF104:AF109) and post-multiply multiply the same by their corresponding vector of ones (1s) in cells (AH104:AH109) resulting in a single value in cell I220.

Efficient Set Constant c
Expanded Asset set→ $c_{DE} = \iota'_{DE} V_{DE}^{-1} \iota_{DE}$

Appendix I (Continued)

D222 $\Rightarrow$ {=MMULT (MMULT (TRANSPOSE (AD170:AD189), C138:V158), AD170:AD189)}

$\Rightarrow$ Pre- and post-multiply the variance-covariance matrix by the vector of ones(1s) in cells (AD170:AD189) resulting in a single value in cell D222.

Benchmark Assets $\rightarrow$ $c_D = \iota'_D V_D^{-1} \iota_D$
I222 $\Rightarrow$ {=MMULT (MMULT (TRANSPOSE (AH104:AH109), Z104:AD109), AH104:AH109)}

$\Rightarrow$ Pre- and post-multiply the variance-covariance matrix by the vector of ones(1s) in cells (AH104:AH109) resulting in a single value in cell I222.

Efficient Set Constant d
Expanded Asset set $d_{DE} = a_{DE} c_{DE} - b_{DE}^2$

D224 $\Rightarrow$ {= (D218*D222)-(D220^2)}

$\Rightarrow$ Deduct the square of efficient set constant (b) from the product of efficient set constant (a) and (c) and place the result in cell D224.

Benchmark Assets $d_D = a_D c_D - b_D^2$

I224 $\Rightarrow$ {= (I218*I222)-(I220^2)}

$\Rightarrow$ Deduct the square of efficient set constant (b) from the product of efficient set constant (a) and (c) and place the result in cell I224.

Summary of Efficient Constants

	Expanded Asset	Benchmark Asset
Efficient Set Constant a	$a_{DE} \rightarrow \rightarrow$ Cell D218	$a_D \rightarrow \rightarrow$ Cell I218
Efficient Set Constant b	$b_{DE} \rightarrow \rightarrow$ Cell D220	$b_D \rightarrow \rightarrow$ Cell I220
Efficient Set Constant c	$c_{DE} \rightarrow \rightarrow$ Cell D222	$c_D \rightarrow \rightarrow$ Cell I222
Efficient Set Constant d	$d_{DE} \rightarrow \rightarrow$ Cell D224	$d_D \rightarrow \rightarrow$ Cell I224

Step 4: (a) Closeness of the Tangency Portfolios

D228 $\Rightarrow$ Tangency Portfolio of Expanded Asset Set $\Rightarrow$ {1+(d/c)}$\rightarrow$ {1+(D224/D222)}

D230 $\Rightarrow$ {=SQRT (D230)} $\rightarrow\rightarrow$ $\sqrt{1 + \frac{d_{DE}}{c_{DE}}}$

Tangency Portfolio Benchmark Asset Set $\Rightarrow$ {1+ (d/c)} $\rightarrow$ {1+ (I224/I222)}

Appendix I (Continued)

I230 $\Rightarrow$ {=SQRT (I230)} $\rightarrow$ $\rightarrow$ $\sqrt{1+\frac{d_D}{c_D}}$

Closeness of the Tangency Portfolios of the Expanded Asset Set to the Benchmark Assets

F234 $\Rightarrow$ {= (D230/I230)} $\rightarrow\rightarrow$ $\left[\sqrt{1+\frac{d_{DE}}{c_{DE}}}\Big/\sqrt{1+\frac{d_D}{c_D}}\right]$

Step 4: (b) Closeness Global Minimum-Variance Portfolios (GMVP)

GMVP$\rightarrow\rightarrow\rightarrow$ Square Root of efficient set constant c

D233 $\Rightarrow$ {=SQRT (D222)} $\rightarrow\rightarrow$ GMVP of Expanded Asset Set$\rightarrow\rightarrow$ $\sqrt{c_{DE}}$

I233 $\Rightarrow$ {=SQRT (I222)} $\rightarrow\rightarrow$ GMVP of Benchmark Asset Set$\rightarrow\rightarrow$ $\sqrt{c_D}$

