International diversification an Australian perspective: international diversification of Australian equity portfolios into emerging equity markets

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Abstract

Aims of the thesis: The objective of this research is to quantify the returns to an Australian investor from investment in emerging markets and identify the factors that may influence the variation in benefits that accrue to investors diversifying their portfolios in this manner.

Scope: The scope of this study is to look at the benefits of investing internationally for Australian investors. The Australian equity market has lower market capitalisation compared with that of many other developed countries and Australian investors can reduce their overall portfolio risk by diversifying into equities from other markets. By investing in the international assets Australian investors expand their investment horizon. Further, by selecting assets that have lower correlations with domestic market assets, investors can increase the expected returns of the portfolio without significantly increasing the risk of the portfolio; and emerging equity markets are one such asset class that provides assets that have lower correlations with Australian assets. The benefits of investing into other markets come from lower correlations with these markets. This study also looks at the changes in correlations over time and tests if the changes in correlations are caused by the changes in the volatilities.

Conclusion and contributions: The objective of a portfolio manager is to achieve optimal risk-return combination for his/her portfolio. Emerging markets, because of their different economic structures as compared with the Australian market provide an opportunity for Australian fund managers to include these assets as part

of their portfolio. However, the recent crisis in the Asian markets, higher volatility of the emerging markets and changing correlations in equity returns of these markets provide unique challenges for Australian investors.

This study makes important theoretical and empirical contributions to existing knowledge. The findings of the study also have significant practical implications for fund managers seeking to exploit the opportunities available through international diversification into emerging markets.

This study finds that the correlations of equity returns of emerging markets with Australia change over time and in general have been increasing. Correlations are influenced by the volatility of the emerging markets in most cases and in some cases by relative volatility of the two markets. However, there are still benefits for Australian investors in diversifying into emerging markets and these benefits are expected to continue in the future. This study uses a theoretically superior and computationally efficient model; Asymmetric Dynamic Conditional Correlation Generalised Autoregressive Conditional Heteroskedasticity Model (Asymmetric DCC GARCH model) to estimate these correlations accurately. Accurate assessment of these correlations will assist the manager in better investment decisions and the resulting portfolio will represent the expected benefits of diversifying into these markets more accurately. The study also identifies the specific emerging markets that have lower correlations thus providing better potential benefits, and further finds that the volatility of the emerging markets has an association with the correlations. The results of the study are robust, as numbers of possible portfolios on the efficient frontier were tested. The validity of the

results was tested with sensitivity to different risk free rates and different restrictions on proportion of emerging market investment.

Limitations: Availability and reliability of data in the emerging market is of concern. This is taken care of in the study by using the stock indexes as the index data is more reliable than individual stocks. Another limitation of the study is the assumption of no transactions cost. To overcome this problem study uses approximate transactions cost based on past studies and results do not change substantially. Study finds that benefits of diversifying into emerging markets for Australian investors are significant even after including transactions costs.

International Diversification of Australian Equity Portfolios into Emerging Equity Markets

Rakesh Gupta

This thesis is presented for the degree of Doctor of Philosophy

To my children Naman and Kriti, they have always provided genuine encouragement and appreciation for their fathers work.

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Finally I thank my parents, who have always believed in my abilities and encouraged me to pursue what I believed in.

Chapter 1

Introduction

Practitioners and academics have long recommended diversification into foreign markets. The benefits from international diversification have been known to the investment community since the 18th century and the development of mutual funds in Holland was based on the benefits of diversification by holding equal proportions of international assets[1]. Grubel (1968) found that U.S. investors could benefit by investing part of their portfolio into foreign assets. Levi and Sarnat (1970) find diversification benefits in both developed and developing countries, and Grubel and Fadner (1971) find industry correlations within countries to be higher than industry correlations across countries, suggesting benefits in diversifying internationally. These earlier studies were followed by extensive literature arguing the benefits of international diversification outlined in literature review chapter.

The objective of this research is to quantify the benefits to an Australian fund manager arising from the inclusion of emerging equity market assets in their portfolio. This topic is of theoretical, empirical and practical interest for the following reasons.

From a theoretical perspective, increasing correlations between international equity market returns would suggest that the benefits from international market diversification will decline over time. Chapter 3 includes a discussion of the theory of diversification as widely used by researchers and academics. Many factors are associated with changes in correlations including globalisation, liberalisation,

[1] Goetzmann, Li and Rouwenhorst (2005) cite from the book by Henry Lowenfeld, "Investment: an Exact Science" published by Financial Review of Reviews in 1909. Financial Review of Reviews also published a monthly magazine on diversification that promoted diversification strategies.

discriminatory taxation, and capital flow restrictions, and market regulations, liquidity of the stock markets, market size, pricing and activity. These factors are reviewed in Chapter 4 of the thesis. Moreover, these factors are known to vary over time. The diversity of factors means that a consideration of the effects on correlations and diversification benefits of these myriad factors is beyond the scope of this research. The aggregate effects of these influences are modelled in this research using the latest econometric models of time-varying correlations.

The benefits of diversification also depend on the level of the correlation between the equity markets. The emerging equity markets[2] are of interest here because empirical research indicates the inclusion of these asset classes provides for lower correlations compared to an all-developed market portfolio. Qualitative characteristics of emerging markets are discussed in Chapter 4. Relative size of the emerging markets and its impact on smaller emerging markets can be of concern for research and portfolio investors, who seek to exploit benefits of including emerging markets in their portfolios. Emerging equity markets are small as compared with the larger developed markets. However, relative to Australian equity market, emerging markets are of a comparable size and Australian investments into these markets are not expected to significantly influence the

[2] The term 'emerging market' arises from the description of emerging economies applied by the World Bank to low and middle income economies. If a country's GNP per capita did not achieve the World Bank's threshold for a high-income country (in 1997 this was $ 9,656), the stock market in that country was said to be 'emerging' however, because of certain limitations of this definition, discussed in detail in the literature review section, in general Standard and Poors (S&P) classifies a stock market as 'emerging' if it meets at least one of two general criteria: (i) it is located in a low- or middle-income economy as defined by the World Bank, and/or (ii) its investable market capitalisation is low relative to its most recent GDP figures. This research uses the emerging markets universe detailed by Bekaert and Harvey (2000) this includes Argentina, Brazil, Chile, Colombia, Greece, India, Jordan, Korea, Malaysia, Mexico, Nigeria, Pakistan, the Philippines, Portugal, South Africa, Sri Lanka, Thailand, Turkey, Venezuela and Zimbabwe as emerging economies.

nature of these markets, the relative market capitalization of these markets has been included in Chapter 6, Table 6.2. [3]Further, integrity of these markets may be of concern for the practitioners and academics, recent working paper by Aitken and Siow (2003) on study of a sample of these markets find these markets to show a high level of integrity and efficiency.

The extent of the diversification benefits also depends on the opportunities for expanding the investment universe. Investors restricted to Australian asset classes forego an international equity investment market corresponding to approximately 98% of the world's equity assets. Thus the portfolio weights and the international diversification benefits are expected to differ for Australian investors compared to investors from the larger developed economies.

The accuracy of the estimates of diversification benefits in an ex-post analysis depends heavily on the correlation estimates. A key factor in the calculation of correlations is the volatility of the equity market returns. The emerging markets are unique in that these markets are noticeable, in recent time, for their volatility. The Asian crisis of 1996 engendered global effects of considerable duration and severity. The causes and effects of the Asian crisis are discussed in Chapter 4 with an example of a key emerging market.

Assessment of the benefits to an Australian investor from emerging equity market diversification is completed using a Markowitz model to determine optimal

[3] Size and liquidity of emerging market has been of concern for investors and this may cause higher transactions costs for Australian investors. This has been included in the analysis and is also one of the limitations for the study. Australian managed funds industry is comparatively large as compared with that of the developed markets, a discussion highlighting this has been included in Chapter 2.

portfolio weights. Theoretical underpinnings for benefits from diversification are discussed in Chapter 3. This section also outlines the asset pricing models and the linkages between theoretical value of asset and diversification. However, determining fair value of assets using CAPM and/or APT models is beyond the scope of the study. Within the asset pricing framework this study recognises that some benefits of diversification may come from Jensen's alpha. Decomposition of these returns with a view to alpha is beyond the scope of this study. In this study a domestic-only portfolio is compared to a series of portfolios incorporating emerging market investments determined by the assumptions of constant and time-varying correlations. A consideration of the results appears in Chapter 6. It is important to note that the aim of this ex-post analysis is not to demonstrate that the time-varying correlation portfolio provided superior risk-adjusted returns compared to the constant correlation portfolio. In a theoretical and empirical analysis the correlations are shown to be time-varying, the comparisons serve to highlight the bias in the estimates of risk-adjusted returns and portfolio weights from the use of a constant correlation model. Volatility spikes are observed in the emerging market equity returns leading to possible biases in the correlation estimates. My research attempts to adjust the correlation estimates for extreme movements in volatility and to assess the significance of time-varying volatility[4] on time-varying correlations. The results of these analyses appear in Chapter 6.

[4] The Penguin International Dictionary of Finance defines volatility as; the extent to which security prices fluctuate, usually measured by hourly percentage changes in a share index or by standard deviation, alpha coefficient or a coefficient of variation. This study measures the volatility of the assets (stock indexes) by its daily variance, see data description, Chapter 6.

These analyses are carried out on the sample of emerging markets that are comparatively large, well developed and are easily accessible to foreign investors.

The determination of the optimum portfolio for an Australian investor also has significant practical relevance. Portfolio managers are observed to exhibit 'home bias' in their asset allocations. The opportunity may exist for these investors to improve the fund performance by including more international equities including emerging market investments. The significance of emerging market investment for Australian portfolio managers is outlined in Chapter 2 through a review of the flows of investment funds from Australia to selected emerging markets.

1.1 Background

There is a correlation between output growth and stock returns within countries (Morck, Shleifer and Vishny 1990). The presence of this link in a variety of countries at different stages of economic and financial development suggests that an understanding of stock market differences and therefore of the potential of international diversification may be gained by understanding this link. The links between the financial and the real sectors, based on early arguments by Schumpeter (1982)[5], have been formally developed and expanded in the contributions of Goldsmith (1969), McKinnon (1973) and Shaw (1973). McKinnon (1973) shows that more effective economic growth will proceed from liberalisation of financial markets and from removal of controls on foreign trade. Shaw (1973) argues that the financial sector of an economy plays an essential role

[5] *The Theory of Economic Development* was first published in 1911 in German and subsequently translated in English in the 1930s and a revised edition published in 1982.

in economic development. If the financial sector is repressed and distorted, this can destroy the impetus to development.

Current financial crises in the emerging markets have been preceded by an expansion of domestic banking sector and large capital inflows. Kaminsky and Reinhart (1999) and Glick and Hutchison (1999) consider the empirical relationship between the banking and currency crises and find that a banking crisis is not just a result of failing of exchange rate regimes. The authors find a source of financial crisis in the interface between the government macroeconomic policies and microeconomics of private financial intermediation[6]. However, Bekaert, Harvey and Lundblad (2002) and Kaminsky and Schmukler (2002) do not find evidence of significant increase in volatility after liberalisation. Krugman (1998a) finds the "moral hazard"[7] to be the main contributory factor in the East Asian financial crisis. In a review of liberalisation literature in the emerging market economies, Das (2004) argues that the equity market cycles become smoother after liberalisation and finds no evidence of intensified volatility caused by financial liberalisation.

The objective of investing outside the national boundaries for an Australian investor is to gain the underlying benefits of diversifying internationally. Investors

[6] According to *first-generation* models (Krugman 1979), crises arise as a result of loose macroeconomic policies (for instance, as a result of excessive public sector deficits, which are monetised and are resorting to international reserves), and which thus become inconsistent with the exchange rate system. *Second-generation* models (Obstfeld 1994 and 1996) analyse the possibility of self-fulfilling crises, due to herding behavior by foreign investors expecting currency realignments, or to contagion effects, and mainly independent from the position of fundamentals.

[7] "Moral hazard" is the nature of individuals, or a group of individuals or organisations to indulge in behaviour that is riskier than they otherwise would, because of an implicit assumption that someone else will bear part or all of the consequences if the actual risk is worse than expected.

are mindful of the reality that international assets have different characteristics as compared with the domestic assets. And by diversifying across different countries or between different industries across countries, investors can improve the performance of their portfolios. As discussed in chapter 3, investing in international markets differs from investing in the domestic market.

> Firstly, the co-variances among assets within a domestic market are much higher than the co-variances among different markets. Second, barriers imposed by taxation, currency controls and/or investor tradition may segment national markets sufficiently enough, that the assets are priced in domestic rather than an international milieu. Third, exchange rates between different currencies deviate from each other, giving rise to currency exposure on international portfolios. (Gupta 2006, page 23)

A review of research into international diversification indicates that despite increasing globalisation, benefits accrue to investors by diversifying internationally. Since developed markets are considered integrated and the correlations between the assets of the developed markets are higher (closer to 0.5 or higher), the benefits of diversifying into developed markets for an investor from developed markets will be much lower. The benefits of diversification will be more pronounced when investing into emerging markets because of the lower correlations between the asset returns of Australian assets with emerging markets and of emerging markets with each other. This section draws from review of research on international diversification of Australian portfolios (Gupta 2006). These benefits arise in part from differences between countries in the nature of

their real economies. In addition, the greatest differences in real economy structures can be observed when comparing emerging markets with developed markets. Thus, theoretically emerging market investments should provide a means by which an investor can achieve higher risk-adjusted returns for a diversified portfolio (Gupta 2006). Recent empirical findings support that the benefits of international diversification are not fully exploited because of the parochial view of investors; Karlsson and Norden (2007) find home country bias in the internationally diversified portfolios. Hatemi-J and Roca (2006) also find potential benefits for an investor diversifying his/her portfolio internationally. More recently Chiou (2008) find that there are still significant benefits in diversifying into international markets. The benefits decline with constraints on the minimum weights for the domestic market and maximum weights for foreign markets but these benefits are not completely eliminated despite restrictions of the lower and upper weighting bounds[8].

With capital markets becoming more integrated, the scope for exploiting any "inefficiencies" may be diminishing rapidly, as the financial analysts identify the excess returns and then arbitrage them away (Fraser, Helliar and Power 1992). However, there may be theoretical justification for potential gains from international diversification as investors gain access to shares in industries which are not represented or are thinly represented in their domestic market. This

[8] In a domestic context Goetzmann and Kumar (2008) find in a study of 40,000 investment accounts held by the US investors, that most investors hold under-diversified portfolios. Authors also find that the investors are aware of the diversification benefits but adopt a strategy of naïve diversification. This finding is not of direct consequence for this study but is relevant with regards to demonstrating the existence of potential unrealised diversification benefits in domestic markets as well.

expansion in the menu of shares available to the potential investor leads to an advantage through an expansion of the feasible set and a change in the shape of the mean variance efficient frontier even if the capital markets are fully integrated.

Research on international diversification from the perspective of the Australian investor is limited. Allen and Macdonald (1995) studied the diversification benefits available to the Australian investor over the period 1970 to 1992 and find that for most pair-wise portfolios; there exist potential long-run portfolio diversification gains. Similar results are reported by Watson and Dickinson (1981), Mitchell, Wapnah and Izan (1988), and Izan, Jalleh and Ong (1991). Australian investors may differ in the size of the diversification benefits received from diversifying internationally, as compared to investors from other major equity markets, because of the nature of Australia's economic and financial markets, such as small market size and low liquidity of the Australian stock exchange[9]. The Australian share market is small compared to the major overseas markets. Country size per se may matter in two ways (Bernstein and Weinstein 1998). First, economic activity in a small country may be geographically localised, so the nearby geographical activity, e.g. monsoons or other local "acts of God", might have local market-wide effects that would not be as evident in a larger economy. Second, economic specialisation is predicted by standard international trade theory across geographical units of similar size, but not across countries. This is consistent with larger countries having less uniform factor endowments, which

[9] Rosenberg, Reid and Lanstein (1985) and Fama and French (1998) find a significant proportion of asset returns can be explained by firm size (in our study country indices are used as investable assets) and Amihid and Mendelson (1986) and Amihud (2002) find significant relationship between liquidity and asset returns.

implies that the stocks of firms in large economies should respond less to emerging market factors.

1.2 Research questions

The diversification benefits from investing in emerging markets may be different for Australian investors as compared with investors in other larger developed markets. This difference in benefits may arise because of the similarities and/or dissimilarities between the macroeconomic factors underpinning these markets.

The early literature on diversification was based on the assumption that correlations are constant over time. However, intuitively one would think that with the integration of world markets, correlations should increase (see 'Emerging Markets and Market Integration, section 4.6.2 on page 64, Chapter 4 for a discussion on world market integration). Several studies have considered the time varying nature of correlation of equity returns and found that correlations tend to change over phases of business and economic cycles (Erb, Harvey and Viskanta 1994 and Longin and Solnik 1995).

This study attempts to ascertain, for an Australian investor, whether there are still any gains to be made by diversifying a portfolio internationally[10] with a possible inclusion of emerging equity markets in the portfolio. And to test volatility and relative volatility of the market returns, as factors that are expected to cause changes in correlation of stock returns among different markets over time. This

[10] Market integration has bearing on the correlations and thus resulting diversification benefits. However, testing of market integration forms a separate area of research and this study does not aim to address that issue.

study will use a theoretically sound and computationally efficient model to achieve these objectives. The specific research questions this study intends to answer are:

1. Are there quantifiable significant potential gains to be made for an Australian investor by diversifying a portfolio into emerging markets?

2. Test if volatilities of the market returns and/or relative volatility of market returns are expected to change correlations over time between equity returns across different markets?

Identification of the factors that are expected to cause these changes in correlations among stock returns over time is important and can help improve decision making for a portfolio manager. Current literature on the time varying correlations among the equity markets does not address the issue of factors that may cause the changes in correlations. However, in a recent paper, Jithendranathan (2005) uses a Dynamic Conditional Correlation model to identify the economic factors that may significantly influence the correlations between US and Russian equity returns. Bekaert and Wu (2000) also use a GARCH model to explain the asymmetric volatility and the risk in the equity markets. Kroner and Ng (1998) and Engle (2002)[11] compare the performance of simple multivariate GARCH models and the Dynamic Conditional Correlation GARCH (DCC) models and find that the DCC model is often the most accurate in estimating the correlations.

[11] The models discussed here are variants of the standard GARCH model which is the best known model for estimating correlations in autoregressive data.

As understanding the reasons of changes in correlations over time may help portfolio managers in development of their investment strategies, portfolio managers attempt to identify the factors which may drive these changes in correlations over time. Jithendranathan (2005) find that the macroeconomic factors can influence the correlations in equity returns for USA and Russian equity markets, and Lorentan and English (2000) test the relationship between volatility and correlations for equities, bonds and foreign exchange. They find that a significant proportion of the changes in correlations over time is explained by the differences in sample volatilities[12]. Forbes and Rigobon (2002) consider the volatility and evidence for contagion[13]. In this study we focus on the volatility because from a theoretical standpoint volatility is a measure of total risk of the expected returns of the asset. Further, the data for macroeconomic factors is available with a long time lag that makes the results obsolete. Good quality high frequency data for volatility is readily available and this timely availability of data makes the results meaningful as compared to macroeconomic factors. The problem of data availability is further exacerbated when we look at information for the emerging markets. This study also includes the period of crisis, thus covering full economic cycle, and takes care of the bias in the results, which could arise if that period were excluded.

[12] When looking at Australia and emerging markets, it is not possible to identify common factors for all pairs of countries that can influence the correlations between Australia and the emerging market pairs because each emerging market has unique characteristics. As such this study uses volatility as an aggregate factor that is also a measure of total risk.

[13] Contagion refers to the transmission of shocks across markets that are over and above that is expected through fundamental linkages (Dungey, Martin and Fry 2006)

Following Eun and Resnick (1988, 1992), Jorion (1985, 1986, 1992) and Liljeblom, Loflund and Krokfors (1997), this research attempts to quantify the returns to an Australian investor from investment in the emerging markets. To decompose the diversification benefits that accrue over time due to the differences in the underlying risk factors, this study uses a modified version of the DCC model proposed by Cappielo, Engle and Sheppard (2006). This model is an adaptation of the DCC model by Engle (2002) with an asymmetric term.

This study contributes to existing literature by using a computationally efficient model for estimation of time varying correlations and testing for underlying factors that may cause the correlations to change over time. These time varying correlations are used in an asset allocation model for an Australian investor to construct a diversified portfolio, including emerging markets, to test the benefits of international diversification. Time varying correlations are calculated for all markets in the sample and a sample period is selected that includes full economic cycle. Results indicate correlations of Australian equity returns with emerging market equity returns in general are increasing, and emerging market volatility has some effect on correlations, albeit weak. The robustness of the analysis of the benefits of international diversification to Australian investors has been assessed by calculating the correlations using different methods. The study finds noticeable benefits of international diversification into emerging markets for Australian investors using alternative methods of estimating correlations. This research also enables a comparison of the emerging market weights for Australian investors compared to those for US investors.

The thesis is organised as follows. Chapter 2 (findings of this chapter were published in Gupta 2007, pp. 167-174) outlines the Australian financial system and flow of funds from Australia to emerging markets and Chapter 3 outlines the theoretical rationale for diversification. Chapter 4 provides a review of academic research into the benefits of international diversification with a particular emphasis on the role of emerging markets in enhancing the benefits of international diversification for Australian investors. Literature review has been published into two papers; Gupta (2006) and Gupta and Basu (2007). Chapter 5 covers the research methodology and briefly reviews the methodologies adopted in current research. And Chapter 6 investigates the changes in correlations over time and includes a comparison of the portfolios constructed using emerging market assets with Australia only portfolio to test the benefits of investing into emerging markets for Australian investors. Initial findings from this chapter were published in conference proceedings; Gupta, Hobbes and Loudon (2007) and Gupta (2008) and subsequently in Gupta and Mollik (2008) and Gupta and Donleavy (2008) as journal articles. Chapter 7 draws conclusions of the thesis highlighting the contribution of the study and lists limitations of this study.

Chapter 2

Australian Financial System

and

Capital flows to emerging markets from Australia

2.1 Introduction

Over the past three decades equity markets over the world have experienced exceptional growth and expansion. Total market capitalisation of the world equity markets increased from a modest US$ 1 trillion in 1974 to in excess of US$ 16 trillion by the end of 1997 (Li 2002). Net private capital inflows into Asia during the mid 1990's were exceptional in terms of the total dollar amounts and also in terms of the size of these economies (Grenville 1998). During 1998, when these countries ran into financial crisis, this inflow of US$ 100 billion reversed into an outflow of US$ 55 billion. There have been numerous studies after the crisis analysing its causes and suggesting possible measures to prevent future crisis[14]. The understanding of the flow of funds from Australia into emerging markets has significant practical relevance for the fund managers who seek to diversify their portfolios internationally[15]. The inclusion of this section in the thesis from the practical standpoint of understanding of market dynamics and the test of direct implications of these flows is beyond the scope of this study. For a similar reason data used in this section is not updated for a more recent date as it does not influence the results of the study.

The Asian crisis was different from other crises in the world. In the affected countries macroeconomic management was sound with low inflation, sound fiscal balance and high economic growth (Gupta and Basu, 2007). With the passage of

[14] Refer Gupta and Basu (2007) for a review of the Asian crisis. Relevance of Asian crisis for this section is in the flow of funds that was significantly influenced immediately after the crisis but these flows have started to improve in the recent past.
[15] This section draws from the book Chapter by Gupta (2007) published in Engagement & Change.

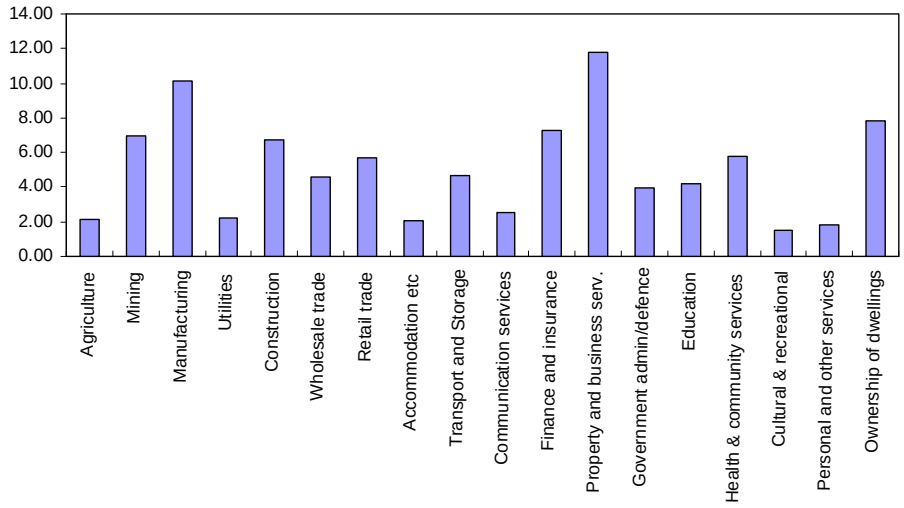
time we now have a clearer picture of the crisis and what happened to capital flows in East Asia during the crisis period. This chapter briefly describes the Australian financial sector and summarises the available data, drawing primarily from the Australian Bureau of Statistics (ABS) and Axis Australia. It focuses on size and volatility of capital flows to emerging markets from Australia, especially into Asia, and in particular equity flows. The chapter concludes with the evidence that the equity flows from Australia to Asian countries are growing and that future prospects for equity flows to these countries are positive.

2.2 The Australian Financial System

Changes in the international capital markets and deregulation in the 1980s in Australia opened up new possibilities for raising capital, investing and hedging risk. Australia has a highly developed financial sector. Australia's economic growth in the recent past has been led by the commodity boom and there is a general perception that Australia is a commodity based economy and that the financial sector does not form a major part of the Australian economy. However, the share of the financial sector in the Australian economy was 7.28% of Australian gross domestic product (GDP) for the year ending 30 June 2007 (Figure 2.1).

Figure 2.1

The Australian financial system, share of each sector



Source: Australian Bureau of Statistics, 2007

The Australian financial market consists of banks, investment bankers, the insurance industry, capital markets, the foreign exchange market, the equities market, the debt securities market and the derivatives market. The following section briefly discusses the salient features of the Australian financial system.

2.2.1 Banks The banking sector the world over has developed at a rapid rate during the recent past. Similar growth has been registered in the banking sector in most countries, including the ones that did not have the economic boom experienced in Australia. An improved credit quality and lower default rates have been some of the underlying reasons for the strengthening of the banking sector around the world (Laker 2004). In Australia impaired assets are at the lowest level of their cycle, capital adequacy percentage is 7% and stress tests by APRA confirm

that Australian banks can withstand a significant correction in the housing market (ibid). The Australian banking sector is dominated by banks with $ 1,369 billion in assets held, followed by finance companies, $ 87 billion; money market companies, $ 80 billion; credit unions, $ 33 billion, and building societies, $ 16 billion (Table 2.1)[16].

Table 2.1

Australian banking sector

Type of institution	No. of institutions	Total assets A $b
Banks	51	1,369
Building societies	14	16
Credit unions	164	33
Money market	26	80
Finance companies	84	87
Total	339	1,585

Source: Reserve Bank of Australia, 2007

2.2.2 Investment Management Compulsory superannuation contributions were introduced in Australia in 1992 and since then they have grown rapidly. Currently

[16] During 2007 Banks in most developed countries were hit by a crisis caused by sub prime home loans, Australian banks were largely unharmed by this crisis. Australian financial system avoided major harm primarily because of its strengths in regulatory arrangements, quick response by the Reserve Bank of Australia in supporting short term liquidity and economic strengths of the Australian economy. These reasons were outlined by John Edwards in his speech at the Flinders University, Adelaide on 16th May 2008.

Australian super funds hold $ 780 billion and the total of managed funds in Australia has grown to $ 1,334 billion (Table 2.2).

Table 2.2

Managed funds in Australia

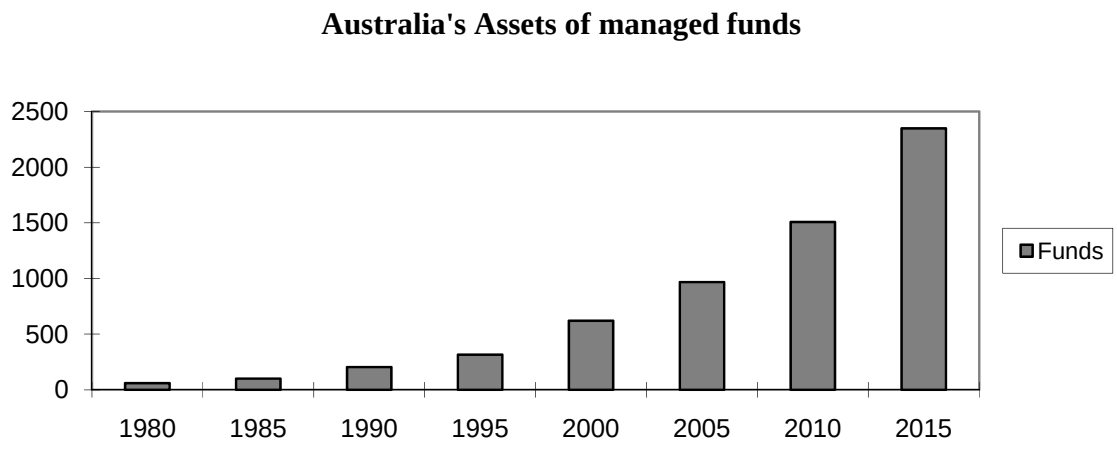
Assets	Amount June 2007 A $b
Superannuation funds	780
Public unit trusts	266
Life insurance	224
All other managed funds	62
Total	1,334

Source: Australian Bureau of Statistics; Managed Funds Australia June 2007

Compulsory superannuation schemes and the government's emphasis on self funded retirement have fuelled the growth in managed funds in Australia. Figure 2.2 shows the growth in managed funds in Australia from a modest total of $ 60 billion in 1980 to $ 1,334 billion at the end of June 2007. The RBA forecasts that by 2015 managed funds will grow to $ 2,350 billion.

Figure 2.2

The Australian managed funds



Source: Reserve Bank of Australia, 2007

2.2.3 Insurance Australia has a well-developed insurance industry, comprising 37 life insurance companies and 133 general insurance companies that manage 188 and 97 billion dollars of assets respectively as of 30 June 2007 (RBA 2007). The Australian insurance industry is one of the major employers in the Australian economy. General insurance alone employs approximately 60,000 people (Insurance Council of Australia 2006).

2.2.4 Financial Markets Deregulation in Australia began in the early 1980's. This timely deregulation helped to develop its financial markets into an important financial centre in the Asia-Pacific region. Australia has been successful in developing a high quality financial market which has liquidity in debt, equities, and foreign exchange and derivative markets. A well functioning regulatory

management, demand from the region and a local supply of well trained workers has helped in development of the market (Axis Australia, 2005).

2.2.5 Foreign Exchange Australia also has a well developed foreign exchange market that is open and accessible to its participants without restrictions. Daily turnover in foreign currencies in the Australian market averaged around US $ 81 billion during April 2004 (RBA 2005). In a survey by the Bank of International Settlements, the Australian foreign exchange market ranks 7th largest in the world and its share of global trading in foreign exchange increased from 2.7% in 1992 to 3.4% in 2004[17].

2.2.6 Debt Securities The Australian debt market forms a small proportion of the global debt market. At the end of December 2001, Australia had US $ 171 billion of domestic securities on issue compared with the global aggregate of US $ 30,489 billion (RBA 2005).

2.2.7 Derivatives: The Sydney futures (SFE) and Australian stock exchanges (ASX) provide markets for trading in derivatives (these markets merged in July 2006). These markets provide a range of products for risk management for market participants. Average daily turnover in the derivatives markets in Australia reached US $ 18 billion during 2004 (RBA 2005). The Australian derivative market offers products in interest and credit derivatives, derivatives in commodities, equities and indexes. An active over-the-counter derivative market trades in swaps, repos and

[17] Triennial Central Bank survey (2005).

contracts-for-difference (CFDs). Contract-for-difference is expected to be listed for trading at SFE[18] towards the end of 2007.

2.2.8 Equities The Australian Stock Exchange (ASX) currently has the largest free float capitalisation in the Asia-Pacific region; it stood at AUS $ 1,162 billion at the end of 2004[19]. In a global context Australia has a weighting of 1.5% in the MSCI world index.

The Reserve Bank of Australia Bulletin (2002) documents the inflow and outflow of capital between 1952 and 2002. The comparisons show that up to about 1980, the current account deficit was around 2% of GDP and there was a similar inflow of capital. After 1980, the current account deficit jumped to approximately 4% and the capital inflow to a similar level. During the same periods, the report documents that there was a negligible outflow of capital due to the capital controls. These controls were specifically designed to restrict these flows. Since the removal of the controls in 1983, the outflow of capital from Australia has averaged around 3% of GDP and the capital inflow has increased to 7%.

The Reserve Bank Report shows that as a percentage of the GDP the outflow of portfolio capital from Australia on average has stayed constant over the preceeding ten years (approximately 2%). An important point which the Reserve Bank Report highlights is the increase in investment by the superannuation funds into overseas

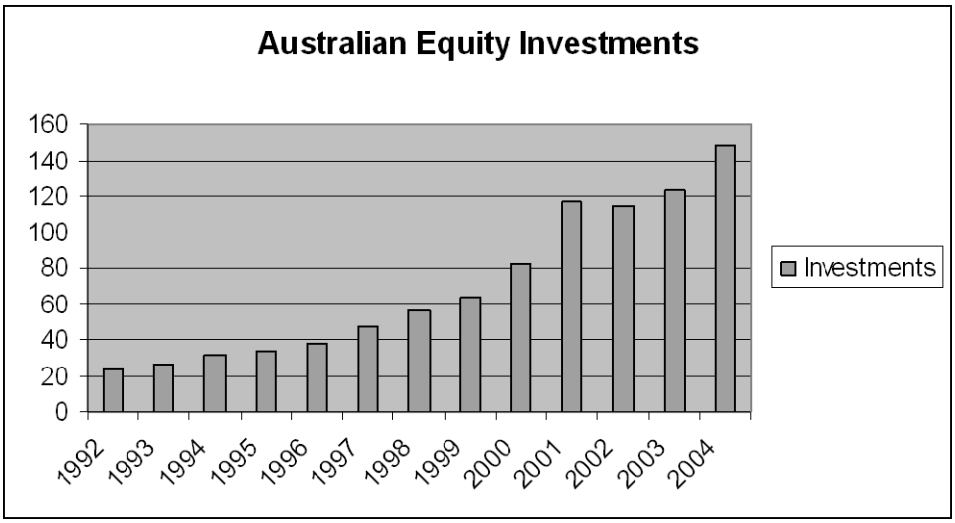
[18] SFE and ASX have merged since July 2006, but the two names still exist and there are still two separate websites.
[19] Australian financial markets report 2006.

equities (currently 25% of the total of superannuation funds are invested in overseas equities).

The level of Australian investment reached $ 649.7 billion as at 31 December 2004, an increase of $ 110.2 billion on the previous year, i.e. an increase of 16.96%. Equity has always been the main form of Australian investment abroad. As at 31 December 2004, total equity investment abroad was $ 403.6 billion, out of which portfolio investment was $ 147.7 billion, and the balance was in foreign direct investment (Australian Bureau of Statistics, 2005). The following chart shows the growth of Australian investments abroad during the period.

Figure 2.3

Australian equity investments, 1992-2004.



Source: Australian Bureau of Statistics; International Investment Position (2005).

The flow of equity from Australia into overseas markets has grown consistently over the period 993 to 2004 (except during the year 2002). Table 3 shows the break up of these equity investments into different emerging markets. Despite the missing data for some of the emerging market countries, sufficient data is available to infer that emerging markets are an important destination for equity investments for Australian investors.

Around the time of the Asian crisis of the mid 1990's Asian emerging markets were out of favour and international investors were withdrawing from the emerging markets in general; more importantly for this study, they were withdrawing from Asian markets. Data shows that around 2000 this trend was reversed and equity investments again started to flow into emerging markets.

Table 2.3

Equity investments into emerging markets, 1999-2004 (millions in AUD)

Year	Chile	Greece	India	Malaysia	Philippines	Thailand	EM Total
1999	6	55	n.a.	139	n.a.	n.a.	200
2000	2	n.a.	n.a.	152	n.a.	81	235
2001	6	39	n.a.	109	13	41	208
2002	7	n.a.	n.a.	65	36	45	153
2003	5	n.a.	539	100	19	139	802
2004	5	n.a.	787	173	26	188	1179

Source: Australian Bureau of Statistics; International Investment Position 2005; all figures in million Australian dollars. [20]

When dealing with emerging market data, there is a problem of missing values and incomplete data. This incomplete data set is sufficient, however to show that equity investments to emerging market economies have increased and more countries are being added to the data set, which suggests that emerging markets are in favour. Table 4 shows the proportion of Australian equity investments into emerging markets as a percentage of total investments abroad. Australian equity investments

[20] EM market total is the total of the data available from the ABS. Actual figures may vary as figures for some of the emerging markets are not available from the ABS.

into emerging markets were at their highest around the time of the Asian financial crisis. The Asian crisis may have caused the withdrawal of these investments and from 2000 the flow of investment into emerging markets started to rise, with a slight fall in the year 2002.

Table 2.4

Australian equity investments outflow into emerging markets 1992-2004

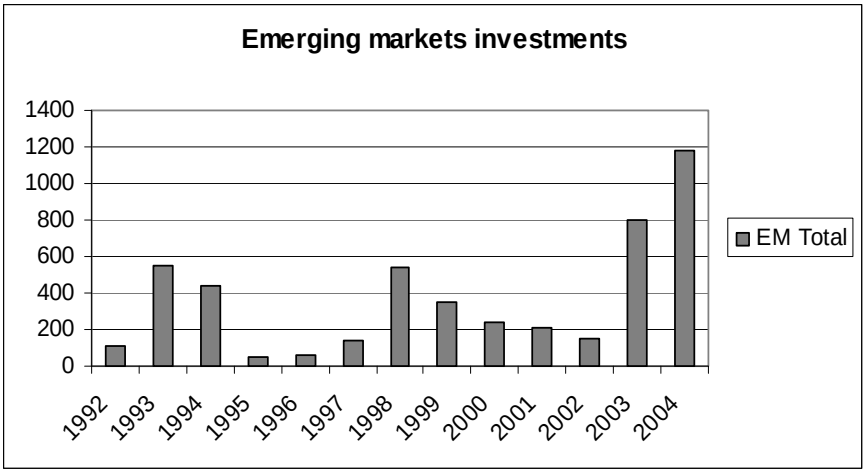
Year	EM Total	% of Total	Year	EM Total	% of Total
1992	115	0.48	**1999**	354	0.56
1993	547	2.09	**2000**	240	0.29
1994	440	1.40	**2001**	214	0.18
1995	47	0.14	**2002**	153	0.13
1996	58	0.15	**2003**	802	0.65
1997	144	0.30	**2004**	1179	0.80
1998	545	0.97			

Source: Australian Bureau of Statistics; International Investment Position 2005; all figures in million Australian dollars. (EM figures are Australian investments into emerging markets (millions in Australian dollars) and % shows the emerging markets investments as a percentage of total equity portfolio investments from Australia during the period).

Figure 2.4 shows Australian equity investments into emerging markets and Australian investments into emerging markets as a percentage of total equity portfolio outflows from Australia during the period 1992 to 2004.

Figure 2.4

Australian equity investments into emerging markets, 1992-2004

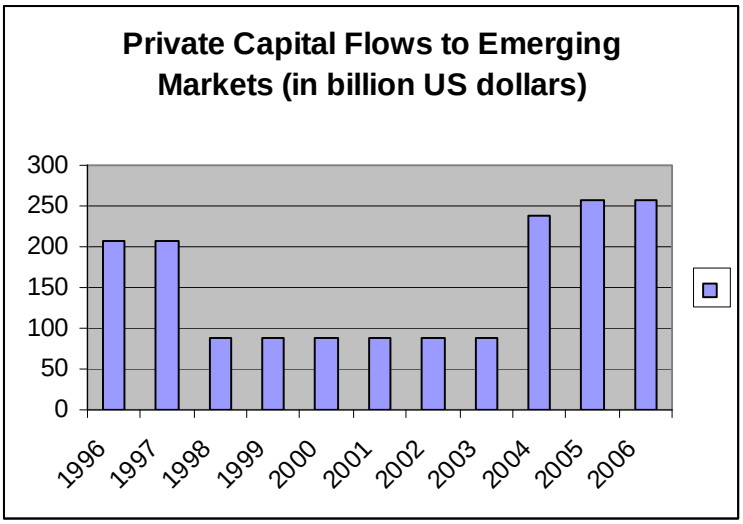


Source: Australian Bureau of Statistics, 2005.

The following figure shows equity portfolio investments into emerging markets from the rest of the world. Investments into emerging markets from the rest of the world have been consistently rising since 2002, with a small decline in 2006 estimated figures. The rise of Australian investments into emerging markets is consistent with the global trend.

Figure 2.5

Equity flow into emerging markets from the rest of the world, 1996-2006



Source: IMF, World Economic Outlook published in BIS 77th Annual Report.

2.3 Conclusion

This review indicates that emerging markets have been and are becoming more important for equity portfolio investments for the rest of the world. As the fall-out from the Asian crisis settles, the flow of portfolio investments is returning to the emerging markets. In Australia, since the removal of exchange controls and other financial deregulation, the flow of equity capital to the emerging markets has been consistently rising, except for the period surrounding the Asian crisis, which caused a reversal in the flow of equity investments to the emerging markets. Further, despite the reservations expressed by some researchers and practitioners, the flow of equity to the emerging markets is in Australia's interest. The growth in equity investments into emerging markets and improved sentiment towards

investments into emerging markets may be reflected in portfolio strategies pursued by the portfolio managers who seek to diversify their portfolios internationally. The purpose of this review is to understand the flow of funds and the Australian financial system from a practical standpoint. The empirical tests on how the aggregate flows contribute to the diversification benefits are beyond the scope of this thesis.

Chapter 3

Theory of portfolio diversification

3.1 Introduction

Diversification is defined as "A risk[21] management technique that mixes a wide variety of investments within a portfolio" by Investopedia. Investors are familiar with the term diversification and understand the need to invest in different assets to reduce risk. This understanding on the part of investors is referred to as naïve diversification and is commonly summed up in a phrase: "don't put all your eggs in the same basket". This statement captures the attitude on diversification but does not illustrate on the practical and theoretical aspects of diversification. This section explains the concept of diversification, its practical implications and theoretical underpinnings of diversification.

Diversification is the process that allows investors to significantly reduce portfolio risk without significantly affecting returns of the portfolio. In the past investors have attempted to achieve this by random selection of unrelated assets without consideration of relevant investment characteristics of the assets chosen in the portfolio. This random diversification is also referred to as Naïve diversification. As additional assets are added into the portfolio there is a large decrease in risk and the decrease in risk diminishes with the addition of more and more assets into the portfolio.

Objective of diversification is to create a portfolio of assets that includes number of assets in order to reduce risk. By including multiple assets in the portfolio one reduces risk because, securities of different companies will be exposed to changes

[21] Risk of investment is defined as the standard deviation of the expected returns from the investment in the asset or portfolio.

in market place with varying degrees owing to their different exposure to underlying factors. On a simplified basis if one invests 100% of its investments in a company producing sunscreen lotion he/she will be exposed to seasonal events such as winter. During winter there will be low sales of sunscreen lotion and in summer business will be good because of increased sale of sun screen. If the same investment was split in two companies 50% in sunscreen Lotion Company and the balance in a company that manufactures winter coats. This investment will be immune to the seasonal patterns of winter and summer and the portfolio is expected to earn consistent returns irrespective of the seasonal changes. This argument was formally developed in to modern portfolio theory by Markowitz (1952).

3.2 Modern Portfolio Theory

Benefits of diversification accrue because assets in the portfolio are exposed to the factors differently and these differences help to achieve an overall reduction in risk. Until Makowitz (1952) presented a formal proof of the concept of diversification the concept was used by investors in their investment processes without actually understanding the theory behind it[22]. Markowitz drew upon the thoughts and different practices and presented a formal framework for this analysis, referred to as modern portfolio theory (MPT). Markowitz considered the covariance[23] of different securities and presented a framework to estimate portfolio

[22] A review of the diversification literature starting form the early 1900, is included in the literature review Chapter of the thesis including studies dating back to Lowenfeld (1909).
[23]Covariance is a measure of co-movements of two assets over time. However, in optimisation models it is common to use correlation coefficient in stead of covariance, correlation coefficient is a standardised

risk and portfolio returns, based upon the risk and returns of individual securities included in the portfolio. Risk of the portfolio is not a simple weighted average of the risk of the individual asset included in the portfolio. In a portfolio context one must also consider the interrelationship between different assets included in the portfolio.

Portfolio risk is a function of the standard deviation of each individual asset included in the portfolio and the co-variances between the returns of pairs of assets included in the portfolio. In Markowitz framework, risk of the asset is estimated in terms of variance of the asset returns and the portfolio risk is as shown in the following equation.

$$\sigma_p^2 = \sum_{i=1}^{n} w_i^2 \sigma_i^2 + \sum_{i=1}^{n} \sum_{\substack{j=1 \\ i \neq j}}^{n} w_i \, w_{j\sigma_{ij}}$$

Where σ_p^2 = the variance of the return of the portfolio

σ_i^2 = the variance for the return of the asset

σ_{ij} = the co-variance between the returns of the assets I and j

w_i = the portfolio weights or percentage of investable funds invested in security i

$\sum_{i=1}^{n} \sum_{i=1}^{n}$ = a double summation sign indicating that n^2-numbers are

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measure of covariance and is calculated as: $\rho_{ij} = {}^{\sigma_{ij}}/_{\sigma_i \sigma_j}$ where ρ_{ij} is correlations coefficient between the returns of I and j, σ_{ij} is the covariance between the returns of the assets I and j and $\sigma_i \sigma_j$ are the variances of assets I and j.

to be added together (that is all possible pairs of values for i and j)

Markowitz approach of portfolio construction suggests that an investor should evaluate portfolios on the basis of their risk, as measured by their standard deviation, and the expected returns. The concept of efficient portfolio was postulated by Markowitz and is defined as a portfolio that has lowest portfolio risk at a given level of expected return or the highest expected returns at a given level of risk. An investor can identify portfolio by either specifying portfolio return and minimising the risk or by specifying investor's risk preference and maximising the expected returns for the portfolio. Rational investors are expected to select an efficient portfolio as these portfolios are optimal on both dimensions that are important for investors; risk and returns.

As discussed in the earlier paragraphs including multiple assets reduces risk, this is because by including these assets we are eliminating the diversifiable risk[24], also known as non-systematic risk. This risk is company specific. The reduction in the portfolio risk depends on the strength of correlations among different assets included in the portfolio. Lower the correlations between the assets included in the portfolio, higher will be the reduction in the risk of the portfolio because of diversification of unsystematic risk. In the initial phase there is a rapid decline in the risk of the portfolio with inclusion of new assets and then the reduction of risk

[24] An asset's total risk which is measured by its variance and is composed of two types; first company specific risk which is also referred to as the non-systematic or idiosyncratic risk. Second, a market wide risk to which all assets are exposed to but in varying degrees called systematic risk or non-diversifiable risk.

diminishes with every additional asset. The notion that unsystematic risk is diversifiable and is not rewarded by the market lead to the development of the capital asset pricing model (CAPM) of Sharpe (1964)[25].