Closeness or Ratio of GMVP$\rightarrow\rightarrow$ Ratio of GMVPs

F236$\Rightarrow$Ratio of GMVP$\Rightarrow$ $\Rightarrow$D233/I233$\rightarrow$ $\frac{\sqrt{c_{DE}}}{\sqrt{c_D}}$

Step 5: Final Stage in the Calculation of F-Test Statistic

Multiplication of the Two Quantities

H240 $\Rightarrow$ {= (F236*F234)} $\rightarrow$ $\rightarrow\rightarrow\rightarrow\rightarrow$ $\frac{\sqrt{c_{DE}}}{\sqrt{c_D}} * \left[\sqrt{1+\frac{d_{DE}}{c_{DE}}}\Big/\sqrt{1+\frac{d_D}{c_D}}\right]$

H244 $\Rightarrow$ $\Rightarrow$ {((T-D-E)/E)*((F224*F236)-1)}

$$\rightarrow \left[\left(\frac{73-5-14}{14}\right)\right] * \left[\left(\frac{\sqrt{c_{DE}}}{\sqrt{c_D}}\right)\left(\sqrt{1+\frac{d_{DE}}{c_{DE}}}\Big/\sqrt{1+\frac{d_D}{c_D}}\right)-1\right]$$ =F-Test Statistic.

Appendix J: Likelihood Ratio Test of Spanning

Step 1: Copy and Paste Efficient Set Constants Derived Under the F-test

	Expanded Asset	Benchmark Asset
Efficient Set Constant a	$a_{DE} \rightarrow \rightarrow$ Cell D218	$a_D \rightarrow \rightarrow$ Cell I218
Efficient Set Constant b	$b_{DE} \rightarrow \rightarrow$ Cell D220	$b_D \rightarrow \rightarrow$ Cell I220
Efficient Set Constant c	$c_{DE} \rightarrow \rightarrow$ Cell D222	$c_D \rightarrow \rightarrow$ Cell I222
Efficient Set Constant d	$d_{DE} \rightarrow \rightarrow$ Cell D224	$d_D \rightarrow \rightarrow$ Cell I224

Step 2: Calculation of the Marginal Information Matrix (Matrix H)

$$\text{B415:C416} \Rightarrow \begin{bmatrix} a_{DE} - a_D & b_{DE} - b_D \\ b_{DE} - b_D & c_{DE} - c_D \end{bmatrix} = \begin{bmatrix} D218 - I218 & D220 - I220 \\ D220 - I220 & D222 - I222 \end{bmatrix}$$

Step 3: Setting up Matrix G

$$\text{H415:I416} \Rightarrow 2*2 \text{ matrix} \rightarrow \rightarrow \begin{bmatrix} 1 + a_D & b_D \\ b_D & c_D \end{bmatrix}$$

Inverse of Matrix G → → → → E415:F416 ⇒ {=MINVERSE (H415:I416)}

Step 4: Multiplication of Matrices H by the Inverse of G

$$\text{E420:F421} \Rightarrow \{\text{=MMULT (B415:C416), (E415:F416)}\} \rightarrow \begin{matrix} E420 & F420 \\ E421 & F421 \end{matrix}$$

Step 5: Calculation of Eigenvalues using the Quadratic Formula

$y^2 + xv - z$

D425 ⇒ -(E420+F421)

Appendix J (Continued)

F425 ⇒ (E420+F421)
F427 ⇒ (E421+F420)
D427 ⇒ (F425-F427)

D430 ⇒ {= ((-D425) +SQRT ((D425^2)-4*1*D427))/2*1} → $\frac{-x+\sqrt{(x^2)-4*y*z}}{2y}$

F430 ⇒ {= ((-D425) −SQRT((D425^2) −4*1*D427))/2*1} → $\frac{-x-\sqrt{(x^2)-4*y*z}}{2y}$

Step 6: Calculation of Maximum Likelihood Ratio Statistic for Spanning

D439 ⇒ {= 73*((LN (1+D430)) + (LN (1+F430)))} →→ $\{T((Ln(1+\lambda_1))+(Ln(1+\lambda_2))\}$

Appendix K: Wald Test Statistic

Step 1: Copy and Paste Efficient Set Constants Derived Under the F-test

	Expanded Asset	Benchmark Asset
Efficient Set Constant a	$a_{DE}\rightarrow\rightarrow$ Cell D218	$a_D\rightarrow\rightarrow$ Cell I218
Efficient Set Constant b	$b_{DE}\rightarrow\rightarrow$ Cell D220	$b_D\rightarrow\rightarrow$ Cell I220
Efficient Set Constant c	$c_{DE}\rightarrow\rightarrow$ Cell D222	$c_D\rightarrow\rightarrow$ Cell I222
Efficient Set Constant d	$d_{DE}\rightarrow\rightarrow$ Cell D224	$d_D\rightarrow\rightarrow$ Cell I224

Wald Test consists of two quantities: The closeness of the distance between the global minimum-variance portfolios and the distance between the maximum Sharpe Ratio obtainable from the combination of the benchmark and the expanded asset set.

Step 2: Closeness of the Global Minimum-Variance Portfolios

E260 $\Rightarrow$ {(D222-I222)/I222} $\rightarrow \dfrac{c_{DE}-c_D}{c_D}$

$\Rightarrow$ express the difference between the standard deviations of the GMVP of the expanded asset set and the standard deviation of the benchmark assets in terms (or as a ratio) of the standard deviation of the GMVP of the benchmark.

Step 3: Return on the Global Minimum-variance Portfolio of the Benchmark Asset

E264 $\Rightarrow$ {= (I220/I222)} $\rightarrow\rightarrow \dfrac{b_D}{c_D}=\eta_D$

Maximum Sharpe Ratio from the Benchmark Assets

E268 $\Rightarrow$ {=((I218)-(2*I220*E264)+(I222*E264^2))} $\rightarrow a_D - 2*b_D*\eta_D + c_D*\eta_D^2$

$\Rightarrow$ calculate the maximum Sharpe Ratio for the benchmark assets with the expected return on the global minimum-variance portfolio of the benchmark asset as risk-free rate.

E270 $\Rightarrow$ {=(1+E268)} $\rightarrow\rightarrow\rightarrow\rightarrow$ {=(1+($a_D - 2*b_D*\eta_D + c_D*\eta_D^2$))}

$\Rightarrow$ add one (1) to the maximum Sharpe Ratio in cell E268

Maximum Sharpe Ratio from the Expanded Asset Set

E272 $\Rightarrow$ {=((D218)-(2*D220*E264)+(D222*E264^2))} $\rightarrow a_{DE} - 2*b_{DE}*\eta_D + c_{DE}*\eta_D^2$

Appendix K (Continued)

⇒ calculate the maximum Sharpe Ratio for the expanded asset set with the expected return on the global minimum-variance portfolio of the benchmark asset as the risk-free rate.

Step 4: Closeness of the Maximum Sharpe Ratios

E276⇒

{=((E272-E268)/E270)}→ $\dfrac{(a_{DE} - 2 * b_{DE} * \eta_D + c_{DE} * \eta_D^2) - (a_D - 2 * b_D * \eta_D + c_D * \eta_D^2)}{1 + (a_D - 2 * b_D * \eta_D + c_D * \eta_D^2)}$

⇒ Express the difference between the Sharpe Ratios of the expanded asset set and the benchmark assets as a ratio of one (1) plus the Sharpe Ratio of the benchmark assets.

Step 5: Calculation of Wald Statistic for Mean-variance Spanning

E280⇒ {=(E260+E276)*73}

⇒ Calculate the Wald statistic for mean-variance spanning as the sum of the closeness of the standard deviations of the global minimum-variance portfolio of the benchmark and the expanded asset sets and the closeness of the maximum Sharpe Ratios attainable from the benchmark assets and from the expanded asset set.