3.3 Capital asset pricing model (CAPM) and Arbitrage pricing theory (APT)

Capital asset pricing theory (CAPM)[26] decomposes risk of an asset (or portfolio risk) into systematic and unsystematic risk. Unsystematic risk is the unique risk of the individual asset (portfolio) and represents the component of the total risk of the asset that is not correlated with the market wide movements. Systematic risk is the common risk that influences all assets in the market albeit to varying degrees. According to CAPM, market compensates investors for the systematic risk of the asset and not for the unique risk as the unique risk of the asset can be diversified away. When an investor holds a well diversified portfolio each individual asset in the portfolio entails unique risk, but because of diversification the investor's net exposure to risk is the systematic risk of the diversified portfolio. Further it is assumed, there are no transactions costs, investors are rational and all investors have homogenous expectations of the expected returns, risk and correlations of the investments available in the market. CAPM also assumes a normal distribution of returns and existence of a risk free asset.

[25] Similar studies were also performed by Treynor in 1961, this study is widely cited by scholars but was never published, Lintner (1965) and Mossin (1966).
[26] CAPM was presented by Sharpe (1964) as a general asset pricing model for which he was awarded Nobel prize in 1990, APT was introduced by Ross (1976) as an alternatively pricing model and is based on the premise that two similar assets in the market should be similarly priced and if there any price anomalies in the assets, it will be arbitraged to an equilibrium level by market participants.

Systematic risk is measured by beta coefficient of the asset (or portfolio), and expected return of the asset (or portfolio) is equal to the return of a risk free asset plus a risk premium which is equal to the product of systematic risk of the asset and the market risk premium. This relationship can be presented in the Equation 3.1 below.

$$E(R_i) = R_f + \beta(R_m + R_f) \quad (3.1)$$

$where$

$E(R_i)\ is\ expected\ return\ of\ the\ asset\ or\ portfolio$

$R_f\ is\ the\ return\ on\ the\ risk\ free\ asset$

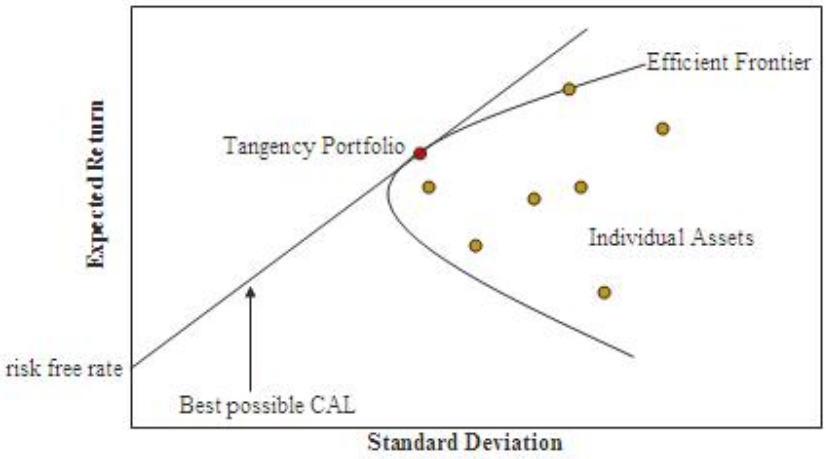
$R_m\ is\ the\ return\ on\ the\ market$

$\beta\ is\ the\ systematic\ risk\ of\ the\ asset$

Using simple mathematical modelling we can optimise the objective function of minimising risk and maximising returns for a given portfolio. This portfolio (also referred to as optimal portfolio) reflects lowest possible risk at the given level of return. Since each additional asset in the portfolio diversifies the unsystematic risk of the portfolio, this portfolio should theoretically include all available assets in the market. This optimal portfolio can be graphically represented as in the Figure 3.1 below.

Figure 3.1

Capital Market Line



(CAL is Capital allocation line)

The efficient frontier shows all combinations of optimal portfolios and the tangency portfolio as a portfolio which gives a portfolio that has least possible risk for the given level of returns.

CAPM though theoretically very appealing but has its own short comings. To develop the model it makes strict assumptions that may not be valid in real world. Assumptions like rational expectations, normal distribution of returns and standard deviation to be a good measure of risk for all assets may not be true but gives a good approximation of the real world. The evidence on success of CAPM in pricing assets is mixed[27]. Economists and practitioners have attempted to develop superior models of asset pricing in the expectation of providing accurate valuation

[27] Seminal paper presenting any forceful argument against CAPM was Roll (1977); commonly referred to as Roll's critique. There has been subsequent papers after Roll's that have presented evidence against the validity of CAPM, for a recent review of this strand of research see; Shanken and Weinstein (2005).

of assets in the market place with fewer restrictions. Other model of asset valuation used in research and practice is arbitrage pricing theory of APT models. These models are based on the premise that when all assets are perfect substitutes of each other there can be no arbitrage opportunities. APT model posits that the value of an asset is determined by factors beyond mean returns and variance. Value of an asset in APT framework is determined by a return generating process that are linearly related to a set of factors as shown in equation 3.2 below.

$$E(R_i) = \alpha_i + \beta_{i1}F_1 + \beta_{i2}F_2 + \ldots. + \beta_{ij}F_j + \varepsilon_i \quad (3.2)$$

where

α_i *is the expected return on the asset if all the factors had a value of zero*

β_{ij} *is the sensitivity of stock i's return to the jth factor*

F_j *is the value of the jth factor*

ε_i *is a random error term*

Equation 3.2 can be rewritten as.

$R_i = \alpha_i + \sum_{j=1}^{J} \beta_{ij} F_j + \varepsilon_i$ and the model that arises from this process can be written as:

$$\bar{R} = R_f + \sum_{j=1}^{J} \beta_{ij} \lambda_j$$

where R_f is the return on the risk free asset, β_{ij} is the sensitivity of the asset returns to j^{th} factor, and $\boldsymbol{\lambda_j}$ is the extra return required due to the jth attribute of the security

Intuition behind the above model is simple; let each asset return be equal to linear combination of a number of factor returns and an idiosyncratic (or unique as in

case of CAPM) return associated with each asset. In a portfolio of large number of assets these idiosyncratic terms can be diversified away by including sufficiently large number of assets in the portfolio. If this idiosyncratic risk can be diversified away then each asset can be priced as a linear combination of its component factors. Milne (1988) provided a formal proof of generalized arbitrage pricing model. Stulz (1981), Solnik (1983) and Cho, Eun and Senbet (1986) have tested different variants of international arbitrage pricing models (IAPT) and the results on the IAPT are mixed. The objectives of this thesis are not to test the validity of pricing models but to see if there are benefits in diversifying into emerging markets and to test the underlying causes for changes in benefits of diversification over time.

3.4 Domestic and international diversification

Diversification in the domestic market is achieved by adding different assets in the portfolio from different sectors of the economy that have less than perfect correlations with other assets included in the portfolio. Inclusion of additional assets in the portfolio reduces the non-systematic risk of the portfolio and the portfolio risk approaches equal to overall market risk. Market risk is non-diversifiable risk and once portfolio risk is close to market risk, diversification can not further reduce portfolio risk. Domestic market assets are exposed to similar factors and thus have a strong tendency for assets to move together and have higher correlations. For the period 1951-67 the correlations between the US industrial common stocks with that of rail road and public utilities were 0.46 and 0.59 respectively (Levy and Sarnat 1970). These higher positive correlations

diminish the potential diversification benefits that can be achieved by including a number of different assets in a portfolio. Assets across different countries are expected to be exposed to different factors and as such expected to have lower correlations than assets within the same market. On theoretical grounds, international portfolios should present higher potential diversification benefits as compared with that of the domestic portfolios owing to different underlying factors that determine the returns of the assets in each economy. The empirical and theoretical evidence related to international diversification and the benefits that can be derived by diversification of portfolios internationally are presented in literature review section of the thesis. Literature review specifically highlights the special characteristics of the emerging markets and Australian market which may influence the benefits available to an Australian investor. A discussion on methodology covering; specific models to estimate correlations, constructing optimal portfolios and test of underlying causes of changes in correlations are discussed in Chapter 5.

Chapter 4

Literature Review

4.1 Introduction

This section highlights the differences in key characteristics between emerging and developed markets, providing a theoretical framework of the interdependence of the global equities markets for empirically analysing the benefits from emerging markets diversification. A key distinguishing characteristic of emerging markets compared to developed markets is the nature of the real economy; this review considers evidence relating to the links between financial and real sectors of an economy. Recently researchers have been especially interested in the effect of globalisation on the differences between emerging and developed markets. Effect of globalisation on the benefits of diversification has been briefly reviewed in this section.

The objectives of my research are to quantify the returns to an Australian investor from investment in the emerging markets and identify empirical relationship between the underlying relative volatilities of Australian and emerging market economies the literature establishing the relationship between the volatility and correlation is also reviewed in this section.

Early literature on the diversification has been based on the assumption that correlations are constant over time. However, intuitively one would think that with the integration of world markets, the interdependence of the equities market should increase and correlations should narrow. This evidence is considered in the review as the changes in correlations will impact the likely benefits of diversification in future.

The diversification benefits for investing in emerging markets may also be different to Australian investors as compared with the investors of the other larger developed markets. This difference in benefits may arise because of the similarities and or dissimilarities between the economic factors underpinnings these markets, international capital flows, legal framework of the different markets, relative mobility of the labour and global market risk. Research relating to the benefits from international diversification for Australian investors is considered in the review to help clarify these distinctions.

The East Asian region forms a substantial part of the emerging market sample, so the evidence from the East Asian crisis is considered to see its likely impact on the diversification benefits for an Australian investor. Because of the likely impact of crisis like situation occurring due to the capital flows to the emerging markets this issue is specifically dealt with in this Chapter.

Methods used to measure the benefits of diversification and whether these benefits are significant after adjusting for the risk has been very briefly included in this section. The detailed discussion on methodologies used in literature is included in the subsequent section, research methodology[28].

[28] This section draws from (Gupta 2006) a review paper published from this study.

4.2 International Diversification

Academic research has documented the benefits of international diversification. Goetzmann, Li, and Rouwenhorst (2005) document early work on international diversification, highlighting Lowenfeld's (1909) study of equal-weighted, industry-neutral, risk-adjusted, international diversification strategies, using price data from global securities trading on the London Exchange around the turn of the century. Lowenfeld (1909) details the imperfect co-movement of securities from various countries. Based on these correlation characteristics, he argues that allocating funds in equal proportions over a number of geographical sectors and carefully re-balancing back to these proportions on a regular basis would enable the investor to obtain superior investment performance.

The objective of international diversification is to improve the risk/return trade-off for investors. The benefits of international diversification per se are well documented in the academic literature. Grubel (1968) found that between 1959 and 1966, US investors could have achieved superior risk and return opportunities by investing part of their portfolio in foreign equity markets. Levy and Sarnat (1970) analysed international correlations for the 1951-1967 period, and demonstrate the diversification benefits from investing in developed and developing equity markets. Grubel and Fadner (1971) showed that between 1965 and 1967 industry correlations within countries exceed industry correlations across countries.

Investors are conscious of the fact that international stocks have different characteristics so that by diversifying between different countries or industries in countries, the performance of the portfolio can be improved. Investing in

international markets differs from domestic market investment in three important ways (Lessard 1976). Firstly, the covariances among assets within a domestic market are much higher than the co-variances among different markets. Second, barriers imposed by taxation, currency controls or investor tradition may further segment national markets sufficiently such that assets are priced in a domestic rather than an international milieu. Exchange rates between different currencies deviate from each other giving rise to currency exposure on international portfolios.

A key factor in the determination of the benefits from international diversification is country risk. Rajan and Friedman (1997) use a two-factor CAPM consisting of a world stock index and country risk factor to show that an international portfolio contains a statistically significant country risk premium. They argue that that the traditional perceptions of country risk encompasses the effects of political conditions and restrictions on foreign ownership of domestic stocks. Capital controls may limit global investments to less developed nations and not to developed nations, thus adding to the segmentation of the less developed markets from the developed markets. This view is mitigated by defining country risk in a broader context to include all the above and discriminatory tax regulations, lack of information, transactions costs and liquidity differences among foreign and domestic stocks. Hence, the definition of country risk becomes more explicitly recognized in both developed and developing nations. Ex-post results show that country risk is priced by the investors, but the size of the risk premium varies over time. Clark, and Tunaru (2001) measure the impact of political risk on portfolio

investment when the political risks are multivariate and correlated across countries and find that individual political risks[29] are not uncorrelated with each other. The authors consider the case of multiple sources of risks that are correlated across countries and integrate the cross-country correlations in the estimation of exposure to loss.

The relevance of variance and covariance is reassessed by Harvey (2000). If markets were completely segmented then what counts is the country's variance and total skewness. If markets are completely integrated, it is the covariance and coskewness. Harvey suggest that in segmented markets expected returns are determined by non-diversifiable risk of each asset in the local national context, whereas in integrated markets expected returns are determined from the perspective of an integrated market portfolio and not with respect to individual national markets. If markets are fully integrated the international diversification advantage is simply the diversification effect, which is a reduction in the non-systematic risk of the portfolio through diversification. However, if markets are segmented, gains may be even greater, as returns adjust to price the previously non-diversifiable risk.

Harvey (2000) considers a model with skewness for 47 international stock markets. His analysis divides countries in to three groups: developed countries, emerging markets and all countries. The author begins the analysis with data for 1988, the start of a period of capital market reforms in emerging markets.

[29] Authors conceptualise political risk as an evolutionary process that incorporates a continuous stochastic element and the discrete arrival of information (events) that cause losses.

Harvey presents evidence that developed markets are not influenced by variance and total skewness, which is consistent with the markets being integrated. Covariance and coskewness do a reasonable job in explaining stock returns in some emerging markets, suggesting that many of these markets are integrated with world capital markets. Many emerging markets appear to be influenced by total risk measures such as; variance and skewness suggesting that these emerging markets are not completely integrated with the world capital markets (from previous paragraph the argument is, if the markets are integrated, the covariance and coskewness is important in explaining the expected returns and not the total variance or total skewness). In some of the tests, both variance and total skewness provide incremental ability to explain the cross-section of expected returns in these markets, which suggest that these markets are not fully integrated. Bekaert and Harvey (2000) argued that; with time total risk measures may be becoming less important for emerging markets because of liberalisation thus suggesting that these markets are becoming more integrated with global markets. Similar findings are reported by Schmukler (2004), that the World markets are not fully globalised. Recent research by Hatemi-J and Roca (2006) find that there are still potential benefits from diversifying internationally and Karlsson and Norden (2007) find evidence of home country bias in the internationally diversified portfolios. Chiou (2008) find that the US investors can still benefit from diversifying into international markets. These benefits decline with the restrictions on the maximum limits on investment into foreign markets but are completely eroded.

Statistical characteristics of returns for emerging and developed markets arise from the underlying real and financial nature of these economies. The nature of capital flows of a country with the rest of the world is different. Different countries have different legal framework, labor market and are at a different stage of development which leads to the argument that there may be potential gains from diversification across countries because of these difference. Thus the links between these sectors of the economy are important for an assessment of the likely future benefits from international diversification[30].

4.3 Links between Financial and Real Sectors.

Different countries are at a different stage of development, which leads to the argument that, there may be potential gains from diversification across countries because of differences in the stages of development and nature of development in different countries. The following section addresses the significance of differences in real sector for diversification benefits.

There is a correlation between output growth and stock returns in both advanced countries (with highly developed markets) and developing countries (with emerging stock markets). The presence of this association in a variety of countries at different stages of economic and financial development suggests that an understanding of stock market differences and the international diversification

[30] Lessard (1974) looked at portfolios of stocks from 16 developed countries and concluded that national risk factors were more important than industry factors. He further argued that diversification across countries, even if with in the same industry, yields in greater risk reduction than diversification across industries. Several studies have documented the importance of country specific factors in determining stock returns (Heston and Rouwenhorst (1994), Serra (2000)). Similar results were reported by Rouwenhorst (1999) for EU market, which are more integrated as compared to the emerging markets.

possibilities may be gained by understanding this association (see Schumpeter 1982[31], Goldsmith 1969, McKinon 1973, and Shaw 1973).

The evidence that economic growth and stock returns are correlated has prompted debate on the causal direction of the underlying relationship. Morck, Shleifer, and Vishny (1990) review five existing theories providing explanations for this link and summarise the relevant empirical literature. In turn these are:

According to "passive informant" hypothesis, the only mechanism underlying the correlation between stock returns and output growth is related to the dividends. Under the assumption that stock prices reflect the present discounted value of all future dividends and that the dividend growth is related to GDP growth, a correlation between this year's stock returns and next year's economic growth arises naturally. If next year's economic growth is buoyant, news revealed this year will typically be positive, resulting in larger stock price increases this year.

Under the "accurate active informant" hypothesis, stock price changes provide managers with information about market expectations of future economic developments. Managers base their investment decisions on this information thereby justifying market's expectations. The stock market acts as a "sunspot" bringing about one of the many possible self-fulfilling equilibriums. In this case stock price changes are perfectly correlated with fundamentals.

[31] *The Theory of Economic Development* was first published in 1911 in German and subsequently translated in English in the 1930s and a revised edition published in 1982.

In the “faulty active informant” hypothesis, the manager’s decision relating to investments is based on stock price movements, but they cannot distinguish between movements reflecting fundamentals and market sentiment. Stock market movements that are not based on fundamentals can therefore mislead managers into under-investing or over-investing compared with the ‘fundamental benchmark’.

The “financing” hypothesis, based upon Tobin’s q theory, suggests when stock prices are above the replacement cost of the capital, entrepreneurs are more likely to expand by investing in new physical capital, possibly financed by issuing new shares of their company, rather than by purchasing existing firms. Therefore, high stock returns will be followed by high investment and economic growth. There is a debate on whether this mechanism allows for irrational movement in stock prices to influence real economic activity, as suggested by Fischer and Merton (1984), or whether rational managers will choose not to respond to changes in financing cost resulting from market sentiment, as argued by Blanchard, Rhee, and Summers (1993).

The “stock market pressure on managers” hypothesis suggests that stock prices may affect investment even if they neither convey information on economic outlook nor change financing costs. If investors have negative views on firm’s future prospects and force down the share price, managers may have to cancel their investment plans to protect themselves from the likelihood of being fired or firm being taken over. In the other case, if investors are confident of a firm’s prospects

and drive its share price upwards, managers may decide to take up investment projects aggressively in order to appear not being too cautious.

In terms of market integration the following studies are important which explain the mechanism through which segmented market effect is removed. Pagano (1993) surveys three additional theoretical channels of causation that have emerged: first, better screening of fund-seekers and monitoring of recipients can lead to more efficient resource allocation; second, the provision of financial services can encourage the mobilization of otherwise idle resources; and finally, improvements in risk-sharing and reductions in origination costs can enhance the savings rates and promote the start of innovative, high quality projects. Many macro-economists have argued that well functioning equity markets can raise long term growth rates by mobilising savings and improving the efficiency with which resources are delivered to productive uses (see Levine and Zervos 1998; Rousseau and Wachtel 1998).

With capital markets becoming more integrated, the scope for exploiting any "inefficiencies" may be rapidly diminishing as the analysts from the world's largest financial institutions identify excess returns and then arbitrage them away (Fraser, Helliar, and Power 1992). Kalra, Stoichev and Sundaram (2004) argue that benefits of international diversification are exaggerated (page 211). On the contrary Li, Sarkar and Wang (2003) demonstrate statistically significant benefits for US equity investor in diversifying in to emerging markets, if there are short sale constrains. Further, there may be a theoretical justification for potential gains from international diversification as investors gain access to shares in industries

which are not represented or are thinly represented in his/her domestic market. This expansion in the menu of shares in all kinds of companies and or industries would lead to an advantage by expansion of the feasible set and a change in the shape of the mean variance efficient frontier even if the capital markets were fully integrated and market returns were highly correlated.[32] Access to these international markets may be achieved by investment in those domestic firms with operations in these markets. It is of interest to assess if the benefits from diversification are achievable on a cost-effective basis by selection of these domestic multinational stocks.

4.4 East Asian Crisis and International Diversification.

Currency crisis are fast outflows of financial capital in expectation of possible currency depreciations, causing exhaustion of reserves, financial instability and finally contraction in the economy[33]. The first recorded financial crisis occurred in the 18th century involving South Sea Company. More recent examples of crisis include Mexican crisis of 1994 and the Asian crisis of 1997-98. These events and global after effects of the events have lead to many theoretical and empirical studies, wherein researchers have attempted to identify causes of the crisis, vulnerability of an economy to a currency crisis, policy implications of the crisis and contagion and suggesting ways to avert crisis in future. The countries most

[32]George Stout (former joint manager of Alliance Trust) has emphasised that the reason for international security diversification is to gain access to high growth industrial sectors that do not exist or are not accessible to investors in the investor's domestic economy or capital market.

[33] Krugman in his introduction to collection on 'currency crisis' has stated, "There is no generally accepted formal definition of currency crisis, but we know them when we see them. The key element is a sort of circular logic, in which investors flee a currency because they fear that it might be devalued, and in which much (though not necessarily all) of the pressure for such a devaluation comes precisely from that capital flight" (Krugman, 2000 page 1)

severely affected by the Asian crisis of 1997-98 were Thailand, South Korea, Indonesia and Malaysia. Hong Kong and Philippines were also affected but less severely.

East Asian markets form a substantial part of the emerging market sample and the recent crisis of the late 90's have led many people to question the justification of investing in the East Asian markets. Stiglitz (2000) has argued that liberalization may lead to increased volatility. The following section discusses the role of liberalization and the causes of the crisis in the East Asian markets. More specifically it addresses the issue whether the portfolio investment was one of the contributory factors in the crisis in the region

Global financial integration, low interest levels in USA and Japan, pushed capital towards the developing economies like East Asian countries. The 'pull factors' in the region were low unit labour costs, incentives to foreign investments and credits, relatively high interest rates, relatively fixed exchange rates and inadequate financial system (IMF 1997 and IMF 1998).

Studies of the causes of financial crisis follow the crisis. For example, after the Mexican crisis Frankel and Rose (1996) suggested current account and public deficits are not good predictors. Authors suggested that, large short term capital flows, low foreign exchange reserves, high domestic credit growth, low international interest rates and over-valued domestic currencies could be better in predicting a financial crisis in a country or region. Sachs, Tornell and Velasco (1996) suggest lending booms fuelled by capital inflows and associated with

financial liberalisation and weak regulatory system, overvalued exchange rates and low ratios of international reserves to narrow money as predictors of financial crisis. Krugman (1998b) suggest moral hazard as the main motivating factor in the onset of East Asian financial crisis. He comments that the problem was a symptom of a banking crisis or more generally a case of an internal financial crisis. Chinn and Dooley (1999) document that during the crisis period (except in case of South Korea) the major proportion of the capital inflows in the East Asian region was composed of bank loans and foreign direct investments and not portfolio investment.

The relevance of East Asian crisis to this study is to review the studies covering causes of the East Asian crisis and see whether portfolio investments cause increase in volatility and contribute to the crisis. Recent sharp economic declines, mainly during the Asian crisis, have led many people to argue that liberalization may lead to increased volatility in a country's economic growth (Stiglitz, 2000). However, Bekaert, Harvey and Lundbland (2002) do not find evidence of significant increase in volatility after liberalization, Krugman (1998b) suggests moral hazard as the main motivating factor in the East Asian financial crisis. In a review of liberalisation literature in the emerging market economies Das (2004, page 887) argues:

> "…Some believed that it was the liberalisation of the equity markets, which was to be blamed for their volatility. Empirical studies showed that the equity markets volatility was not intensified by financial liberalisation. If anything, the opposite is the truth. Equity market cycles become smoother after liberalisation. .."

Similar findings were reported by Kaminsky and Schmukler (2002). This is further supported by the evidence that during the crisis period the major proportion of the capital inflows in the region was composed of bank loans and foreign direct investments and not portfolio investment, (Chinn and Dooley 1999)[34]. This review finds that the portfolio investments into emerging markets are not likely to cause crisis in the emerging markets further this investments has been found to reduce the volatility of stock market returns in the emerging markets.

4.5 Diversification without investing abroad.

Investment in multinational companies can be viewed as a portfolio of internationally diversified cash flows originating from different countries and denominated in different currencies. Returns from such companies are less likely to be highly correlated with the returns of domestic-only countries and are more likely to be governed by factors, which affect foreign companies (Wright and McCarthy 2002).

Holding shares in multinational companies (MNC) appears to provide an attractive and cost efficient vehicle for international portfolio diversification for the following reasons: First, there may be barriers, formal and informal which prevent an investor from undertaking direct foreign investment. Second, investors may lack necessary expertise to invest selectively in the shares of foreign companies. These investors may have a better knowledge and understanding of the domestic stock market as opposed to the overseas market. Consequently with a seemingly

[34] For a comprehensive review of the causes of the Asian crisis see Gupta and Basu (2007), Have we learnt anything from the Asian Crisis? Looking at the crisis from the perspective of India.

better knowledge of the prospects of the MNC's, these investors may prefer to invest in the MNC's. Third, the purchase of shares in a MNC enables the investor to ignore the foreign currency risk, a problem for the MNC and not the investor. Finally, large MNC's are expected to benefit from financial economies of scale (Wright and McCarthy (2002)).

The empirical evidence is mixed on this issue. Jacquillat and Solnik (1978) find the share price behaviour of MNC's is indistinguishable from that of the shares of the purely domestic companies. The returns from the shares of nine MNC's in different countries are more closely related to movements in the domestic equity index of the country in which their head offices are located than to changes in international equity markets.

However, the results of Mikhail and Shawky's (1979) research provide evidence for the benefits of investing in MNC's. In their study, the average level of returns from their sample group of 30 MNC's is higher on both an absolute and a risk-adjusted basis than the aggregate return on the S&P 500 index. But, Aggarwal (1980) criticizes the Mikhail and Shawky methodology on a number of grounds and suggest caution when interpreting their results. The author notes that their sample is not random in that the names of 28 of 30 companies in their sample begin with letters from the first third of the alphabet. And their proxy for purely domestic companies, the S&P 500 index, is inappropriate because it includes a number of MNC's. With the less than optimal international diversification gains from investment in multinational stocks, the emphasis in the search for

international diversification benefits is focused on the role of the emerging markets in investment strategy.

4.6 Emerging markets diversification

Major capital markets of the world are considered to be nearly efficient and the correlations between these markets during the past years appear to have risen. Consequently the expected gains from diversifying across these major markets are assumed to be minimal. To gain diversification benefits it would appear necessary to invest in the emerging markets, which are still assumed to be less efficient. The correlations between these markets and the major markets also appear to be lower.[35]

The argument that the investors should increase the proportion of their portfolios committed to emerging country equities is developed by Divecha, Drach and Stefek (1992)[36], Wilcox (1992), and Speidell and Sappenfield (1992)[37]. This research notes the higher volatility of the emerging market stock returns. In particular, Cheung and Ho (1991) find that although the correlations between returns in developing markets and the returns in Asian emerging markets are smaller than those amongst developed markets, the most recent three years

[35] Solnik (1991), p. 61 has suggested the type of asset diversification that portfolio manager should seek is "one with high volatility and low correlation with the portfolio".

[36] They use a three stage multifactor model to explain the excess returns from country factor, called country risk index.

[37] Wilcox (1992) and Speidell and Sappenfield (1992) use similar methodologies. They compare the excess returns achieved by including different percentage of emerging markets (EAFE index) into their portfolio and compare the results. Their results show inclusion of EAFE index enhance the returns without significantly increasing the risk as measured by standard deviation of the portfolio returns.

examined (1986-88) were characterised by increased instability of the correlation matrix.

In spite of the high volatility of returns for the emerging markets, the argument in favour of investment still holds though the high volatility may deter some potential investors. Although there is a greater risk of low growth in the emerging markets than in developed markets, average growth has been much higher in emerging markets.[38] Also, emerging capital markets tend to be relatively uncorrelated with each other (except Malaysia, Singapore and Hong Kong) and with developed markets, so a greater representation of emerging market securities in portfolio should decrease the portfolio risk. In addition, the overall portfolio return is enhanced, providing that the weighting of the emerging country securities is not more than 15 percent (Speidell and Sappenfield 1992) or 20 percent (Divecha, Drach and Stefek 1992). The actual exposure to the emerging market securities will depend upon investor's risk tolerance.[39]

In addition, research has highlighted the parochialism of the investors such that they limit their investment in the emerging markets and consequently they do not maximize the risk return benefits from international diversification; (See Friedman and Sharma 1980, Errunza 1983, Gill and Tropper 1988, Clark 1991, Solnik 1991, Wilcox 1992, Speidell and Sappenfield 1992, Divecha, Drach and Stefek 1992). A

[38] The annualized compounded return on International Finance Corporation (IFC) Emerging Country Index was 18.3%, compared with 12% for the S&P 500 Index, for the previous five years ending 30th June 1991. Second, though the volatility of the emerging markets has been much higher than in developed markets, the volatility of emerging markets as a whole is lower than that of most individual markets (The Economist, 1991).

[39] Speidell and Sappenfield (1992), p. 67 have analysed the effect on optimal portfolio weightings of changes in risk tolerance.

decision to include emerging markets' stocks in an international portfolio will depend theoretically on the differences in characteristics between the emerging markets and between the more developed markets. Recent empirical studies find there are potential benefits in diversifying into emerging markets; see Ibrahim (2006), Chiang et al (2007), Driessen and Laeven (2007) and Chiou, Lee and Chang (2008).

4.6.1 How are emerging markets differentiated from other markets?

Distinction between emerging markets and the developed markets should be based on the economic differences between the two. However, in literature the distinction between the two has been adapted from the term as used by the World Bank.

The term 'emerging market' arises from the description of emerging economies applied by the World Bank to low and middle income economies. If a country's GNP per capita did not achieve the World Bank's threshold[40] for a high-income country, the stock market in that country was said to be emerging. More recently this definition has proved to be less than satisfactory due to wide fluctuations in dollar-based GNP per capita figures. Dollar based figures have been significantly affected by swings in exchange rates, especially in Asia. And reported GNP

[40] Based on 1997 data, economies with a GNP per capita of $ 9,656 and above were classified as high-income countries

figures are, since they take a significant time to prepare, are often out-of-date by the time they are released[41].

In general, Standard and Poors (S&P) classifies a stock market as 'emerging' if it meets at least one of two general criteria: (i) it is located in a low- or middle-income economy as defined by the World Bank, and/or (ii) it's investable market capitalisation is low relative to its most recent GDP figures. Owing to these problems, S&P has adopted new criteria for market to be deleted from index coverage. To exclude a market, GNP per capita for an economy should exceed the World Bank's upper income threshold for at least three consecutive years. The three-year minimum limits the possibility that the GNP per capita level is biased by an overvalued currency.

For a new market to be included in the index coverage, the market must be located in an economy whose GNP per capita place it in the World bank's lower and middle income classifications in at least one of the last three years.

Emerging markets can be distinguished based on a number of financial, economic and structural characteristics. For example, emerging markets distinguish themselves from the capital markets of developed economies with respect to information efficiency and institutional infrastructure. A stock market's institutional infrastructure is characterised by the taxation of dividends and capital

[41] The World Bank emphasizes that "…developing economies… does not imply that all the economies belonging to the group are actually in the process of developing nor that those in the group are have necessarily reached some preferred or final level of development." http://www.worldbank.org/databytopic/cladd.ht.

gains, restrictions on capital flows and the quality of available information.[42] The more important characteristics defining the difference between and emerging market and a developed market are considered below:

Discriminatory Taxation

Taxation of capital gains may lead to a misallocation of resources. If capital gains are taxed investors may try to avoid realising profits by delaying the sale of assets thereby reducing tax burden and effectively the present value of tax.[43] Especially, in less developed countries a discriminatory taxation regime affects the capital allocation in a negative way, because foreign investors are affected directly from this disadvantage compared to domestic investors. Thereby, necessary capital inflows for real growth are absent and portfolio selection may be inefficient.

Capital flow restrictions and market regulation

Regulatory frameworks that prohibit the free market entry and exit restrict capital mobility because foreign investors are only allowed to transact investments in a certain nature or to an extent in the domestic market. Vice-versa, the amount of foreign securities in the portfolio of domestic investors can be curtailed through regulatory actions (Podding 1996 and Solnick 1996).

Differences in economic culture and language barriers produce asymmetric information between foreign and domestic investors. The resulting disadvantage for the foreign investor may make international investment seem more risky for the

[42] See Mobius (1995), p. 15
[43] See Fuss (2002)

foreign investors and can only be overcome with additional information costs. This information asymmetry can be overcome, to some degree, by public dissemination of information by stock exchange and companies.

In most countries quarterly or semi-annual reports are required to be released by companies for the local markets. In 1994 the accounting standards in Brazil, Chile, Mexico, Korea, Malaysia, Philippines, Sri Lanka and South Africa were seen to meet the international standard. However, in countries such as China and Indonesia, the reform is yet to be completed. In the meantime, most of the countries have made significant changes and have efficient exchange authorities.[44]

Liquidity

A key characteristic of an emerging market is the market liquidity and market risk. In some of the emerging stock markets trading volumes are so small that institutional investors are not prepared to invest in these relatively less liquid markets. If buy or sell orders are not executed due to lack of share liquidity, disadvantageous stock price effects and holding costs are created (ibid).

Market activity

Turnover ratio is an indicator describing the relationship between the quality of institutional infrastructure and the level of market activity. For example, in 1998 Taiwan showed US $885 billion of traded value, one of the highest turnovers in stocks to be found worldwide. A major reason for this turnover is the predominant

[44] IFC (1994), p 268 and Kumar and Tsetsekos (1999), p 445

presence of private investors. Around 50% of the market capitalisation is in the hands of these investors who are characterised by a relatively high speculative behaviour. Korea (176%), Turkey (145%), China (130%), Hungary and Pakistan (111%) demonstrated turnover ratios above average. In emerging markets like Nigeria (4.9%) and Colombia (9.4%), where the rate of foreign investments is restricted through investment barriers, the ratios were low. For the industrialised nations Spain (202%) and Germany (145%), followed by the USA (106%) and Italy (104%) presented the highest turnover ratios in 1998.[45]

Market Size

Stock market capitalisation is an indicator of a market's age and development level. In general it can be said that older markets have a better institutional framework. In 1998 the total worldwide market capitalisation of the emerging markets was $US1,900 billion, with Taiwan accounting for $US260 billion, China $US231 billion and South Africa $US170 billion. At the same time USA held $US13,451 billion, Japan $US2,496, England $US2,374 billion, and Germany $US1,094 billion of the entire market capitalisation of $US25,065 billion for the industrialised nations.[46]Following Table 4.1, shows the salient features of the Australian stock market and the emerging stock markets, that are included in the final analysis of the study. The first column shows that the number of listed companies is largest in India, followed by Australia, Korea, Chile, Greece and the

[45] IFC (1999), p. 15; it is noted that that these figures are out of date but this data is used for illustration of the validity of the theoretical rational for the diversification and is not used in the analysis. This has been updated only for the markets used in the final analysis.
[46] IFC (1997), p. 23 and IFC (1999), p. 23

Philippines. Second column shows the capitalization of each market, India has the highest capitalisation followed by Brazil, Korea and Australia. Following column shows stock market capitalisation as percentage of GDP for each market. This ratio has been used as an indicator of stock market development. The last column shows the PP-adjusted figures for per capita GDP for the markets included in the study. This table shows the markets used in the study are fairly developed. Some of the markets that have been excluded from the final analysis are smaller markets and assumed to have higher transactions costs and less accessible to foreign investors.

Table 4.1: Summary stylised facts for the capital markets included in the study

Market	Number of listed companies	Market Capitalization (2006)	Market Capitalization % of GDP (2007)	GDP per Capita (PPP adjusted 2005)
Australia	1998	1,095,858	140	34,106
Brazil	497	1,370,377	67	8,474
Chile	259	212,910	120	12,248
Greece	282	208,284	68	29,261
India	4811	1,819,101	90	2,222
Korea	1648	1,123,633	94	21,273
Malaysia	636	325,663	156	11,678
Philippines	206	103,224	58	2,956

Source: Number of listed companies from stock exchange web sites; market capitalization, market capitalization as % of GDP, and GDP per capita estimates are 2008 World Development Indicators.

An interesting characteristic relates to the number of firms listed on local markets. By the end of 1998, 26,234 firms were traded on emerging markets, 4,696 more than traded in markets of developed countries. It may be surprising that India ranks

second with 5,860 listed companies, after the USA with 8,450 listed companies. India profits from a very high economic dynamics combined with a traditionally high savings pattern of the Indian population.[47] Dellas and Hess (2001) have argued that firm capitalisation depends positively on the level of financial development and a better functioning financial system leads to larger stock market (more and bigger firms).

Market Pricing

The valuation of market profits is dependent on the dividend payout ratio, potential profit growth and risk. All these factors are of relevance to the level of the price-earnings-ratio (P/E).[48] At the end of 1998 the average price earnings ratio in the emerging markets ranged from –106.2 in Indonesia to +33.6 in Greece. The difference in figures is representative of different expansion paths in each country. The P/E in larger economies is, on average, smaller than that for the emerging markets. In addition the price mechanism is partly determined by real dividend yields. In 1998 the real dividend yield was 0% in Brazil, while in Pakistan it was on average 10.6%. In the industrial nations the real dividend yield ranged from 0.8% in Sweden to 3.2% in Hong Kong.

In summary, the key characteristics of the emerging markets of relevance to international diversification are institutional infrastructure, market regulation, liquidity, market size and market pricing. These differences between emerging and

[47] IFC (1997), p. 23 and IFC (1999), p. 23; number of listed firms vary in two estimates (Table 4.1) because of different time periods.
[48] Kumar and Tsetsekos (1999), p 446

developed markets are expected to lead to gains to investors in the emerging markets depending on the degree of market integration. Here globalisation is an important factor in determining trends in the integration of equity markets and changes in the benefits from diversification into emerging markets.

While these factors segment the emerging markets from the developed markets, some of these factors work as disincentives for foreign investors to invest in the emerging markets. Existence of large listed companies that are poorly traded, poor protection of minority investors may influence the foreign investor negatively who may be thinking of investing in emerging markets.

4.6.2 Emerging Markets and Market Integration

The emphasis in early research into diversification benefits arising from less integrated markets is on the impact of market integration on security prices (Stulz (1981a, 1981b), Errunza and Losq (1985), Eun and Janakiramanan (1986), Alexander, Eun and Jankiramanan (1988), Errunza, Senbet and Hogan (1998), Bekeart and Harvey (1995)). In the context of Sharpe (1964) and Linter's (1965) capital asset pricing model (CAPM), a simple intuition suggests in a completely segmented market, assets will be priced in relation to the local market return. The local expected return is a function of the local beta of the asset and the local market risk premium. In the event of high volatility of local returns, it is likely that local expected returns will be high. If the capital markets are integrated, expected returns are determined by the beta with respect to the world market portfolio multiplied by the world risk premium. In case markets were integrated the

expected returns of the emerging markets are expected to be lower based on the global risk premium. Consequently, as integration proceeds in segmented markets, prices should rise and expected returns should decrease[49]. This theoretical effect is confirmed by recent empirical evidence that demonstrates, after controlling for other economic and financial events, returns do decline (Bekaert and Harvey 2000, Henry 2000a, Kim and Singal 2000).

Market integration has an ambiguous impact on volatility. While it may be argued that foreigners tend to abandon markets when risk increases, leading to higher volatility, the empirical evidence do not indicate significant changes in volatility in the transition from a segmented to an integrated capital market (Bekaert and Harvey 1997 & 2000, Richards 1996, Kim and Singal 2000, De Santis and Imrohoroglu 1997, Aggarwal, Inclan and Leal 1999).

In addition, it would be expected that market integration is associated with higher correlations between local returns and returns for other markets (Bekaert and Harvey, 2002). However, a country with an industrial or economic structure substantially different to world's 'average structure' may have a lower correlation with world equity returns, even after liberalization. When correlations increase, the benefits of diversification decrease. However, evidence suggests that the

[49] Term globalisation is commonly used in International economics with similar meaning. In that reference, globalisation help financial sector to operate in a global environment enabling investors to diversify risk internationally and facilitate consumption smoothing, Schmukler (2004)

correlation associated with emerging market returns is still sufficiently low to provide portfolio diversification benefits.[50]

Temporary changes in correlations are possible due to short-term local effects. For example, a reduction in barriers to trade induces foreign capital inflow and initial capital flows bid up prices and help create a 'return to integration'. But these flows level out in the three years of post-liberalization (Bekaert, Harvey and Lumsdaine 2002, Stulz 1999, Griffin, Nardari and Stulz 2002). Also, contagion (abnormally high correlation between markets during crisis period) can have a substantial effect on the gains from diversification. There have been many economic crises during the period 1992 to 2002 in emerging markets: Mexico in 1994-95, East-Asia 1997-98, Russia 1998, Brazil 2000 and Argentina in 2002. These crises are associated with abnormal correlations between markets. Abnormal correlations are defined as extreme correlations, determined by comparing correlations with expected correlations (possibly derived from a factor model). In defining contagion in this manner, there is evidence of contagion during the Asian crisis but no evidence of contagion during the Mexican crisis (Tang 2002).

Another relevant characteristic distinguishing emerging markets is the nature of the return distribution. In finance applications, a common assumption is the equity returns follow a normal distribution. However, emerging market returns are not normally distributed (Harvey 1995). The author finds similar results for both post

[50] De Santis (1993), Harvey (1995) document the initial portfolio diversification benefits, Bailey and Lim (1992), Bekaert and Urias (1996, 1999), Errunza et al. (1999) evaluate the diversification benefits of country funds and ADR's. De Roon Nijman and Werker (2001) re-examine the diversification benefits with transactions costs and short-sale constraints.

and pre-liberalization returns. While liberalization events impact on expected returns and correlations, emerging market return distributions are skewed and have fat tails.

Emerging market equity returns are also found to have higher serial correlation than developed equity markets. This serial correlation is symptomatic of infrequent trading and slow adjustment to current information (Harvey (1995), Kawakatsu and Morey (1999)). Emerging market returns are less likely to be impacted by company specific news announcements than developed market returns. There is further evidence that insider trading occurs well before release of information to the public (Bhattacharya, Daouk, Jorgenson and Kehr 2000).[51]

Market integration is a major development from the segmented market for the emerging markets, inducing a structural change in the capital markets of the country. Hence, it is important to identify the dates of these structural changes for any empirical analysis. A number of different strategies have been pursued to determine the timing of integration of the world capital markets. The four main approaches are: event association, inference from the behaviour of the financial assets and inference from the behaviour of key economic aggregates and market infrastructure. The event association strategies include: (1) the regulatory reform date, (2) the date (preferably announcement) of the first country fund,[52] (3) date (announcement) of the first local equity listing or American Depositary Receipt on a foreign exchange. The finance strategies require looking for changes in the

[51] Choe, Kho and Stulz, (2002) examine the informativeness of domestic versus foreign investors..
[52] See Miller (1999), Karolyi (1998), Foerster and Karolyi (1999), Urias (1994)

behaviour of asset returns and establishing a link between the date of change with the market integration. For example, if dividend yields have an association with expected returns, a sharp drop in dividend yields could be linked to market liberalization (Bekeart and Harvey, 2002, Basu, Kawakatsu and Morey 1999). The economic strategies involve analyzing the key economic aggregates that may be impacted by liberalization to establish the time of integration (Kim and Singal 2000, Basu et al. 1999). Market infrastructure effects relate to the degree of investor protection and quality of accounting information. For example, some researchers consider the date of the enforcement of the capital market regulations, such as insider trading prosecution, as an indicator of market integration (Bekaert and Harvey 2000, Henry 2000a, Bhattacharya and Daouk 2002).

The date of regulatory liberalization does not necessarily define an event time for market integration. Care should be taken to differentiate between the concepts of liberalization and integration. A country may pass a law, which appears to drop all barriers to foreign participation in local markets. The act involves liberalization but this may not lead to effective market integration. The market may have been integrated before this event, because the foreign investors could have had access to the market through other means[53]. The other possibility is that the liberalization has little or no effect because either foreign investor thinks these regulatory

[53] Some may argue that the harmonization of accounting standards and work of International Organisation of Securities Committee may hasten the integration process and negate the benefits of diversification that may exist today. However, the standardization in itself is not expected to hasten the integration but offcourse this will lead to a better comparison of the equities and may reduce the research costs in the emerging markets. However the integration will depend on the regulatory framework and the economic structures of the economies.

reforms will not be long lasting or other market imperfections exist (Bekeart and Harvey 2002).

Moreover, market integration is a gradual process and the speed of process will be determined by the situation in each individual country. There are numerous barriers to integration when one country starts the process. Bekaert (1995) lists three main categories of barriers to the emerging market investments: legal barriers, indirect barriers that arise from information asymmetries, accounting standards and investor protection and risks that are especially significant in emerging markets such as liquidity risk, political risk, economic policy risk and currency risk. These barriers discourage foreign investments and it is unlikely that these barriers will disappear immediately. Empirical models have been developed which allow the degree of market integration to change through time (Bekaert and Harvey 1995 & 1997, Adler and Qi 2002).

There are important links between the real economy and financial sector. As noted above, market integration is associated with lower expected returns and consequent decrease in cost of capital. This should lead to an increase in investments as more projects will have a positive net present value (Bekaert and Harvey 2000, Henry 2000b). Evidence also suggests that the trade balance worsens after equity market liberalizations, suggesting that the additional investment is financed by foreign capital. Personal consumption does not increase and real GDP growth increases. As discussed in the previous sections, although it is difficult to attribute causality from the financial sector to the real economy, the evidence

points to the important role of capital markets in the economic growth prospects of less developed countries.

While there is no robust evidence that the volatility of equity returns increase with liberalization, it is the volatility of real economy that is of greater importance. Recent sharp economic declines, mainly during the Asian crisis, have led many people to argue that liberalization may lead to increased volatility in a country's economic growth (Stiglitz, 2000). However, Bekaert, Harvey and Lundblad (2002) do not find evidence of significant increase in volatility. If the Asian crisis is excluded, the evidence suggests rather a decrease in economic growth volatility. The volatility of economic growth is related to the concept of globalization leading to improvements in risk sharing. When the predictable components of consumption growth are stripped out, the evidence weighs in favor of risk sharing (decreased idiosyncratic consumption growth volatility after liberalization).[54] Das (2002) has argued that the volatility is more a cause of the weaker financial system and not the liberalization per se. He argues that if there is a proper supervision of the regulatory framework and financial sector progress the negative impacts of the globalization can be eliminated.

4.7 Changes in Correlations.

Correlations in international equity returns have changed over time (Erb, Harvey and Viskanta 1994; Longin and Solnik 1995) and intuitively the correlations are expected to increase as integration proceeds in segmented markets (Bekaert and

[54] See Lewis (1996, 1999, 2000), Athanasoulis and van Wincorp (2000, 2001) for tests of risk sharing. Bekaert, Harvey and Lindbland (2002) link international risk sharing with equity market liberalization.

Harvey 2002). Empirically Goetzmann, Li and Rouwenhorst (2005) find global correlations have increased with globalisation. Research in the area of portfolio management has also looked into the factors which may drive the changes in correlations over time. Jithendranathan (2005) tests whether macroeconomic factors can cause changes in correlations in equity returns for the USA and Russian equity markets. He finds that interest rate spread, change in exchange rates and change in energy price index had statistically significant relationship with the correlations between two market returns. Loretan and English (2000) test the relationship between volatility and correlations for equities, bonds and foreign exchange. Loretan and English (2000) find that a significant proportion of the changes in correlations over time is explained by the differences in sample volatilities. Forbes and Rigobon (2002) look at the volatility and evidence for contagion. Antoniou, Pescetto and Stevens (2007) in the study of world market integration find correlations in equity returns to change over time. Changes in correlations affect potential benefits of diversification and accurate measurement of these correlations can help accurately estimating the benefits of diversification. The justification of the model used for estimating changing correlations has been discussed in section 4.9 and the technical discussion of the model has been included in Research Methodology Chapter.

In periods of increased market volatility, correlations between returns on financial assets have a tendency to increase as compared with the correlations during periods of standard volatility. Several studies have documented the contagion in the market and argue that markets' covariance increase faster than their

variances[55]. This increase in correlations in the asset returns during the periods of abnormal volatility is often explained as resulting from the changes in the relationship that determine the asset returns.