Appendix L: Lagrangian Multiplier Test

Step 1: Copy and Paste the Efficient set Constants derived Under the F-test

	Expanded Asset	Benchmark Asset
Efficient Set Constant a	$a_{DE}\rightarrow$ → Cell D218	$a_{D}\rightarrow$ → Cell I218
Efficient Set Constant b	$b_{DE}\rightarrow$ → Cell D220	$b_{D}\rightarrow$ → Cell I220
Efficient Set Constant c	$c_{DE}\rightarrow$ → Cell D222	$c_{D}\rightarrow$ → Cell I222
Efficient Set Constant d	$d_{DE}\rightarrow$ → Cell D224	$d_{D}\rightarrow$ → Cell I224

The lagrangian multiplier statistic consists of two quantities: The closeness of the distance between the global minimum-variance portfolios and the distance between the maximum Sharpe Ratio obtainable from the combination of the benchmark and the expanded asset set.

Step 2: Closeness of the Global Minimum-Variance Portfolios

L260$\Rightarrow$=(D222-I222)/D222 → $\frac{c_{DE}-c_{D}}{c_{DE}}$

$\Rightarrow$ express the difference between the standard deviations of the GMVP of the expanded asset set and the standard deviation of the benchmark assets in terms (or as a ratio) of the standard deviation of the GMVP of the expanded asset set.

Step 3: Return on the Global Minimum-variance Portfolio (Benchmark Asset)

L264$\Rightarrow$ = (D220/D222) →→ $\frac{b_{DE}}{c_{DE}}=\eta_{DE}$

Maximum Sharpe Ratio from the Expanded Asset Set

L268$\Rightarrow$ {=((D218)-(2*D220*L264)+(D222*L264^2))}→ $a_{DE}-2*b_{DE}*\eta_{DE}+c_{DE}*\eta_{DE}^{2}$

$\Rightarrow$ calculate the maximum Sharpe Ratio for the benchmark assets with the expected return on the global minimum-variance portfolio of the expanded asset set as risk-free rate.

L270$\Rightarrow$ =(1+L268) →→→→ =1+($a_{DE}-2*b_{DE}*\eta_{DE}+c_{DE}*\eta_{DE}^{2}$)

$\Rightarrow$ add one (1) to the maximum Sharpe Ratio in cell L268

Maximum Sharpe Ratio from the benchmark assets

L272$\Rightarrow$ =((I218)-(2*I220*L264)+(I222*L264^2)) → $a_{D}-2*b_{D}*\eta_{DE}+c_{D}*\eta_{DE}^{2}$

Appendix L (Continued)

⇒ calculate the maximum Sharpe Ratio for the benchmark assets with the expected return on the global minimum-variance portfolio of the expanded asset set as the risk-free rate.

Step 4 : Closeness of the Maximum Sharpe Ratios

L276⇒
=((L272-L268)/L270)

$$\rightarrow \frac{(a_{DE} - 2 * b_{DE} * \eta_{DE} + c_{DE} * \eta_{DE}^2) - (a_D - 2 * b_D * \eta_{DE} + c_D * \eta_{DE}^2)}{1 + (a_{DE} - 2 * b_{DE} * \eta_{DE} + c_{DE} * \eta_{DE}^2)}$$

⇒ express the difference between the Sharpe Ratios of the expanded asset set and the benchmark assets as a ratio of one (1) plus the Sharpe Ratio of the expanded asset set.

Step 5: Calculation of Lagrangian Multiplier Statistic for Mean-variance Spanning

L280⇒=(L260+L276)*73

⇒ calculate the lagrangian multiplier test statistic for mean-variance spanning as the sum of the closeness of the standard deviations of the global minimum-variance portfolio of the benchmark and the expanded asset sets and the closeness of the maximum Sharpe Ratios attainable from the benchmark assets and from the expanded asset set multiplied the number of observations.