When the movements of random variables are more volatile, sample correlations between these variables should increase even if the principal processes generating the variables remain unaffected, Boyer et al (1999) provided a formal proof for this link. Loretan and English (2000) use this in their study of relationship between variances and correlations. They find an evidence of contagion in the markets around the crisis. A later and more rigorous study by Forbes and Rigobon (2002) use the major market crisis as the shock events and find no evidence of contagion[56]. Contrary to the Boyer et al (1999) and Loretan and English (2000), Yoon (2005) argued that lower (higher) volatility will cause correlations to move higher (lower) and test the relationship empirically using a stochastic unit root process. The author finds that for the US economy the cross-country correlations have increased after adjusting for lower variability in the US economy over the years. The development of the argument that the correlations and volatility of the underlying asset are linked has an important implication for this study.

4.8 International diversification from an Australian investor's perspective.

The research on international portfolio diversification from an Australian investor's perspective is limited, especially in respect of the emerging markets.

[55] See Lin, Engle and Ito (1994), Erb, Harvey and Viskanta (1994), Longin and Solnik (1995), Karolyi and Stulz (1996), Solnik, Boucrelle and Le Fur (1996), De Santis and Gerard (1997), Ang and Bekaert (1999) and Das and Uppal (2001).

[56] They use 1997 Hong Kong crash, 1994 Mexico crash and 1987 U.S. crash as shocks for the study of contagion around the crash periods.

Studies quoted here are all based on a sample of developed economies. Allen and Macdonald (1995) assess the diversification benefits available to the Australian investor over the period 1970 to 1992 and find that for most pairwise portfolios there exist potential long-run portfolio diversification gains. Similar results are reported by Watson and Dickinson (1981), Mitchell, Wapnah and Izan (1988) and Izan, Jalleh and Ong (1991).

Wright and McCarthy (2002) consider investments in multi-national corporations and their international portfolio diversification benefits for Australian investors. The authors find the returns realised by an equity portfolio of Australian based MNC's are not significantly different to those realised by a portfolio of purely domestic Australian firms. It is suggested that this result may arise because Australian-based MNC's are small by world standards and do not themselves offer sufficient diversification to provide investors in them the benefits implied on theoretical grounds. The study also suggests that the low liquidity of Australian Stock Exchange, coupled with the Australian investor's risk aversion to purchasing foreign shares, means that the Australian equity market lies closer to the segmentation end of the segmentation-integration continuum. This argument has an important bearing on the diversification opportunities available for Australian investors. As discussed earlier market segmentation arises from imperfections in national capital markets and causes the required rates of return on comparable assets, after adjusting for foreign exchange risk and political risk, to differ between national markets, (Wright and McCarthy 2002, p. 80).

Investors in the United States exhibit a strong home-country bias because of the perceived convenience and familiarity of the domestic stock exchange. Similarly, in Australia, investors prefer to purchase shares listed on Australian Stock Exchange, because of their lack of knowledge and/or perceived convenience and familiarity. Australian market has a market capitalisation of less than 4% of the New York Stock Exchange, (Wright and McCarthy 2002, p. 80). Though many of these barriers have been reduced recently, investor perceptions continue to produce segmentation (Russel 1998).

The Australian share market is small compared to the major overseas markets. And country size per se may matter in two ways (Bernstein and Weinstein (1998)). First economic activity in a small country may be geographically localized, so the nearby geographical activity, e.g. monsoons or other local "acts of God" might have local market-wide effects that would not be as evident in a larger economy. Second, economic specialisation is predicted by standard international trade theory across geographical units of similar size, but not across countries. This is consistent with larger countries having less uniform factor endowments, and implies that the stocks of firms in large economies should respond less.

The effect of the size on the Australian market on the benefits from the inclusion of emerging markets stocks in an Australian portfolio is yet to be determined. We can conclude that given the nature of the Australian market, significant liberalization in many developing countries and the segmentation of the emerging markets that there are likely to be gains for Australian investors from diversification into the emerging markets.

4.9 Methodologies used

Whether there are benefits in diversifying or not; this question can only be answered by testing whether these additional assets provide investors with significant benefits, and if so, how we can measure these benefits. Huberman and Kandel (1987) provide a formal tool to analyse this question. They develop a regression-based test for whether the introduction of some new assets significantly expands the mean-variance frontier spanned by existing assets. Kan and Zhou (2001) provide a comprehensive review of the literature in this area and refine the regression-based mean variance spanning test by deriving both the asymptotic and small sample properties of this test. (A detailed discussion on the selection of the model used and the rationale is included in the following chapter on research methodology).

Motivated by the duality between mean-variance frontiers of asset returns and Hansen-Jagannathan (1991) bounds on stochastic discount factors, Ferson, Forester, and Keim (1993), and DeSantis (1995) propose a series of GMM tests for mean-variance spanning. Bekaert and Urias (1996) show the equivalence between these two types of tests and apply the latter to test the diversification benefits of closed-end country funds. Recently, Hentschel and Long (2002) have developed a numeraire portfolio test of market integration based on non-arbitrage principle and have applied it to evaluate the diversification benefits of emerging markets. The other method of estimating correlations is to use multivariate GARCH models. The initial models in this group were based on the Constant Correlation Coefficient model of Bollerslev (1990). These models were based on the

assumption that the correlations coefficients are constant over time, which is unrealistic; this was the main weakness of the models of this class. Second set of the GARCH models used in this context are based on multivariate GARCH model introduced by Kroner and NG (1998). Though theoretically appealing these models were computationally complex because of the need for estimation of too many coefficients at the same time. These models were complex and time consuming because the number of parameters needed to be estimated were large. As such most studies considered only five assets despite the apparent need for much larger correlation matrices.[57] Engle (2002) introduced multivariate GARCH models called "Dynamic Conditional Correlation Models", which combined flexibility of the univariate models with theoretical appeal of time varying correlations. This model is used by Jithendranathan (2005) in his study on changes in correlations between the US and Russian equity markets. Similar model was also used by Cha and Jithendranathan (2007) for evaluating the time varying correlations and benefits of diversification into emerging markets for US investors. This development in the series of multivariate GARCH models was the introduction of 'Dynamic Conditional Correlation' model of Engle (2002)[58], main weakness of this model is its two step estimation process that makes it easier to estimate but correlation processes are restricted to same dynamic structure. Another weakness of the DCC model was in ignoring the asymmetric effects in the initial model. In general when time varying volatility is not important the relative

[57] The number of potential assets that could be included in an optimised portfolio will be significantly more than five assets used in the studies using alternative multivariate GARCH models as inclusion of more assets will make it harder to estimate these models.
[58] Robert Engle was awarded Nobel Prize in 2003 for his work *'for methods of analysing economic time series with time-varying volatility (ARCH)'*.

advantages of the DCC model is reduced and DCC model is difficult to estimate for a shorter series because of convergence problems. Current model as proposed in Cappielo, Engle and Sheppard (2006) and used in this study overcomes the problem of asymmetry. And two-step estimation though causes some efficiency losses but makes it easier for estimation of more number of parameters together. Engle (2002) find DCC to be competitive with other multivariate GARCH specification and similar results are reported by Wong and Vlaar (2003). Jithendranathan (2007) in a comparison of ex post performance of the optimised portfolios finds that the portfolios constructed with correlations estimated using DCC model yields better results as compared with the rolling estimator. Engle (2002) reviewed the performance of the multivariate GRACH models in his paper and find that the DCC GARCH model is a good approximation.

> The comparison of DCC with simple multivariate GARCH and several other estimators shows that the DCC is often the most accurate. [.] Statistical tests on real data indicate that all these models are miss-specified but that the DCC models are competitive with the multivariate GARCH specifications and are superior to moving average methods.
>
> (Engle 2002, p. 348)

This research proposes to use this model because it is theoretically sound, easy to use and has been used in a similar study. Jithendranathan (2005) uses this model for estimating time varying correlations for the USA and Russian equity returns. Though Russia is not included in the emerging market sample, from the time of the break-up of Soviet Union, a market economy has been evolving in the Russian

federation and one of the key components of this market economy is the emerging equity market. Since the Russian market is very similar to the emerging market, it is appropriate to use this model for the emerging market analysis.

4.10 Conclusion

My review of the theoretical and empirical research into international diversification indicates, despite increasing globalisation, benefits accrue to investors holding stocks listed in other countries. These benefits arise, in part, from differences between countries in the nature of their real economies. And the greatest differences in real economy structures arise when comparing the emerging markets with the developed markets. Thus, on theoretical grounds, emerging market investments should provide a means by which an investor can achieve higher risk-adjusted returns for a diversified portfolio.

Empirical research indicates that there are still benefits to be realised in diversifying internationally, because World financial markets are still not fully integrated (globalised), e.g. see Schmukler (2004) and Li, Sarkar and Wang (2003), Ibrahim (2006), Driessen and Laeven (2007).

Differences between emerging and developed economies are reflected into the financial markets in the key characteristics of return, risk and correlations. Correlations are of direct relevance for diversification advantages. Previously enumerated financial characteristics are time-varying as a result of the increasing globalisation of the world's economies. Increasing market integration has significantly reduced the diversification benefits from a portfolio drawn from

developed markets but not influenced the benefits from emerging markets investments to the same degree (Harvey 2000). While differences continue in the real and financial sectors of emerging markets compared to those of the developed markets, these diversification advantages are likely to continue. Direct investment in the financial sectors of other countries is indicated since investments in multinational corporation stocks provide a less than optimum mechanism for investment.

The published research, thus far indicates on theoretical grounds Australian investors will continue to benefit from investment in emerging markets. First, all investors are likely to gain from the greater segmentation of the emerging markets compared to that of the developed markets despite the trend towards globalisation. Second, the Australian market is small by comparison with other markets such that international diversification benefits are more apparent for local investors. Finally, differences in the real economies of Australia, the emerging markets and other developed markets provide a theoretical basis for the selection of emerging market stocks by Australian investors. Since benefits of international diversification are diminishing and emerging markets may have higher risk exposure, an accurate estimate correlations and thus potential diversification benefits is key to a successful portfolio strategy. This study will use Asymmetric DCC GARCH model for estimate of changing correlations. Asymmetric DCC GARCH model is expected to give an accurate estimate of changing correlations thus a better estimate of potential benefits of diversifying into emerging markets for Australian investors.

Research also indicates that the correlations in equity markets across different countries are not constant over time. This relationship has been tested with regards to the tests of contagion but not as underlying factors that may influence correlations in equity returns in normal circumstances. This study will test if the volatilities of the market pairs or the relative volatility of these market pairs can influence the correlations of the returns of the two markets over time.

Research into the benefits of international diversification from the perspective of major equity markets is well established. Further the research has looked in to the specific benefits of investing into emerging equity markets owing to the special characteristics of the emerging equity markets. This study extends the literature to look in to the benefits of international diversification in to emerging markets from the perspective of an Australian investor.

Chapter 5

Research Methodology

5.1 Introduction:

The past twenty years has seen an increasing interest among investors to diversify across borders and across different asset classes. The trend of diversification is matched by the increasing accessibility to international capital markets and a greater variety of investment vehicles. A natural question that investors seek to answer is whether these assets indeed provide them with significant diversification benefits, and if so, how we can measure these benefits. Huberman and Kandel (1987) provide a formal tool to analyze these questions. They develop a regression-based test for whether the introduction of some new assets significantly expands the mean-variance frontier spanned by existing assets. Kan and Zhou (2001) provide a comprehensive review of the literature in this area and refine the regression-based mean-variance spanning test by deriving both the asymptotic and small sample properties of this test.

Motivated by the duality between mean-variance frontiers of asset returns and Hansen-Jagannathan (1991) bounds on stochastic discount factors, Ferson, Forester, and Keim (1993), and DeSantis(1995) propose a series of GMM tests for mean-variance spanning. Bekaert and Urias (1996) show the equivalence between these two types of tests and apply the latter to test the diversification benefits of closed-end country funds. Recently, Hentschel and Long (2002) have developed a numeraire portfolio test of market integration based on non-arbitrage principle and have applied it to evaluate the diversification benefits of emerging markets. The other method of estimating correlations is to use multivariate GARCH models. The initial models in this group were based on the Constant Correlation

Coefficient model of Bollerslev (1990). The assumption that the correlations coefficients are constant over time was the main weakness of these models. Second set of the GARCH models used in this context are based on multivariate GARCH model introduced by Kroner and NG (1998). Multivariate GARCH models were theoretically appealing but were computationally complex because of the need for estimation of too many coefficients at the same time. Engle (2002) introduced multivariate GARCH models called "Dynamic Conditional Correlation Models", which combined flexibility of the univariate models with theoretical appeal of time varying correlations. This model is used by Jithendranathan (2005) in his study on changes in correlations between the US and Russian equity markets. My research proposes to use this model because it is theoretically sound, easy to use and it has been used in a similar study.

5.2 Background

The existing literature on testing diversification benefits generally falls under three categories: regression based mean-variance spanning tests, stochastic discount factor (SDF) based GMM tests, numeraire portfolio tests based on non-arbitrage principles and the multivariate GARCH models. In this section, I briefly review these tests and discuss the inadequacy of using their results as the measure for diversification benefits. On the basis of this review selection of methodology best suited to the study is made.

5.2.1 Regression Based Spanning Tests

Huberman and Kandel (1987) introduce a simple regression based test for the hypothesis that the introduction of new assets (test assets) expands the mean-variance frontier spanned by the existing assets (benchmark assets):

$$r = \alpha + BR + e \quad (5.1)$$

where r is the $NX1$ return vector of test assets and R is the $KX1$ return vector of benchmark assets. Authors show that this hypothesis is equivalent to imposing the following restrictions on the Equation 1:

$$\alpha = 0$$

$$B \times \acute{\iota}_K = \acute{\iota}_N \quad (5.2)$$

They show that these restrictions can be tested using a likelihood ratio (LR) test. Jobson and Korkie (1989) extend this test to a multivariate setting. Kan and Zhou (2001) point to an error in the Huberman and Kandel (1987) test, as well as the lack of power of the LR test in multivariate cases. To resolve the problem with the power of the LR test, the authors suggest that one should look at the results of all other equivalent tests, i.e. Lagrangian multiplier test (LM) and Wald test. Moreover, they derive both the asymptotic and small sample test statistics for all three equivalent tests. Kan and Zhou also show that regression based mean-variance spanning tests performs similarly with SDF based GMM tests when the underlying asset returns are normally distributed. However, the former tests show

superior properties to the latter when the asset returns distribution deviates from normality.

5.2.2 SDF Based GMM Tests

Ferson, Forester, and Keim (1993), DeSantis(1995), and Bekaert and Urias (1996) propose a series of tests for mean-variance spanning by exploiting the duality between the mean-variance frontiers of asset returns and the Hansen-Jagannathan (1991) bounds on stochastic discount factors. Under Hansen-Jagannathan (1991) framework, the conditional asset pricing restriction can be expressed as follows:

$$E\left((R_{t+1} + \acute{\imath})m_{t+1} | \Phi_t\right) = \acute{\imath} \quad (5.3)$$

where R_{t+1} is the vector of asset returns, m_{t+1} is the stochastic discount factor, and Φ_t is the information set at time t. Define $m^{\alpha}{}_{t+1}$ as the stochastic discount factor formed from the projection of m_{t+1} onto asset returns R_{t+1};

$$m^{\alpha}{}_{t+1} \equiv \alpha + [R_{t+1} - E(R_{t+1})]' \beta^{(\alpha)} \quad (5.4)$$

Let $\beta_N^{(\alpha)}$ be the portion of $\beta^{(\alpha)}$ corresponding to the test assets, then the spanning restrictions in the Hansen-Jagannathan (1991) framework are:

$$\beta_N^{(\alpha)} = 0_N$$

$$E(R_{t+1} m^{\alpha}{}_{t+1}) + E(m^{\alpha}{}_{t+1}) = \acute{\imath} \quad (5.5)$$

Bekaert and Urias (1996) explicitly show that the restrictions above are equivalent to those in Huberman and Kandel (1987) as in Equation 2, and these restrictions can be tested using a GMM test. However, since GMM tests generally rely on the

validity of its asymptotic distribution, they do not perform well in small samples. Bekaert and Urias (1996) compare the LR test of Huberman and Kandel (1987) with the GMM test. Using various simulations, they find a lack of power of the latter test, especially in small sample.

5.2.3 Numeraire Portfolio Tests

Long (1990) shows that, when trading is restricted to a set of assets, the non arbitrage condition is equivalent to the existence of a numeraire portfolio of these assets that satisfy the following conditions:

$$Prob_t\,[1 + r_{N,t+1} > 0] = 1$$

$$Et\,[(1+r_{i,t+1})/(1+r_{N,t+1})] = 1 \quad (5.6)$$

where *ri;t*+1 represents any asset return, and *rN;t*+1 is a numeraire portfolio.3 Based on this concept, Hentschel and Long (2002) develop a test of market integration by searching for such a numeraire portfolio. They also extend this approach to the context of measuring diversification benefits.

5.2.4 Multivariate GARCH models

Initial models in the group of multivariate GARCH models were based on the Constant Correlation Coefficient model of Bollerslev (1990). Models in this category assumed that the correlation coefficients are constant over time. This assumption is the main weakness of these models. Kroner and Ng (1998) introduced another variant of multivariate GARCH models. Though theoretically

appealing, these models are computationally complex requiring estimation of too many coefficients. Engle (2002) introduced a new class of multivariate GARCH models called "Dynamic Conditional Correlation Models" which combine the flexibility of univariate models with the theoretical appeal of time varying correlations.

5.3 Estimating time-varying correlations

Latest development in the series of multivariate GARCH models was the introduction of 'Dynamic Conditional Correlation' model of Engle (2002)[59], main weakness of this model is its two step estimation process that makes it easier to estimate but correlation processes are restricted to same dynamic structure. Another weakness of the DCC model was in ignoring the asymmetric effects in the initial model[60]. In general when time varying volatility is not important the relative advantages of the DCC model is reduced and DCC model is difficult to estimate for a shorter series because of convergence problems. Current model as proposed in Cappielo, Engle and Sheppard (2006) and used in this study overcomes the problem of asymmetry. And two-step estimation though causes some efficiency losses but makes it easier for estimation of more number of parameters together. Engle (2002) find DCC to be competitive with other multivariate GARCH specification and similar results are reported by Wong and Vlaar (2003). Jithendranathan (2007) in a comparison of ex post performance of the optimised

[59] Robert Engle was awarded Nobel Prize in 2003 for his work *'for methods of analysing economic time series with time-varying volatility (ARCH)'*.

[60] Karolyi and Stulz (1996), Ang and Bekaert (1999), Longin and Solnik (2001), Ang and Chen (2002) and Bae, Karolyi and Stulz (2003) have shown asymmetrical nature of the correlations in the asset prices for global markets.

portfolios finds that the portfolios constructed with correlations estimated using DCC model yields better results as compared with the rolling estimator. Engle (2002) reviewed the performance of the multivariate GRACH models in his paper and find that the DCC GARCH model is a good approximation.

The comparison of DCC with simple multivariate GARCH and several other estimators shows that the DCC is often the most accurate. Statistical tests on real data indicate that all these models are miss-specified but that the DCC models are competitive with the multivariate GARCH specifications and are superior to moving average methods.

(Engle 2002, p. 348)

The[61] conditional correlation between two random variables r_1 and r_2 that have mean zero can be written as:

$$\rho_{12,t} = \frac{E_{t-1}(r_{1,t} r_{2,t})}{\sqrt{E_{t-1}(r_{1,t}{}^2) E_{t-1}(r_{2,t}{}^2)}} \qquad (5.7)$$

Let $h_{i,t} = E_{t-1}(r_{1,t}{}^2)$ *and* $r_{i,t} = \sqrt{h_{i,t}\varepsilon_{i,t}}$ *for* $i = 1, 2,$ *where* $\varepsilon_{i,t}$ is a standardised disturbance that has zero mean and a variance of one ; $\varepsilon_t = D_t^{-1} r_t$

Substituting the above into equation (1) we get:

$$\rho_{12,t} = \frac{E_{t-1}(\varepsilon_{1,t}\varepsilon_{2,t})}{\sqrt{E_{t-1}(\varepsilon_{1,t}{}^2) E_{t-1}(\varepsilon_{2,t}{}^2)}} = E_{t-1}(\varepsilon_{1,t}\varepsilon_{2,t}) \quad (5.8)$$

Using GARCH(1,1) specification, the covariance between the random variables can be written as:

[61] For ease of read detailed assumptions for the DCC model are omitted here but included in Annexure 6

$$q_{12,t} = \overline{\rho}_{12} + \alpha(\varepsilon_{1,t-1}\varepsilon_{2,t-1} - \overline{\rho}_{12}) + \beta(q_{12,t-1} - \overline{\rho}_{12}) \quad (5.9)$$

The unconditional expectation of the cross product is $\overline{\rho}_{12}$, while for the variances

$\overline{\rho}_{12} = 1$

The correlation estimator is:

$$\rho_{12,t} \frac{q_{12,t}}{\sqrt{q_{11,t}q_{22,t}}} \quad (5.10)$$

This model is mean reverting if $\alpha + \beta < 1$. The matrix version of this model is written as:

$$Q_t = S(1 - \alpha - \beta) + \alpha(\varepsilon_{t-1}\varepsilon'_{t-1}) + \beta Q_{t-1} \quad (5.11)$$

where S is the unconditional correlation matrix of the disturbance terms and $Q_t = |q_{1,2,t}|$. The log likelihood for this estimator can be written as:

$$L = -\frac{1}{2}\sum_{t=1}^{T}(n\log(2\pi) + 2\log|D_t| + \log|R_t| + \varepsilon'_t R_t^{-1}\varepsilon_t) \quad (5.12)$$

where $D_t = diag\left\{\sqrt{h_{i,t}}\right\}$ and R_t is the time varying correlation matrix.

As this model does not allow for asymmetries and asset specific news impact, the modified model which Cappiello, Engle and Sheppard (2006) use for incorporating the asymmetrical effect and the asset specific news impact is:

$$Q_t = (\overline{Q} - A'\overline{Q}A - B'\overline{Q}B - G'\overline{N}G) + A'\varepsilon_{t-1}\varepsilon'_{t-1}A + B'Q_{t-1}B + G'n_{t-1}n'_{t-1}G \quad (5.13)$$

where A, B and G are diagonal parameter matrixes, $n_t = I[\varepsilon_t < 0]o\ \varepsilon_t$ (with o indicating Hadamard product), $\overline{N} = E[n_t n'_t]$. For $\overline{Q}$ and $\overline{N}$, expectations are infeasible and are replaced with sample analogues, $T^{-1}\sum_{t=1}^{T}\varepsilon_t\varepsilon'_t$ and $T^{-1}\sum_{t=1}^{T}n_t n'_t$, respectively. $Q_t^* = [q_{ii,t}^*] = [\sqrt{q_{ii,t}}]$ is a diagonal matrix with the square root of the ith diagonal element of Q_t on its ith diagonal position[62].

5.4 Efficient Portfolios

The efficient frontier is defined as the set of portfolios that exhibit the minimum amount of risk for a given level of return or the highest return for a given level of risk, and that lies above the global minimum variance portfolio. Elton, Gruber and Padberg (1976) show that one is able to use a simple decision criterion to reach an optimal solution to the portfolio problem by assuming a risk free asset exists, and that either the single index model adequately describes the variance-covariance structure, or a good estimate of pair wise correlations is a single figure. This simple criterion not only allows one to determine which stocks to include but also how much to invest in each.

[62] In this case I have used notation as given in Cappielo, Engle and Sheppard (2006). In that paper authors replace 'α' with 'A' and 'β' with 'B' and introduce third term 'G' for asymmetric effects, in equation 5.13 this study has used the notation similar to that of the authors.

The first approach utilises the single-index model[63] to construct optimal portfolios.

Where returns are determined as follows:

$$r_i = \alpha_i + \beta_i r_m + \varepsilon_i \qquad (5.14)$$

where r_i is the return on security i

r_m is the return on the market index

α_i is the return on security i that is independent of the market's performance

β_i is a constant that measures the expected change in R_i given a change in R_m

ε_i is the random error term with mean of zero and variance of $\sigma^2_{\varepsilon_i}$

Assuming that short selling is possible, the task would be to find the unconstrained vector of relative weights for each security so that the Sharpe ratio is maximised. That is:

To find the relative weights, X_i's on each security to maximise

the Sharpe ratio, $\theta = \dfrac{\bar{r}_p - r_f}{\sigma_p}$ (5.15)

where $\bar{r}_p$ is the mean return on the portfolio

σ_p is the standard deviation of the return on the portfolio

[63] The assumption that single index model holds is synonymous with the assumption that CAPM holds. However, tests of CAPM and/or single index model is beyond the scope of this study.

given that

$$\bar{r}_p - r_f = \sum_{i=1}^{N} X_i \left(\bar{r}_p - r_f\right) \tag{5.16}$$

and

$$\sigma_p^2 = E\left(\sum_{i=1}^{N} X_i r_i - \sum_{i=1}^{N} X_i \bar{r}_i\right)^2$$

$$\sigma_p^2 = \left[\sum_{i=1}^{N} X_i^2 \beta_i^2 \sigma_m^2 + \sum_{i=1}^{N}\sum_{j=1}^{N} X_i X_j \beta_i \beta_j \sigma_m^2 + \sum X_i^2 \sigma_{\varepsilon_i}^2\right] \tag{5.17}$$

These equations are substituted into the Sharpe ratio equation and in order to maximise the Sharpe ratio it is necessary to take the derivative of the Sharpe ratio with respect to each X_i and set it equal to zero. The derivation yields the amount of the portfolio that should be invested X_i^0 in any security as:

$$X_i^0 = \frac{\dfrac{(\bar{r}_j - r_f) - C_0 \beta_i}{\sigma_{\varepsilon_j}^2}}{\sum_{i=1}^{N} \left| \dfrac{(\bar{r}_j - r_f) - C_0 \beta_i}{\sigma_{\varepsilon_j}^2} \right|}$$

$$\text{where } C_0 = \sigma_m^2 \frac{\sum_{i=1}^{N} \left[\dfrac{\bar{r}_j - r_f}{\sigma_{\varepsilon_j}^2} \beta_j \right]}{1 + \sigma_m^2 \sum_{i=1}^{N} \dfrac{\beta_j^2}{\sigma_{\varepsilon_j}^2}} \tag{5.18}$$

Thus by applying the above equation one is able to determine the respective weightings for each security within the portfolio and to find the optimal portfolio's risk and return measures. That is, the risk and returns are obtained by substituting

the respective weights found for each security into the returns and variance formula given in (9) and (10) respectively[64].

Sharpe measure is often criticised for being too simple and a text book measure however, Eling and Schuhmacher (2007) in a review of performance measures find that Sharpe and other measures result in similar rankings. For validation purpose this study uses another risk adjusted measure proposed by Modigliani and Modigliani (1997) referred to as RAP measure. M2 measure is a common name RAP measure. The M2 measure is equivalent to the return a portfolio would have achieved if it had had the same risk as the benchmark risk (in this case we use Australian index as a benchmark index). The risk adjusted performance (RAP)[65] measure can be calculated as:

$$RAP_{(i)} = (\sigma_M / \sigma_i)(r_i - r_f) + r_f \quad (5.19)$$

where σ_M and σ_i are the volatilities of the market and the stock, r_i and r_f are the returns of the portfolio and risk free returns respectively and $RAP_{(i)}$ is the risk adjusted performance measure of the portfolio.

[64] The model is for no restrictions on short sale. The standard optimisation problem can be written as:

$Min\sigma_P^2 = \sum_{i=1}^{N} X_i^2 \sigma_i^2 + \sum_{i=1}^{N} \sum_{\substack{k=1 \\ k \neq i}}^{N} X_i X_k \sigma_i \sigma_k \rho_{i,k}$ subject to the constraint : $\sum_{i=1}^{N} X_i = 1$; if short selling is not allowed the additional constraint will be of non-negative weights, expressed as $0 \leq X_i \leq 1$. Similar minimum or maximum weight restrictions are imposed when introducing restrictions of minimum investments into Australian index and/or maximum restrictions into emerging market indexes.

[65] In this study M2 is used for RAP thereafter.

5.5 Testing relationship between Volatility and Correlations

Bekaert and Wu (2000) give an empirical framework for analysing the asymmetric volatility in the equity markets and Forbes and Rigobon (2002) develop a relationship between volatility and the correlations. Studies prior to these studies did not address the asymmetric dynamics in the correlations and/or the economic rationale for changes in correlations.

According to Bekaert and Wu (2000), a negative shock at the market level produces two effects. Firstly, investors may change their expectations of conditional variance upwards; as this upward movement in conditional volatility at the market level is rewarded by an increase in returns, the current value of the market will fall. Secondly[66], the fall in prices across the market will result in an increase in leverage at market level and hence higher stock volatility. The second outcome will cause the volatility feedback.

The external shock may cause a change in the conditional variances of one or both markets[67] and this change in conditional variances at market levels can result in a change in correlations between the expected returns of the markets. If the influence of the external shock is the same on both the markets, the external shock is not expected to have any impact on the correlations between the expected returns of the two markets. In addition, if the external shock is asymmetrical on the conditional variances, it will cause a change in the correlations. Further, a higher volatility in the random variables can cause the sample correlations between these

[66] Leverage effect has a reverse causal relationship to the volatility feedback.
[67] This is with reference to the pairs of markets for which the correlations are being estimated.

variables to increase even if the principal processes that generate the variables remain unchanged; Boyer, Gibson and Loretan (1999) initially developed this theoretical argument[68]. Loretan and English (2000) use this in their study of the relationship between volatility and correlations. Following this argument Forbes and Rigobon (2002) find no evidence of contagion with the US market during the financial crises in the Hong Kong and Mexico. Yoon (2005) has argued that lower (higher) volatility will cause correlations to move higher (lower) and test the relationship empirically using a stochastic unit root process. The author finds that for the US economy the cross-country correlations have increased after adjusting for lower variability in the US economy over the years. Based on the findings of Yoon (2005), I assume a decrease in volatility of the equity returns to cause increase in correlations among the markets.

When the expected risk of an asset changes, this change also influences the correlations of the returns of this asset with the returns of the other assets included in the portfolio. Since I am using the emerging market indexes for the study, overall change in the country risk may change the risk of the equity market index of the country. To capture this changing country risk I use the volatility of the returns of the broad based equity index of the country as one of the variables that can cause the changes in the expected risk of the emerging market equities and subsequently correlation of the returns of the emerging market with the returns of

[68] See Boyer, Gibson and Loretan (1999) for a formal proof and Loretan and English (2000) for application of the relationship.

the Australian equities[69]. I test for volatility of the emerging market, volatility of the Australian market and the ratio of the volatility of the emerging equity market to the volatility of the Australian equity market. Following Young and Johnson (2004), I use this ratio as a measure of relative volatility of the two markets.[70] Purpose of using the ratio of the volatility is to capture the relative volatility measure as used in the market. Practitioners in the market frequently use the ratio as a measure of the relative volatility of the two markets. Intuitively, this can be compared with the beta as used in the asset pricing; beta in CAPM is a measure of relative volatility of the asset to the market volatility.

Study uses the following regression model to estimate the factors that may cause the correlations to vary over time:

$$\rho_{i,t} = \alpha_i + \beta_1 Volatility_E + \beta_3 {}^{Volatility_E}\!/_{Volatility_{AUS}} + \varepsilon_t \quad (5.20)$$

Where $Volatility_E$ is the volatility of the emerging market equity index and the ${}^{Volatility_E}\!/_{Volatility_{AUS}}$ is the ratio of the volatility of the emerging market equity index to the volatility of the Australian market equity index, α is a constant and ε is a random error term.

[69] Asymmetric DCC GARCH model estimates the conditional correlations based on the conditional variances of the two markets. We run these regressions as a simple test of relationship between the estimated time varying correlations and the unconditional volatility of each market. A test of correlation and volatility has been conducted by Knif and Pynnonen (2007); they use a logit type regression model.

[70] Using volatility ratio as a measure of the relative volatility is common in portfolio management practice; see the explanatory notes on the definition of risk and returns, Fidelity International, www.fidelity.no/docs/business_centre/common/explaination.pdf.

Study also estimates a regression of correlations as a dependent variable and Australian market volatility as an independent variable; a regression of correlations against volatility of the emerging market and a regression of correlations against relative volatility.

Chapter 6

Data Analysis and Results

My research performs the analysis in two parts; first section estimates the correlation matrix for asset returns of a sample of emerging markets and Australia using Asymmetric DCC GARCH model and estimates the potential benefits for Australian investor by diversifying into emerging markets. As discussed earlier in the methodology section the study compares the Australia only portfolio with different optimal portfolios constructed using Australian and emerging market indexes. Study uses Sharpe ratios and the M2 measure for comparison of these portfolios. Second section of the analysis estimates the time varying correlations between the returns of Australian market and emerging market returns and tests if the volatilities of the returns of the either market and/or relative volatility of the two markets contribute to the changes in correlations.

6.1 Time varying correlations and optimal portfolios construction

The main focus of this section of the study is to test if the efficient portfolios created with correlation estimates using the multivariate GARCH models will have superior ex-post performance over the Australia only portfolio. This study contributes to the existing literature by using a multivariate GARCH model that allows the correlations to change over time and incorporates asymmetrical effects. Using unconditional correlations in an optimisation may lead to overestimation or underestimation of the benefits of diversification, as the unconditional correlations do not represent the true nature of correlations; consequently the Sharpe ratio calculated using unconditional correlations may not be an accurate assessment of the future. Conditional correlations calculated using the Asymmetric DCC GARCH model may sometimes yield a lower Sharpe ratio as compared with the unconditional correlations, but that does not suggest

that there are lower benefits in diversification using the Asymmetric DCC GARCH model. The Asymmetric DCC GARCH model gives a better estimate of correlations (Jithendranathan 2005; Gupta, Hobbes and Loudon 2007; and Cappiello, Engle and Sheppard 2006), thus a more accurate estimate of future expected benefits of investing in emerging markets.[71] Another contribution of the study is to test for an Australian investor if there are benefits in diversifying his/her portfolio into emerging equity markets.

The DCC GARCH model has been recently used in similar studies, for example, Yang (2005) studies the correlations between Japan, Taiwan, Singapore, Hong Kong and South Korea and finds that return correlations changed considerably during the period of study. Jithendranathan (2005) studies the correlations between the US and Russian equity markets and finds changes in sovereign credit risk, world energy prices and exchange rate to be the reasons for the changes in correlations. Dunis and Shannon (2005) show that for an unconstrained portfolio of the US and emerging markets the portfolio weights are India (6%), Malaysia (52%), Taiwan (6%) and US (36%). For the period 1st September 2003 to 5th July 2004, they find that the Sharpe ratio improves from 1.03 to 1.12 by including emerging markets in the optimised portfolio[72]. More recently in Gupta and Jithendranathan (2008) look at the diversification benefits for

[71] The Asymmetric DCC model presents correlations that are not influenced by extreme episodic events such as the Asian crisis of 1997-98. Financial crises have been shown to increase the volatility of the markets and the correlations between the market pairs tend to increase during financial crises (Gupta, 2006).

[72] The authors also look at different restrictions on maximum investments in foreign assets based on the argument that investors are not willing to invest more than a certain proportion of their portfolio into foreign funds. They find an improvement in the Sharpe ratio with as little as 15% investments in foreign funds.

Australian investments into Russian ADRs[73] using the DCC model. Thus far research has ignored looking at the international diversification benefits for an Australian investor which may be different from the benefits that accrue to the investors of the developed markets.

6.1.1 Data

For this study we use monthly returns of the 'All ordinaries' and the monthly returns of the broad based indexes[74] in the emerging market countries for the period February 1988 to December 2005[75]. Since the emerging market indexes are either available in US dollars or their respective currencies, for consistency we use the US dollar denominated index values for all the indices. Returns are calculated in US dollar terms.

In order to calculate the volatility of the respective index, we use daily prices to calculate the daily returns and the daily average volatility of each market index returns. We calculate monthly volatility (Volatility_m = Daily volatility X $\sqrt{n}$, where m represents period and n number of trading days in the period) of each market on the basis of the actual number of trading days in the month for the emerging market. We use DataStream for index values of the respective equity indexes. Markets included

[73] ADRs are American Depository Receipts issued over an underlying listed in domestic markets os the lsted company. These ADRs traded in American Stock Exchanges as any other listed stock.
[74] This study uses indexes for classes of assets in different markets and indexes has been commonly used for asset classes. However, the study notes that frequent changes in the construction of indexes by the stock exchanges are a weakness of the study. However, this is not expected that it will significantly influence results of the study.
[75] We use Australian index and emerging market indexes as asset classes that are available for an Australian investor for investment. All emerging markets included in the sample are accessible to investors in Australia either directly investing into emerging markets through broker networks in the country or through exchange traded funds (EFTs) listed on the American Stock Exchange (AMEX). Some of these EFTs are listed on ASX, most of the EFTs listed on AMEX are available through brokers in Australia, e.g. TradingPro.

in the study are: Australia, Brazil, Chile, Greece, India, Korea, Malaysia, and the Philippines. Market capitalisation for the markets included in the study is given in Table 4.1, in Chapter 4. The markets are fairly developed as demonstrated by the number of listed companies and the market capitalisation to GDP ratio of these markets.

Data for emerging markets is limited and the series for different emerging market countries start from different dates. We have used the earliest date from which the data is available for most of the emerging market countries. The start date for the data is February 1988 and the end date is December 2005 (December 2005 is the latest date to which data was available)[76]. We have used eight markets in this study to demonstrate that there are potential benefits in diversifying into emerging markets. We exclude smaller markets from this study as the transactions cost could be higher in smaller markets and the access for foreign investors difficult, which may erode the benefits of diversifying into these markets. Correlations among emerging markets and with Australia have increased over a period of time but there are still potential benefits in diversifying into these markets. This research uses the subset of eight markets from emerging markets universe as used by Bekaert and Harvey (2000)[77].

Table 6.1 lists market returns and their summary statistics for the seven emerging market indices and the Australian index. Australia has mean returns of 0.6%,

[76] We use the monthly data for the period 1988 to December 2005 for the GARCH estimates; for some countries, the data set starts from a later date. For the volatility estimates, the starting date is chosen as February 1988 and the ending date as December 2005 because of the availability of the daily data.

[77] The distinction between emerging markets and the developed markets should be based on theoretical constructs, but in most empirical studies, the distinction is drawn from the World Bank definition of emerging markets and the data suppliers use a similar definition. We have randomly selected seven emerging equity markets from the available set of countries.

minimum returns of -10.2%, and maximum returns of 10.5% with a variance of 0.001 during the period. Brazil has mean returns of 3.3%, minimum returns of -66.9%, and maximum returns of 95.4% with a variance of 0.039. Returns for other indexes that are included in the portfolio range between returns for the Australian index and the Brazilian index. Australian returns show a negative kurtosis which is close to zero suggesting return distribution could be normal. A formal test of normality is conducted for all series (results included in Annexure 5) and is discussed later.

Table 6.1

Summary statistics of the returns data

Market	Obs.	Mean	Skewness	Kurtosis	Jarque-Bera	Variance	Min	Max
Australia	215	0.006	-0.270	-0.056	2.648	0.001	-0.102	0.105
Brazil	215	0.033	0.832	3.598	140.8	0.039	-0.669	0.954
Chile	215	0.013	0.207	0.098	1.624	0.004	-0.178	0.230
Greece	207	0.014	1.441	4.612	255.1	0.011	-0.233	0.524
India	215	0.011	0.546	0.884	17.73	0.008	-2.218	0.374
Korea	215	0.011	1.184	3.968	191.3	0.011	-0.282	0.556
Malaysia	215	0.008	0.595	4.662	207.4	0.008	-0.298	0.492
Philippines	215	0.009	0.563	3.310	109.5	0.008	-0.274	0.454

Following Table 6.2 is based on the S&P/Citigroup Global Equity Index. It shows the capitalisation of the emerging markets included in the study. These markets are small as compared with the larger markets of the world, e.g. The USA and the UK.

However, when compared with the size of the equity market of Australia these markets are similar in market capitalisation. Some academics have raised concerns on the smaller size of these markets and the impact that Australian investments can make on these markets. As these markets are similar in market capitalisation to Australian market, Australian investments spread into these markets is not expected to significantly impact the nature of the markets. Moreover, investments into these markets are expected to be spread across multiple markets and not concentrated in one single market. This concern is further mitigated by restricting investment into one single market to 10% in the analysis.

Table 6.2

Relative size of the global equity markets

Market	Market Capitalisation in US million dollars	Weight	Size relative to Australia
Australia	1,158,249	2.82	-
Brazil	1,155,954	1.68	0.99
Chile	177945	0.21	0.15
Greece	208,937	0.38	0.18
India	1,041,275	0.90	0.90
Korea	NA	NA	NA
Malaysia	238,227	0.28	0.20
Philippines	65,367	0.06	0.05

Source: S&P/Citigroup Global Equity Index, weight is the weight of a specific country index in the global index at the end of 2007.

6.1.2 Discussion

In this study correlation dynamics of the monthly returns of seven of the emerging market indexes and the Australian index are calculated using the Asymmetric Dynamic Conditional Correlation Model. The period of this study covers February 1988 to December 2005. These correlations are used to construct optimal portfolios for an Australian investor.

The results of correlations of different equity index returns are given in Table 6.2. Towards the lower end the correlations between Greece and Korea were 0.049 and between India and Philippines were 0.048; on the higher end correlations between Malaysia and Philippines were 0.361 and between Brazil and Chile were 0.350. Low correlations between Greece and Korea and India and the Philippines pairs can possibly be explained by geographical segmentation of these markets from world markets and smaller capital markets in these countries that add to segmentation. Higher correlations of Malaysia-Philippines and Brazil-Chile could possibly be because of geographical proximity. Australian correlations with emerging markets are low, with average correlations of 0.19, suggesting that there are potential benefits in international diversification into the emerging markets. Average US correlations with emerging markets are 0.23, slightly higher than the Australian correlations[78].

[78] Average correlations for US and emerging markets are calculated from Li, Sarkar and Wang's (2003) paper. These correlations are not directly comparable with Australian correlations, as the sample set used by this study is different in terms of country indices and time period.

Table 6.3
Correlations for the period February 1988 to December 2005

	Australia	Brazil	Chile	Greece	India	Korea	Malaysia	Philippines
Australia	1							
Brazil	0.308	1						
Chile	0.066	0.350	1					
Greece	0.178	0.217	0.164	1				
India	0.092	0.230	0.281	0.119	1			
Korea	0.257	0.110	0.163	0.049	0.071	1		
Malaysia	0.190	0.150	0.304	0.117	0.240	0.210	1	
Philippines	0.284	0.187	0.304	0.153	0.048	0.276	0.361	1

A frequently used method to estimate correlations that change over time is the moving average specification wherein correlations are estimated using a moving window-of-time. The weakness of this method is that it gives equal weight to all the observations, used in the moving average calculations within the window of time. The other method used to calculate time varying correlations is to adopt multivariate GARCH models. Early models of this group were based on the Constant Correlation model of Bollerslev (1990). The main weakness of these models was the assumption that correlations were constant. The second set of models in this category is based on Kroner and Ng (1998). These models, though theoretically sound, were deficient in computational ease, as these models require estimating too many coefficients at the same time. Engle (2002) introduced another variant of the multivariate GARCH model called "Dynamic Conditional Correlation Models", which combined the theoretical appeal of time-varying correlations and the computational flexibility of the univariate models. In this paper we use an extended version of this model that incorporates asymmetrical effects to estimate time varying correlations between pairs of assets.

The main focus of this study is to test if the efficient portfolios created with correlation estimates using the multivariate GARCH models will have superior ex-post performance over the Australia only portfolio. This study contributes to the existing literature by using a multivariate GARCH model that allows the correlations to change over time and incorporates asymmetrical effects. If unconditional correlations are used in an optimisation, it may lead to overestimation or underestimation of the benefits of diversification. This is because the unconditional correlations do not represent the true nature of correlations; consequently the Sharpe ratio calculated using unconditional correlations may not be an accurate assessment of the future. Conditional correlations calculated using the Asymmetric DCC GARCH model may sometimes yield a lower Sharpe ratio as compared with the unconditional correlations, but that does not suggest that there are lower benefits in diversification using the Asymmetric DCC GARCH model. The Asymmetric DCC GARCH model gives an improved estimate of correlations (Jithendranathan 2005; Gupta, Hobbes and Loudon 2007; and Cappiello, Engle and Sheppard 2006), thus a more accurate estimate of future expected benefits of investing in emerging markets.[79] Another contribution of the study is to test for an Australian investor if there are benefits in diversifying his/her portfolio into emerging equity markets.

The DCC GARCH model has been recently used in similar studies, for example, Yang (2005) studies the correlations between Japan, Taiwan, Singapore, Hong Kong and South Korea and finds that return correlations changed considerably during the period

[79] The Asymmetric DCC model presents correlations that are not influenced by extreme episodic events such as the Asian crisis of 1997-98. Financial crises have been shown to increase the volatility of the markets and the correlations between the market pairs tend to increase during financial crises (Gupta, 2006).

of study. Jithendranathan (2005) studies the correlations between the US and Russian equity markets and finds changes in sovereign credit risk, world energy prices and exchange rate to be the reasons for the changes in correlations. Dunis and Shannon (2005) show that for an unconstrained portfolio of the US and emerging markets the portfolio weights are India (6%), Malaysia (52%), Taiwan (6%) and US (36%). For the period 1st September 2003 to 5th July 2004, they find that the Sharpe ratio improves from 1.03 to 1.12 by including emerging markets in the optimised portfolio[80]. Thus far research has ignored looking at the international diversification benefits for an Australian investor.

DCC Model

In this study we estimate the time varying correlations using the Asymmetric Dynamic Conditional Correlation (DCC) model of Cappielo, Engle and Sheppard (2006). This model incorporates the introduction of the asymmetric term into the original DCC model of Engle (2002) as modified by Sheppard (2002) as a general model. This model can be expressed as[81]:

$$Q_t = (\overline{Q} - A'\overline{Q}A - B'\overline{Q}B - G'\overline{N}G) + A'\varepsilon_{t-1}\varepsilon'_{t-1}A + B'Q_{t-1}B + G'n_{t-1}n'_{t-1}G$$

Where A, B and G are diagonal parameter matrixes, $n_t = I[\varepsilon_t < 0]o\ \varepsilon_t$ (with o indicating Hadamard product), $\overline{N} = E[n_t n'_t]$. For $\overline{Q}$ and $\overline{N}$, expectations are

[80] This study also looks at different restrictions on maximum investments in foreign assets based on the argument that investors are not willing to invest more than a certain proportion of their portfolio into foreign funds. They find an improvement in the Sharpe ratio with as little as 15% investments in foreign funds.
[81] For detailed discussion, see Chapter 5.

infeasible and are replaced with sample analogues, $T^{-1}\sum_{t=1}^{T}\varepsilon_t\varepsilon_t'$ and $T^{-1}\sum_{t=1}^{T}n_t n_t'$, respectively. $Q_t^* = [q_{ii,t}^*] = [\sqrt{q_{ii,t}}]$ is a diagonal matrix with the square root of the ith diagonal element of Q_t on its ith diagonal position. In this paper we only look for the asymmetrical effects and not the asset specific news impacts.

Table 6.4 shows the correlations between different markets at the end of December 2005[82]. The highest correlations are between the pairs: Australia-Brazil 0.481, followed by India-Australia 0.436, and the lowest for India-Philippines 0.149, followed by Greece-Korea 0.152. These correlations will be used for constructing our optimal portfolios.