Appendix M: Generalised Methods of Moment Wald Test

Step 1: Computation of AB-C → → → (Θ)

B409:O410 $\Rightarrow$

{=(B402:O403)-(B377:O398)}→ A= $\begin{bmatrix} 1 & 0'_D \\ 0 & -1'_D \end{bmatrix}_{2x6}$ *B= $\begin{bmatrix} \alpha'_E \\ b'_{uk_E} \\ b'_{sw_E} \\ b'_{ns_E} \\ b'_{fr_E} \\ b'_{ge_E} \end{bmatrix}_{6x14}$ $-$ C= $\begin{bmatrix} 0'_E \\ -1'_E \end{bmatrix}_{2x14}$

Step 2: Formation of the Vector Operator of Matrix (AB-C) → → Vec(Θ)

AE605:AE618 $\Rightarrow$ {=TRANSPOSE (B409:O409)}

$\Rightarrow$ Transpose the first row vector (B409:O409) of matrix B409:O410 to the column space AE605:AE618 to form a column vector

AE619:AE632 $\Rightarrow$ {=TRANSPOSE (B410:O410)}

$\Rightarrow$ Transpose the second row vector (B410:O410) of matrix B409:O410 to the column space AE619:AE632 to form next

Step 3: Covariance Matrix of Regression Residuals

This results from running regressions with the emerging markets as dependent and the developed markets as independent variables. With all 14 emerging markets for 73 months this is a 14x14 square matrix.

$\Rightarrow$ copy the covariance matrix of regression residuals from S394:AF409 to J449:AF409.

Step 5: Kronecker Product of regression residuals and average of squared returns

R468:AS495 $\Rightarrow \frac{1}{T}\left[(1, R'_D)(1, R'_D)\right]' \otimes \varepsilon\varepsilon \Rightarrow \Rightarrow \Rightarrow S_T$

Step 3: Calculation of A_T

B480:C481 $\Rightarrow$ {=MMULT (B476:G477, B467:G472)} → $A\left[\frac{1}{T}\left[(1, R'_D)(1, R'_D)\right]\right]^{-1}$ → A_T

Appendix M (continued)

$\Rightarrow$ Multiply the 2*6 matrix A by the 6*6 matrix of squared returns. Using the Partition matrix formula this ends up with a 2*2 matrix A_T

E480:F481 $\Rightarrow$ {= (TRANSPOSE (B480:C481)}

$\Rightarrow$ Transpose the values in matrix A_T

Step 4: Identity Matrix for Returns on Test Assets

B486:O499 $\Rightarrow I_E$

B504:AC531 $\Rightarrow A_T \otimes I_E$

$\Rightarrow$ Kronecker product of A_T and the Identity matrix of the test assets

B538:AC565 $\Rightarrow A_T' \otimes I_E$

$\Rightarrow$ Kronecker product of the transposed matrix of A_T and the identity matrix of the test asset

Step 5: Asymptotic Variance of Vec(Θ)

B570:AC597 $\Rightarrow$ {=MMULT (MMULT (B504:AC531, R468: AS495), B538:AC564)}

$\rightarrow [(A_T \otimes I_E)S_T(A_T \otimes I_E)]$

$\Rightarrow$ Pre-multiply the matrix S_T by $A_T \otimes I_E$ and post-multiply by $A_T' \otimes I_E$

B605:AC632 $\Rightarrow$ {=MINVERSE (B570:AC597)} $\rightarrow [(A_T \otimes I_E)S_T(A_T' \otimes I_E)]^{-1}$

Step 6: Calculation of the GMM Wald Test of Spanning

G637 $\Rightarrow$ {=MMULT (MMULT (TRANSPOSE (AE605:AE632), B605:AC632), AE605:AE632)}

$\rightarrow$ Vec(Θ) $[(A_T \otimes I_E)S_T(A_T' \otimes I_E)]^{-1}$ Vec(Θ)

$\Rightarrow$ Pre- and post-multiply the vector operator of matrix Vec(Θ) by its asymptotic variance

G639 $\Rightarrow$ 73*G637$\rightarrow\rightarrow$ T [vec (Θ) $[(A_T \otimes I_E)S_T(A_T' \otimes I_E)]^{-1}$ vec(Θ)]

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