Study uses a simple test for testing if these correlations are different from unconditional correlations presented below within parenthesis in Table 6.4. This is done by testing against a null hypothesis that these correlations have equal strength[83]. The results for the test are mixed. Theoretical rationale for using the Asymmetric DCC GARCH model was discussed in the introduction section of the paper and based on theory and empirical results from other papers; use of the Asymmetric DCC GARCH is strongly recommended[84].

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[82] This study uses the correlations at the end of the period for portfolio construction as the portfolio construction forward looking and Asymmetric DCC GARCH model estimates the current correlations based on the lagged conditional variances, i.e. current estimate of correlations (or the current conditional variances) is the best predictor for future correlations.

[83] Two correlation coefficients are transformed with the fisher Z-transform $Z_f = \frac{1}{2}\times\ln\left(\frac{(1+R)}{(1-R)}\right)$ the difference $z = (Z_{f1} - Z_{f2})/sqrt(1/(N_1-3)+1/(N_2-3)$ is approximately standard normal distribution.

[84] Cappiello, Engle and Sheppard (2006) use weekly data to estimate the correlations for the 21equity markets and 13 bond markets using this model and strongly dismiss the argument of constant correlations.

Table 6.4

Correlations calculated using Asymmetric DCC GARCH

	Australia	Brazil	Chile	Greece	India	Korea	Malaysia	Philippines
Australia	1							
Brazil	0.481 (0.034)	1						
Chile	0.275 (0.026)	0.340 (0.907)	1					
Greece	0.196 (0.848)	0.245 (0.761)	0.226 (0.507)	1				
India	0.43 (0.000)	0.345 (0.196)	0.317 (0.684)	0.187 (0.473)	1			
Korea	0.352 (0.28)	0.229 (0.207)	0.232 (0.46)	0.152 (0.284)	0.132 (0.526)	1		
Malaysia	0.222 (0.731)	0.207 (0.544)	0.346 (0.629)	0.157 (0.675)	0.252 (0.895)	0.269 (0.519)	1	
Philippines	0.315 (0.726)	0.221 (0.715)	0.350 (0.596)	0.086 (0.484)	0.048 (1.000)	0.260 (0.859)	.361[85] (1.000)	1

Figures in parenthesis are 'p' values.[86]

In terms of comparing the benefits of diversification we will compare the returns from the Australia only portfolio against the optimised portfolio. Table 6.5 shows the mean returns and the standard deviation of the Australia only portfolio (returns of the Australian Index). The Australia only portfolio has mean returns of 8.16% with a standard deviation of 13.99% and the Sharpe ratio of 0.199. Study uses 5.5% as the risk free rate for calculations of the Sharpe ratio[87]. Chincarni and Kim (2006, p. 479) state, '*For the risk-free rate, the exact value actually does not matter for comparison purposes, as long as some consistent rate is chosen. Many people use the average*

[85] As the Asymmetric DCC GARCH model for the country pairs the Philippines-Malaysia and India-Philippines do not converge, we use unconditional correlation coefficients for these pairs.
[86] Null hypothesis is both correlations: unconditional correlations and conditional correlations have equal strength.
[87] Proxy for risk free rate is overnight rates for December 2005, acquired from International Financial Statistics Online available through Central Queensland University, International Financial Statistics database.

monthly return on 1-month or 3-month U.S. Treasury bills for r_f'. However, to test if our results are sensitive to the risk free rate, calculations of the Sharpe ratios are repeated using an average of risk free rate for the sample period. We also calculate the probability of achieving the mean returns in a simulation process with 12,800 iterations[88]. The probability of achieving mean returns is 56.68%.

Table 6.5

Australia only portfolio

Australia only portfolio	
Mean annual returns	**8.16%**
Standard deviation	**13.99%**
Sharpe ratio risk free return 5.5%	**0.19**
Sharpe ratio risk free return 7.3%[89]	**0.06**
Probability of achieving mean returns[90]	**56.68%**

Efficient Portfolios

The efficient frontier is defined as the set of portfolios that exhibit the minimum amount of risk for a given level of return or the highest return for a given level of risk, and that lies above the global minimum variance portfolio. Elton, Gruber and Padberg (1976) show that one is able to use a simple decision criterion to reach an

[88] Number of iterations in the software is calculated on the formula Min((number of assets)^2)*200, Max=65,000.
[89] 5.5% risk free return is at the end of the sample period, i.e. December 2005, and 7.30% is the average of the short term rates for the sample period.
[90] Probability is the probability of achieving at least the target return; we use probability of achieving the mean returns in a similar meaning through the rest of the paper.

optimal solution to the portfolio problem by assuming a risk free asset exists, and that either the single index model adequately describes the variance-covariance structure, or a good estimate of pair wise correlations is a single figure. This simple criterion not only allows one to determine which stocks to include but also how much to invest in each.

$$X_i^0 = \frac{\dfrac{(\bar{r}_j - r_f) - C_0\beta_i}{\sigma_{\varepsilon_j}^2}}{\sum_{i=1}^{N}\left|\dfrac{(\bar{r}_j - r_f) - C_0\beta_i}{\sigma_{\varepsilon_j}^2}\right|}$$

$$\text{where } C_0 = \sigma_m^2 \frac{\sum_{i=1}^{N}\left[\dfrac{\bar{r}_j - r_f}{\sigma_{\varepsilon_j}^2}\beta_j\right]}{1 + \sigma_m^2 \sum_{i=1}^{N}\dfrac{\beta_j^2}{\sigma_{\varepsilon_j}^2}}$$

Weights are calculated in an optimisation model using a following model. Thus by applying the following equation one is able to determine the respective weightings for each security[91].

The results of optimisation using simple correlations are given below in Table 6.6, the mean annual returns for the portfolio are 19.19%, with a standard deviation of 21.61%

[91] For discussion on the model, see Chapter 5. The model is for no restrictions on short sale. The standard optimisation problem can be written as:

$Min\sigma_P^2 = \sum_{i=1}^{N} X_i^2\sigma_i^2 + \sum_{i=1}^{N}\sum_{\substack{k=1 \\ k\neq i}}^{N} X_i X_k \sigma_i \sigma_k \rho_{i,k}$ subject to the constraint : $\sum_{i=1}^{N} X_i = 1$; if short selling is not allowed the additional constraint will be of non-negative weights, expressed as $0 \leq X_i \leq 1$. Similar minimum or maximum weight restrictions are imposed when introducing restrictions of minimum investments into Australian index and/or maximum restrictions into emerging market indexes.

and a Sharpe ratio[92] of 0.63 for a portfolio with no restrictions. The Sharpe ratio of this portfolio is considerably better than for the Australia only portfolio. We also calculate another risk adjusted performance measure referred to as the M2 measure.[93] Allocations into Australian market for an unrestricted portfolio are very small, i.e. 6.96% of the total portfolio and the Australian investors may be hesitant in investing major proportion of their portfolio into foreign markets. The unrestricted optimisation, in this instance may look attractive from a theoretical standpoint but many investors are reluctant to invest a larger proportion of their portfolio into one emerging market and expose themselves to a foreign market because of perceived unfamiliarity.

As such, portfolios with different restrictions are constructed: one with maximum 10% in an individual emerging market, maximum 20% in an individual emerging market, maximum 50%[94] into emerging markets with 10% in each market and finally maximum 50% in emerging markets with a maximum limit of 20% in one single market. No short sale constraints are also imposed in the optimisation process, as many emerging markets have direct or indirect constraints on short sales. Results from optimisation show that with maximum 50% investment into emerging markets and a restriction of

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[92] In a review of performance measures, Eling and Schuhmacher (2007) find that Sharpe and other measures result in similar rankings.

[93] The M2 measure is a common name for a measure proposed by Modigliani and Modigliani (1997). The M2 measure is equivalent to the return a portfolio would have achieved if it had had the same risk as the benchmark risk (in this case we use Australian index as a benchmark index). The risk adjusted performance (RAP) measure can be calculated as:

$RAP(i) = (\sigma_M / \sigma_i)(r_i - r_f) + r_f$ where σ_M and σ_i are the volatilities of the market and the stock, r_i and r_f are the returns of the portfolio and risk free returns respectively and RAP(i) is the risk adjusted performance measure of the portfolio, also sometimes referred to as the M2 measure.

[94] This is based on the common practice in portfolio management, called the 'prudent man rule', derived from the argument that a portfolio manager is risk averse and will not diversify away from his/her home market securities, despite the suggestions from the portfolio optimisation model for a higher investment into foreign equities. Dunis and Shannon (2005) use 15% restriction on emerging market investment and Stevenson (2000) uses a similar argument to constrain the equity investments into emerging markets to a maximum 10% in the analysis of a mixed international portfolio of equity and real estate.

not more than 10% in a single emerging market the portfolio gives us an annualised return of 14.02%, standard deviation 15.54, the Sharpe ratio 0.55, and the M2 measure of 13.17. This is a substantial improvement from the Australia only portfolio that has a mean return of 8.16% with a standard deviation of 13.99 and a Sharpe ratio of 0.19. The probability of achieving the mean returns of the optimal portfolio equal to at least that of the Australia only portfolio is around 60%, which is very similar to that of the Australia only portfolio.

The main focus of this section of the study is a computationally efficient model for estimating the correlations; the optimisation process is repeated using correlations generated by the Asymmetric DCC GARCH model. In the next step an unrestricted portfolio is constructed and portfolios with restrictions similar to the ones used in the preceding analysis. The results show that in the unrestricted optimisation the allocation in Australian market is very small, i.e. 6.47%, maximum allocation is in to Chile, i.e. 43.57%. Higher allocation into Chile can be explained intuitively on the basis of geographical segmentation of the Chilean market with Australia and empirically on lower correlations with Australian equity returns. The markets that are in close geographical proximity to Australia and are considered developed have smaller allocations, e.g. Malaysia has an allocation of 0.17% (see Table 6.7).

The results on the proportion invested into different markets, annualised returns, and standard deviation of the portfolio with the Sharpe ratio and the M2 measure are given in Table 6.7. Annual mean returns for the unrestricted portfolio are 19.56%, with a standard deviation of 23.14 and the Sharpe ratio of 0.61 and the M2 14.00. This is much better than for the Australia only portfolio. The mean return for a restricted

portfolio that has 50% restriction on foreign investments and 10% in a single emerging market is 14.04%, with a standard deviation of 17.29; the Sharpe ratio is 0.49 and the M2 measure is 12.41. The restricted portfolio does not perform as well as the unrestricted portfolio, but the improvement in mean annual returns and risk adjusted returns are substantially higher than those of the Australia only portfolio. In all cases the probability of achieving the expected mean returns is very similar to what it would be with the Australia only portfolio.

The portfolios construction using Asymmetric DCC GARCH correlations is repeated by changing the risk free rate to an average (7.299%) for the period February 1988 to December 2005, (see Table 6.8). As the risk free rate increases, the investment into the Australian market further drops and overall portfolio returns also improve. The Sharpe ratio and the M2 measure also slightly improve with the changed risk free rate.

Results in Tables 6.6 to 6.8 show that the optimal portfolios with no restrictions on investing into emerging markets have very low allocation into Australian equities and higher allocations into emerging markets. As investors are risk averse and because of their perceived familiarity with the Australian market they tend to restrict their investments into emerging markets to an arbitrary level. Results show that substantial improvement in portfolio returns could be achieved even if investors restricted their investments into emerging markets to the level of maximum 50% in total into emerging market equities and no more than 10% into any one emerging market.

Table 6.6

Australian portfolio with different restrictions on emerging markets investments using unconditional correlations.

Country	Aus	Brz	Chi	Gre	Ind	Kor	Mal	Phi	Optimal Portfolio Return	Standard Deviation	Sharpe Ratio*	M2 Measure	Probability
Investment weights (Unrestricted-simple correlations)	6.96	17.15	34.09	13.37	11.94	10.07	2.51	3.91	19.19	21.61	0.63	14.36	69.56
Investment weights (Max 10% in emerging market)	42.60	10.00	10.00	10.00	10.00	10.00	0.70	6.70	14.50	16.05	0.56	13.30	65.34
Investment weights (Max 20% in emerging market)	8.42	20.00	20.00	20.00	20.00	10.07	0.27	1.25	19.89	23.09	0.63	14.21	69.42
Investment weights min 50% Aus & 10% emerging markets	52.66	10.00	10.00	8.36	10.00	0.10	0.10	2.08	14.02	15.54	0.55	13.17	64.73
Investment weights min 50% Aus & 20% emerging markets	50.57	10.63	16.19	10.54	7.03	4.30	0.63	0.12	14.56	15.86	0.57	13.49	65.70

* Proxy for Risk free rate is overnight rates for December 2005, acquired from International Financial Statistics Online available through Central Queensland University database (5.50%).

Table 6.7

Australian portfolio with different restrictions on emerging markets investments using Asymmetric DCC GARCH correlations.

Country	Aus	Brz	Chi	Gre	India	Korea	Mal	Phi	Optimal Portfolio Return	Standard Deviation	Sharpe Ratio*	M2 Measure	Probability
Investment weights (Unrestricted-DCC correlations)	6.47	17.54	43.57	10.15	10.84	3.59	0.17	7.68	19.56	23.14	0.61	14.00	50.76
Investment weights (Max 10% in emerging market)	38.32	10.00	10.00	10.00	10.00	10.00	1.68	10.00	14.64	18.01	0.51	12.59	59.28
Investment weights (Max 20% in emerging market)	8.44	20.00	20.00	20.00	11.94	8.84	2.41	8.36	19.56	24.11	0.58	13.65	59.28
Investment weights min 50% Aus & 10% emerging markets	51.87	10.00	10.00	10.00	9.55	1.85	0.25	6.49	14.04	17.29	0.49	12.41	59.27
Investment weights min 50% Aus & 20% emerging markets	50.30	14.68	13.84	6.83	4.13	3.56	2.74	3.92	15.24	19.09	0.51	12.63	59.15

* Proxy for Risk free rate is average money market rates for December 2005, acquired from International Financial Statistics Online available through Central Queensland University database (5.50%).

Table 6.8

Australian portfolio with different restrictions on emerging markets investments using Asymmetric DCC GARCH correlations

Country	Aus	Brz	Chi	Gre	India	Korea	Mal	Phi	Optimal Portfolio Return	Stad. Deviation	Sharpe Ratio*	M2 Measure	Probability
Investment weights (Unrestricted-DCC correlations)	4.01	32.13	30.35	21.92	4.41	1.35	2.34	3.49	23.52	30.28	0.54	14.79	58.88
Investment weights (Max 10% in emerging market)	37.08	10.00	10.00	10.00	10.00	10.00	2.92	10.00	14.64	18.05	0.41	12.98	59.26
Investment weights (Max 20% in emerging market)	2.20	20.00	20.00	20.00	19.28	5.65	3.73	9.13	19.92	24.66	0.51	14.45	59.23
Investment weights min 50% Aus & 10% emerging markets	50.71	10.00	10.00	10.00	10.00	6.12	0.32	2.85	14.16	17.49	0.39	12.78	59.27
Investment weights min 50% Aus & 20% emerging markets	52.63	18.26	16.04	6.94	2.35	0.44	1.55	1.78	16.32	20.68	0.44	13.40	59.98

* Proxy for Risk free rate is average money rates for the period February 1988 to December 2005, acquired from International Financial Statistics Online available through Central Queensland University database (7.30%).

Minimum variance portfolios are also constructed to test if the results are driven by a particular choice of portfolio. We construct portfolios with no restriction on investment in emerging markets and another portfolio with a 10% maximum investment into any one emerging market and no less than 50% in the Australian market. Risk free rate of return[95] used for the portfolio below is 5.5%. These results (Table 6.9) show that minimum variance portfolio for the Australian investor including emerging equity markets is superior to the Australia only portfolio as given in Table 6.5. The allocation into emerging equity markets for the minimum variance portfolio is small[96], as most emerging markets have a higher volatility as compared to the Australian equity market and the optimal solution in this case seeks for the portfolio that has minimum variance.

Table 6.9

Minimum variance portfolio

Minimum variance portfolio	**Expected return**	**Standard deviation**	**Sharpe ratio***	**M2 measure**
With no restriction on emerging market investments	9.84%	13.09%	.3315	10.14
With maximum investment in emerging market restricted to 10% and no more than 50% in total.	9.60%	13.16%	.3114	9.86

[95] Portfolios with 20% constraint and with a risk free rate of return of 7.30% were also constructed. For space reasons the results presented are for an unrestricted portfolio and a portfolio with maximum 10% into any one emerging market and minimum 50% into the Australian market.
[96] The allocation into emerging markets is insignificant and as such that information has been omitted here.

*Proxy for risk free rate is overnight rates for 31 December 2005, acquired from International Financial Statistics Online available through Central Queensland University database (5.5%).

The diversification benefits were tested by having an Australian investor invest into emerging markets with different levels of restrictions on investment into emerging markets: firstly with no restriction into emerging market allocations; secondly, with maximum 10% into any one emerging market and no more than 50% into emerging markets; and thirdly, with maximum 20% into any one emerging market and no more than 50% into emerging markets. Study finds benefits to be significant in all cases. Results indicate that the expected returns of the optimised portfolio with maximum 50% into emerging markets and no more than 10% in one single emerging market are substantial. The mean annual return increases to 14.16%, with a standard deviation of 17.49 and a Sharpe ratio of 0.39, as against 8.16%, 13.99%, and 0.19 respectively for an Australia only portfolio. The M2 measure, which is a measure of the expected return of the portfolio, assuming the same level of risk for the optimal portfolio, is 12.78. Transactions costs in the emerging markets are likely to be higher than in the developed markets, Bekaert et al (1997) estimate 1.1% transactions costs for investing in the emerging markets and similar costs are considered by Kargin (2002). If 1.1% transaction cost of investing into emerging markets is included in analysis the Sharpe ratio changes to 0.33, this is significantly better than the Australia only portfolio.

6.1.3 Summary results

In this section the benefits that accrue to the Australian investor by investing into emerging markets are estimated. Over the years portfolio managers and academics have found that the benefits of international diversification have been significant, but as the

world markets move towards integration from the stage of segmented markets, the benefits that an investor can derive from international diversification are gradually declining. Nonetheless, there are still unrealised gains to be made by Australian investors diversifying into emerging markets. Study finds that an Australian investor can improve expected returns of his/her portfolio from 8.16% to 14.16 % without significant increase in risk. On a per unit measure of risk as measured by the Sharpe ratio, there is a significant improvement in expected returns for an Australian investor by diversifying into emerging markets. The benefits of investing into these markets are apparent despite restricting the foreign investments to a maximum of 50% and investment into a single emerging market to the maximum of 10%. The M2 measure suggests that despite the restrictions the optimised portfolio will have an expected mean return of 12.78. Study finds that the benefits of investing into emerging markets are significant despite the higher transactions costs in the emerging markets. Cost of investing into emerging markets for Australian investors could be different as compared with that of the investors from other larger markets. These costs are likely to be higher for Australian investors owing to the compliance costs in Australia, however the benefits for Australian investors are significantly large and it is expected that there will be potential benefits despite higher costs.

Study finds that correlations within emerging market pairs and correlations of the emerging markets with Australia are low and that despite increasing globalisation, there are still unrealised gains to be made by Australian investors in diversifying into emerging markets. Relatively high returns and low correlations offer better diversification benefits, while high volatility in the equity returns of these markets

require better econometric models to capture the time-varying nature of the correlations. Based on the results, this study recommends use of emerging markets to improve the risk-return relationship for an Australian portfolio manager.

Some emerging markets have restrictions on short sales and these restrictions limit the benefits of portfolio optimisation. Despite the restrictions on short sales, the results show significant benefits in diversifying into emerging markets.

The results for benefits by diversifying into emerging markets are similar, both when using a simple correlations measure and when using the more complex 'Asymmetric DCC GARCH model'. Theoretically, Asymmetric DCC GARCH estimates should provide us with a better estimate of correlations and the results indicate that correlations do change over time. On theoretical grounds this study recommends using the Asymmetric DCC GARCH model for estimates of correlations. The academic literature also indicates that the Asymmetric DCC GARCH model provides an accurate estimate of the changing correlations (Cappiello, Engle and Sheppard 2006; Jithendranathan 2005). As such use of unconditional correlations in an optimisation process can lead to selection of incorrect portfolios that will not represent the true nature of benefits of diversification.

The findings of this study, i.e. that correlation of Australian equity returns with foreign equity markets, specifically with emerging market equity returns, have been changing and increasing in general, have important implications for Australian fund managers seeking to diversify their portfolios internationally to achieve an optimal risk-return ratio for their investors. This study makes two major contributions to the existing

literature in the area of benefits of international diversification, specifically into emerging markets for Australian investors. Firstly, the study finds that Australian investors can still continue to benefit by investing into emerging markets, as correlations of Australian equity returns with emerging markets are still lower and Australian investors can improve their risk adjusted returns by investing into emerging equity markets. The second contribution of the study is in proposing a computationally efficient method of estimating changing correlations that will reflect the true potential benefits of international diversification[97]. In order to test the robustness of the findings different sets of portfolios were tested, different risk free rates were used and also different restrictions on emerging market investments including, no short-sale constraint in the emerging markets was tested. Correlations have changed over time and the benefits of diversification do change with the changes in correlations[98]. It is important to address the issue of the causes of the changes in correlations over time. In the following section the study tests volatility of these markets as an underlying factor that could cause the changes in correlations[99].

6.2 Time varying correlations and volatility

This section looks at the time varying nature of the correlations and tests to see if the changes in correlations are explained by the changes in the volatilities of the emerging markets; volatility of Australian market and/or the relative volatility of the two markets.

[97] An out-of-sample study needs to be conducted to verify that the Asymmetric DCC GARCH model produces better estimates of the true correlations. Currently availability of data
[98] Ignoring changes to other factors that may occur.
[99] Findings of this section of the study have been published as Gupta and Donleavy (2008).

Different techniques have been used in measurement of time varying correlations. The most common method used is a moving average specification. In this method correlations are estimated by using a specific window of time. The primary weakness of this method is that it gives equal importance to all observations within the time period used in the moving average calculations. The other method of estimating correlations is to use multivariate GARCH models. The initial models in this group were based on the Constant Correlation Coefficient model of Bollerslev (1990). These models were based on the assumption that the correlations coefficients are constant over time, which is unrealistic; this was the main weakness of the models of this class. The second set of GARCH models used in this context is based on the multivariate GARCH models introduced by Kroner and Ng (1998). Although theoretically appealing, these models were computationally complex because of the need for estimating a large number of coefficients at the same time. Engle (2002) introduced multivariate GARCH models called "Dynamic Conditional Correlation Models", which combined flexibility of the univariate models with the theoretical power of time varying correlations. This model is used by Jithendranathan (2005) in his study on changes in correlations between the US and Russian equity markets.

The Dynamic Conditional Correlation Model (DCC GARCH) of Engle (2002) permits asymmetries in variances, but not correlations, and is developed on the argument that any univariate GARCH model which has stationary covariance and assumes that errors are normally distributed (irrespective of the factual distribution) can be used to model variances. The model is estimated in two steps: the first step

estimates variances using a univariate GARCH specification and then parameters of dynamic correlations are estimated. Sheppard (2002) extended the DCC model to allow for asymmetric dynamics in the correlations along with asymmetric dynamics in variances. Cappielo, Engle and Sheppard (2006) used this in their study of asymmetric dynamics in the correlations of global and bond equity returns.[100] The authors find considerable evidence of asymmetries in conditional covariance of both equity and bond returns. Further, the asymmetries are present in different ways in different markets. Evidence recommends the use of the asymmetric GARCH model for estimating conditional correlations as against the use of the standard multivariate GARCH that does not allow for asymmetric dynamics in correlations.

Time varying correlations in this study are estimated using the Asymmetric Dynamic Conditional Correlation (DCC) model of Cappielo, Engle and Sheppard (2006). This model is an introduction of the asymmetric term into the original DCC model of Engle (2002) as modified by Sheppard (2002) as a general model. Many methods have been used to estimate correlations, initially unconditional correlations were used that ignored that correlations change over time. Another commonly used method is to use a rolling estimator, where the unconditional means, variances and co-variances are estimated using a rolling window of fixed number of X observations over the sample period. The main weakness of this method is that it does not capture the time varying nature of the means, variances and co-variances. As discussed in the preceding section numbers of multivariate GARCH models were introduced to estimate time varying correlations. These models were complex and time consuming

[100] Cappielo, Engle and Sheppard (2006) have explained the economic rationale of asymmetric volatility on the basis of two models: leverage effect and time varying risk premia (volatility feedback).

because the number of parameters needed to be estimated were large. As such most papers considered only five assets despite the apparent need for much larger correlation matrices.[101] Next development in the series of multivariate GARCH models was the introduction of 'Dynamic Conditional Correlation' model of Engle (2002)[102], main weakness of this model is its two step estimation process that makes it easier to estimate but correlation processes are restricted to same dynamic structure. Another weakness of the DCC model was in ignoring the asymmetric effects in the initial model. In general when time varying volatility is not important the relative advantages of the DCC model is reduced and DCC model is difficult to estimate for a shorter series because of convergence problems. Current model as proposed in Cappielo, Engle and Sheppard (2006) and used in this study overcomes the problem of asymmetry. And two-step estimation though causes some efficiency losses but makes it easier for estimation of more number of parameters together. Engle (2002) find DCC to be competitive with other multivariate GARCH specification and similar results are reported by Wong and Vlaar (2003). Jithendranathan (2007) in a comparison of ex post performance of the optimised portfolios finds that the portfolios constructed with correlations estimated using DCC model yields better results as compared with the rolling estimator. Engle (2002) reviewed the performance of the multivariate GRACH models in his paper and find that the DCC GARCH model is a good approximation.

[101] The number of potential assets that could be included in an optimised portfolio will be significantly more than five assets used in the studies using alternative models and will make it harder to estimate these multivariate GARCH models.

[102] Robert Engle was awarded Nobel Prize in 2003 for his work *'for methods of analysing economic time series with time-varying volatility (ARCH)'*.

> The comparison of DCC with simple multivariate GARCH and several other estimators shows that the DCC is often the most accurate. Statistical tests on real data indicate that all these models are miss-specified but that the DCC models are competitive with the multivariate GARCH specifications and are superior to moving average methods.
>
> (Engle 2002, p. 348)

We use the same Asymmetric DCC GARCH model in this section for estimation of the time varying correlations between Australian and emerging market returns. The matrix version of the model is written as:

$$Q_t = S(1-\alpha-\beta) + \alpha(\varepsilon_{t-1}\varepsilon'_{t-1}) + \beta Q_{t-1}$$

where S is the unconditional correlation matrix of the disturbance terms and $Q_t = \left|q_{1,2,t}\right|$. The log likelihood for this estimator can be written as:

$$L = -\frac{1}{2}\sum_{t=1}^{T}(n\log(2\pi) + 2\log\left|D_t\right| + \log\left|R_t\right| + \varepsilon'_t R_t^{-1}\varepsilon_t)$$

where $D_t = diag\left\{\sqrt{h_{i,t}}\right\}$and R_t is the time varying correlation matrix.

As this model does not allow for asymmetries and asset specific news impact, the modified model which Cappiello, Engle and Sheppard (2006) use for incorporating the asymmetrical effect and the asset specific news impact is:

$$Q_t = (\overline{Q} - A'\overline{Q}A - B'\overline{Q}B - G'\overline{N}G) + A'\varepsilon_{t-1}\varepsilon'_{t-1}A + B'Q_{t-1}B + G'n_{t-1}n'_{t-1}G$$

where A, B and G are diagonal parameter matrixes, $n_t = I[\varepsilon_t < 0] o\ \varepsilon_t$ (with o indicating Hadamard product), $\overline{N} = E[n_t n_t']$. For $\overline{Q}$ and $\overline{N}$, expectations are infeasible and are replaced with sample analogues, $T^{-1}\sum_{t=1}^{T}\varepsilon_t\varepsilon_t'$ and $T^{-1}\sum_{t=1}^{T}n_t n_t'$, respectively. $Q_t^* = [q_{ii,t}^*] = [\sqrt{q_{ii,t}}]$ is a diagonal matrix with the square root of the ith diagonal element of Q_t on its ith diagonal position.

If the expected risk of an asset changes, it will influence the expected return of that asset and the correlations of the returns of the asset with the returns of the other assets in the portfolio. Since we are using the emerging market indexes for the study, overall change in the country risk may change the risk of the equity market index of the country. To capture this changing country risk we use the volatility of the returns of the broad based equity index of the country as one of the variables that can cause the changes in the expected risk of the emerging market equities and subsequently correlation of the returns of the emerging market with the returns of the Australian equities[103]. We test for volatility of the emerging market, volatility of the Australian market and the ratio of the volatility of the emerging equity market to the volatility of the Australian equity market. Following Young and Johnson (2004), we use this ratio as a measure of relative volatility of the two markets.[104] Purpose of using the ratio of the volatility is to capture the relative volatility measure as used in the market.

[103] Asymmetric DCC GARCH model estimates the conditional correlations based on the conditional variances of the two markets. We run these regressions as a simple test of relationship between the estimated time varying correlations and the unconditional volatility of each market. A test of correlation and volatility has been conducted by Knif and Pynnonen (2007); they use a logit type regression model.
[104] Using volatility ratio as a measure of the relative volatility is common in portfolio management practice; see the explanatory notes on the definition of risk and returns, Fidelity International, www.fidelity.no/docs/business_centre/common/explaination.pdf.

Practitioners in the market frequently use the ratio as a measure of the relative volatility of the two markets.

Study uses the following regression model to estimate the factors that may cause the correlations to vary over time:

$$\rho_{i,t} = \alpha_i + \beta_1 Volatility_E + \beta_3 {Volatility_E}/{Volatility_{AUS}} + \varepsilon_t$$

Where $Volatility_E$ is the volatility of the emerging market equity index and the ${Volatility_E}/{Volatility_{AUS}}$ is the ratio of the volatility of the emerging market equity index to the volatility of the Australian market equity index, α is a constant and ε is a random error term.

Regression of correlations as a dependent variable and Australian market volatility as an independent variable is also estimated and regression of correlations against volatility of the emerging market and a regression of correlations against relative volatility.

6.2.1 Data

This section of the study uses monthly returns of the Australian 'All Ordinaries Index' and the monthly returns of the broad based indexes in the emerging market countries for the period February 1988 to December 2005. Since the emerging market indexes are either available in US dollars or their respective currencies, for consistency the dollar denominated index values for all the indices is used. Returns are based on US dollar indexes.

In order to calculate the volatility of the respective index, this study uses daily prices to calculate the daily returns and the daily average volatility of each market index returns. Monthly volatility is calculated as ($Volatility_m$ = Daily volatility X $\sqrt{n}$, where m represents period and n number of trading days in the period) of each market on the basis of actual number of trading days in the month for the emerging market. Ratio of the emerging market volatility to Australian market volatility is used as a measure of the relative volatility of the two markets. Study uses Datastream for index values of the respective equity indexes. Markets included in the study are: Australia, Brazil, Chile, Greece, India, Korea, Malaysia, Mexico, Pakistan, the Philippines, Sri Lanka, and Turkey.

Data for emerging markets is limited and the series for different emerging market countries span different periods. For consistency study uses the earliest date from which the data is available for most of the emerging market countries. There is still a sufficiently long series of data: the start date for the data is February 1988 and the end date is December 2005 (December 2005 is the latest date to which data was available)[105]. The classification of emerging markets and the developed markets should be based on the theoretical constructs, but in most empirical studies, the distinction is drawn from the World Bank definition of emerging markets and the data suppliers use a similar definition. This study uses the emerging markets universe as used by Bekaert and Harvey (2000). Reliable and high frequency data for these countries is available and other researchers use a similar sample set. Other countries

[105] Monthly data for the period 1988 to 2006 is used for the GARCH estimates, where available; for some countries this data set starts at a later date. For the volatility estimates the starting date is chosen as February 1988 and the ending date as December 2005 because of the availability of the daily data. For consistency this study presents the results for correlations for the period up to December 2005.

are excluded from the sample because of one or more of the following reasons: stock markets in those economies are not well developed, reliable high frequency data is not available, or foreign investors do not have direct access to the shares and assets in those countries.

In this study of correlations, dynamics of the monthly returns of eleven of the emerging market indexes with those of the Australian index are calculated using the Asymmetric Dynamic Conditional Correlation Model. The period of this study covers February 1988 to December 2005. Table 6.10 lists the market returns and summary statistics for the markets that form the study sample. There are 215 observations for each market (except Pakistan that has a shorter series with 204 observations). The mean returns for Australia are 0.006% per month and for emerging markets they range between 0.008% for Sri Lanka and 0.033% for Brazil. The monthly variance for emerging markets ranges between 0.004 for Chile and 0.039 for Brazil as against 0.001 for the Australian market.

Table 6.10

Summary statistics of the returns data for the sample

Market	Obs.	Mean	Skewness	Kurtosis	Jarque-Bera	Variance	Minimum	Maximum
Australia	215	0.006	-0.270	-0.056	2.648	0.001	-0.102	0.105
Brazil	215	0.033	0.832	3.598	140.8	0.039	-0.669	0.954
Chile	215	0.013	0.207	0.098	1.624	0.004	-0.178	0.230
Greece	207	0.014	1.441	4.612	255.1	0.011	-0.233	0.524
India	215	0.011	0.546	0.884	17.73	0.008	-2.218	0.374
Korea	215	0.011	1.184	3.968	191.3	0.011	-0.282	0.556
Malaysia	215	0.008	0.595	4.662	207.4	0.008	-0.298	0.492
Mexico	215	0.022	0.200	3.701	124.1	0.011	-0.371	0.553
Pakistan	204	0.013	0.318	2.384	51.78	0.010	-0.386	0.442
Philippines	215	0.009	0.563	3.310	109.5	0.008	-0.274	0.454
Sri Lanka	215	0.008	0.502	1.090	19.69	0.006	-0.205	0.358
Turkey	215	0.023	1.046	2.481	94.40	0.037	-0.449	0.811

6.2.2 Discussion

Study begins analysis with an estimate of unconditional correlations between these markets. Table 6.11 below shows unconditional correlations of the Australian equity returns with the equity returns of the emerging markets.

Table 6.11

Average correlation of Australia with emerging markets during different periods based on raw returns.

	1988 to 1998	1998 to 2005	1988-2005
Brazil	0.271	0.504	0.308
Chile	0.006	0.305	0.066
Greece	0.192	0.132	0.178
India	-0.028	0.431	0.092
Korea	0.164	0.548	0.257
Malaysia	0.250	-0.019	0.190
Mexico	0.275	0.632	0.342
Pakistan	0.083	0.061	0.075
Philippines	0.304	0.205	0.284
Sri Lanka	0.012	-0.035	0.000
Turkey	0.086	0.354	0.153
Median	**0.164**	**0.305**	**0.178**

As seen in Table 6.11, the average correlations of Australian equity returns with emerging market returns for the period 1988 to 2005 are as low as 0.000 with Sri Lanka and up to 0.342 with Mexico. If data is partitioned into different periods, 1988 to 1998 (time of the Asian crisis) we see that Australia has lowest correlations with Sri Lanka but highest correlations with Brazil and not with Mexico. In the period 1998 to 2005 correlations with Pakistan are still lower, i.e. 0.061 (slightly lower than for the 1988 to 2005 and the 1988 to 1998 period). After the split the higher correlations are with India, i.e. 0.431, much higher than for the full sample period and the sub-sample of the 1988 to 1998 period. Similarly, in the case of Brazil the correlations for this period rise to 0.504 from the 0.308 for the period 1988 to 2005 and 0.271 for the period 1988 to 1998. Correlations with Malaysia fell to -0.019 from a high of 0.190 for the period 1988 to 2005 and 0.250 for the period 1988 to 1998.

Median correlations between Australia and emerging markets increased from 0.164 for the period 1988-1998 to 0.305 in 1998-2005.

These results show that the correlations of Australian equity returns with different emerging equity market returns are changing over the period (1988 to 2005) and that the change is not uniform. With some emerging equity markets the correlations have increased, for example Brazil as reflected in the table above increased from 0.271 in 1988 to 1998 to 0.504 in 1998 to 2005, and during the same period the correlation with Malaysia fell from 0.250 to -0.019.

Time varying correlations are estimated using the Asymmetric DCC GARCH model[106] and the graphs in Annexure 1 show the changes in the correlations over the full sample period. Results from the Asymmetric DCC model as given in Table 6.12 show that the correlations in the markets have a significant relationship with the lagged conditional variances (t-statistic is significant at 1% level in most markets) and with lagged squared error term in some markets. The asymmetric term is only significant in Korea, Pakistan and the Philippines at 1%.

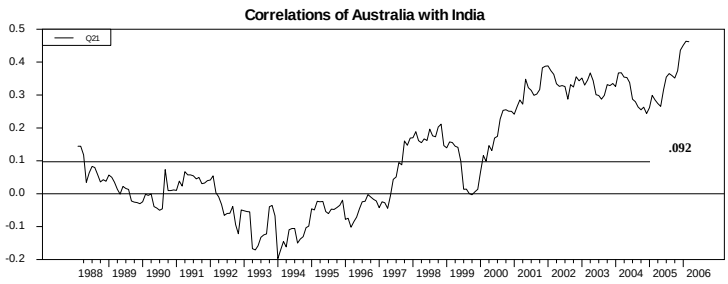
The following two graphs (Figure 6.1) show the different patterns of changes in correlations for Australian equity returns with the emerging market equity returns. Results for other markets are given in Annexure 1. Unconditional correlations are marked on the graphs as a straight line to show the comparison of unconditional correlations with time varying correlations.

[106] This study uses RATS 6.2 software by Estima for our estimation purposes.

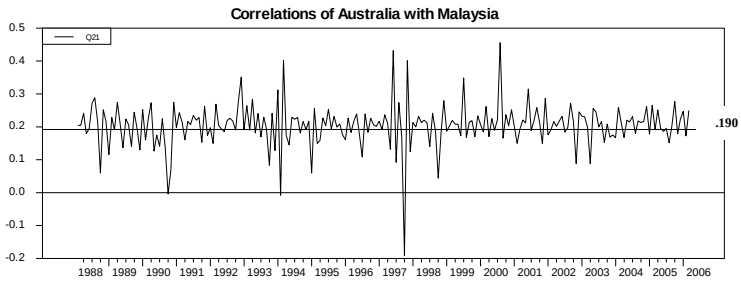
Figure 6.1

Time varying correlations for Australia vs. emerging markets.

Australia and India



Australia and Malaysia



Australian equity returns with Malaysia fluctuate over the period with no apparent trend, whereas Australian correlations with India increase over the period. The graphs for the correlations for the period 1988 to 2005 between Australia and emerging market pairs are given in Annexure 1. The effect of the Asian financial crisis of 1997-98 on the countries that were affected by the crisis can be seen in the graphs as extreme fluctuations in the correlations around the crisis period. This accurate estimate of correlations and the understanding of changes in correlations over time can help the investor make informed decisions and enhance the risk adjusted expected returns of his/her internationally diversified portfolio. Table 6.3 presents the results of Asymmetric DCC GARCH coefficient estimates.

Study of variation in correlations over time in equity markets is a new area and has recently emerged with the development of advanced GARCH models. Jithendranathan (2005) finds that the correlations of US equity returns with Russian markets change over time. He finds a statistically significant relationship between the correlations and changes in energy prices, interest rate spreads and exchange rates.

The results show the wide differences in correlations with the emerging equity markets for Australia. They also show that the correlations fluctuated in a wide range with a low of -0.6426 in January 1994 with Greece and a high of 0.8921 with Mexico in October 1998. In general the correlations were lowest with the emerging markets around 1988 (the beginning of the sample)[107] and highest in 1997 and 1998, the period of the Asian crisis. The Asian crisis caused a rapid outflow of capital from the Asian countries[108]. This simultaneous withdrawal of funds from the Asian markets could have caused the correlations in the equity markets to increase during the period. Table 6.12 shows the Asymmetric DCC GARCH estimates and Table 6.12 shows the correlations of Australia with emerging markets as estimated at the end of the sample period. Coefficients of Asymmetric DCC GARCH are significant at 1% level for the lagged conditional variances in most markets, which suggests that the lagged conditional variances have a significant association with the correlations. Coefficients for the asymmetric term in most cases are not significant, suggesting asymmetries in correlations do not significantly influence the correlations between the equity returns. Results for the lagged squared error term are mixed.

[107] 1988 is widely considered to be the time when globalisation started in most emerging markets.
[108] Gupta and Basu (2007) review the literature on the Asian crisis and Chapter 3 documents the export of Australian investment into emerging markets.

Table 6.12

Asymmetric DCC GARCH estimates of Australian vs. emerging market returns.

Coefficients	Brazil	Chile	Greece	India	Korea	Malaysia
Lagged squared error	0.0213	0.0365	0.1185	0.0309	-0.0381	-0.0523
t-statistics	1.1327	0.5529	1.5099	1.5613	-556.51*	-5.2902*
Lagged conditional variance	0.9735	0.9497	0.0379	0.9652	-0.3919	-0.2569
t-statistics	37.344*	18.420*	0.2996	203.13*	-2233.1*	-1.0334
Asymmetric term	0.0493	-0.0555	-20.2127	0.0337	0.1141	-0.7874
t-statistics	1.1651	-0.1231	-0.2140	0.5001	556.62*	-1.4320
	Mexico	**Pakistan**	**Philippines**	**Sri Lanka**	**Turkey**	
Lagged squared error	0.0412	-0.0379	-0.0383	-0.0474	0.0813	
t-statistics	2.3206**	-36.990*	-1.7059**	-1.0692	1.1034	
Lagged conditional variance	0.9630	-0.6550	-0.4246	-0.6177	0.6106	
t-statistics	73.905*	-2.7677*	-1.3961	-0.2504	12.666*	
Asymmetric term	-0.0129	0.0734	0.1731	0.0944	-1.2918	
t-statistics	-0.0960	12.012*	2.9470*	0.1593	-0.5244	

* significant at 1%, ** significant at 5% and *** significant at 10% level. t-statistics are based on robust standard errors.

Log-likelihood function maximised under normality assumption for the disturbances is:

$$L = -\frac{1}{2}\sum_{t=1}^{T}(n\log(2\pi) + 2\log|D_t| + \log|R_t| + \varepsilon_t' R_t^{-1}\varepsilon_t)$$

From equation 7, $\overline{Q}$ is the unconditional covariance of the standardised residuals resulting from the first stage estimation, and

$$Q_t^* \begin{bmatrix} \sqrt{q11} & 0 & 0 & \dots & 0 \\ 0 & \sqrt{q22} & 0 & \dots & 0 \\ . & . & . & . & . \\ 0 & 0 & 0 & .. & \sqrt{qkk} \end{bmatrix}$$

so that Q_t^* is a diagonal matrix composed of the square root of the diagonal elements of Qt

Table 6.13

Comparison of ADCC correlations with unconditional correlations of Australian equity returns with emerging market equity returns.

	ADCC Correlations	1988 to 1998	1998 to 2005	1988-2005
Brazil	0.481	0.271	0.504	0.308
Chile	0.275	0.006	0.305	0.066
Greece	0.196	0.192	0.132	0.178
India	0.436	-0.028	0.431	0.092
Korea	0.352	0.164	0.548	0.257
Malaysia	0.222	0.250	-0.019	0.190
Mexico	0.329	0.275	0.632	0.342
Pakistan	0.098	0.083	0.061	0.075
Philippines	0.315	0.304	0.205	0.284
Sri Lanka	0.100	0.012	-0.035	0.000
Turkey	0.240	0.086	0.354	0.153
Median	**0.275**	**0.164**	**0.305**	**0.178**

Second column gives correlations of Australian equity returns with emerging markets calculated using Asymmetric DCC model and columns three; four and five shows unconditional correlations for different sample periods. Asymmetric correlations are point estimates for the period ending December 2005.

A comparison of the Asymmetric DCC correlations with the simple correlations (or unconditional correlations) shows that the Asymmetric DCC correlation estimates do not have the extreme correlations that were present in the simple correlations; e.g. correlations for India for the period 1988 to 2005 are 0.092 and if we estimate this using a sample period of 1998 to 2005 the correlation coefficient is 0.431 and for Malaysia the estimate for 1998 to 2005 period is -0.019. As numeric comparison of two correlation estimates is difficult, we present the unconditional correlation estimates on the graphs of the conditional correlations in Annexure 1. It is evident from seeing the graphs that the correlations deviate substantially from the point estimates of the unconditional correlations and in most cases the unconditional

correlations are different from the correlations as estimated by Asymmetric DCC GARCH correlations.

As discussed in the review of literature (see Chapter 2), in the classic portfolio theory diversification benefits depend on the correlations between the domestic and the foreign assets. An accurate estimate of the correlations can significantly help in improving the returns for a portfolio manager by switching the international portfolio between different emerging market indexes over a period, based on the estimates of the correlations of each market. If unconditional correlations are used to construct an optimised portfolio and the true estimates of the correlations are the ones estimated by the Asymmetric DCC GARCH model, the resulting optimal portfolio will not represent the potential benefits of diversification.

To understand the factors that may influence the correlations and changes in correlations over a period, regressions for up to two lags of all independent variables are estimated. Independent variables are: volatility of the Australian market (Aus), volatility of the emerging market (e.g. Arg, Brz, Chi) and the ratio of the emerging market volatility to Australian market volatility (Ratio). The dependent variable for the study is correlations between the two markets, the Australian equity market and the emerging equity market. In the next step a stepwise regression is estimated for up to two lags to identify[109] the best fit model for the data using only emerging market volatility and the ratio. The results of stepwise regression are similar to the ones

[109] Manera, McAleer and Grasso (2006) find two lags to be important in their study of volatility of oil spots and futures.

using the selection of variables based on intuition. Below (Table 6.14) are presented the results of the stepwise regression.

Table 6.14

Regression results of factors affecting the correlation between Australian returns and emerging market returns (Asymmetric DCC GARCH)

Regression Equation: $\rho_{i,t} = \alpha_i + \beta_1 Volatility_E + \beta_2 {Volatility_E}/{Volatility_{AUS}} + \varepsilon_t$

Market	Variable(Lags)	Coefficients	T-stat	No. of observations	Adj. R^2 (Uncentred R^2) (DW-Statistic)	(Significance level of F)
Brazil	Brzvol	-0.6175	-2.6130*	213	0.0548	0.0096
	Ratio(1)	-.0036	-1.6453***		-	0.1014
					(0.1367)	0.0009
Chile	Chivol	-13.9893	-5.2290*	213	0.2572	0.0000
	Chivol(1)	-5.6854	-2.4075**		-	0.0169
	Chivoll(2)	-6.2216	-2.8554*		(0.2042)	0.0047
	Ratio	0.0784	4.2812*			0.0000
						0.0000
India	Indvol	-6.7991	-3.0788*	213	0.0482	0.0023
	Ratio	0.0493	3.4472*		-	0.0006
					(0.2787)	0.0020
Malaysia	Malvol(1)	-1.9334	-4.9926*	213	0.0986	0.0000
	Ratio(2)	0.0126	2.9184*		-	0.0039
					(1.7257)	0.0000
Mexico	Mexvol	-0.9948	-1.7857**	213	0.0910	0.0755
	Ratio	0.0150	3.1808*		-	0.0016
	Ratio(2)	0.0103	2.9563*		(0.1333)	0.0034
						0.0000
Philippines	Phivol(1)	-7.4018	-3.7599*	213	0.0738	0.0002
	Ratio(1)	0.0645	4.1295*		-	0.0000
					(0.3512)	0.0001

* significant at 1%, ** significant at 5% and *** significant at 10% level. Variables are: Brzvol means volatility of Brazil market (emerging market), Ratio means ratio of volatility of emerging market to Australian market volatility. Terms in brackets represent the lags[110].

As expected in the theory, the signs of the coefficients are negative (see Research Methodology, Chapter 5, Section 5.4) that is, as the volatility decreases the correlations should increase and vice versa. Signs of the coefficients in other

[110] Regressions using first differences were also estimated to overcome the correct the series for the problems of non-stationary and the results were not very different from uncorrected series.

regressions estimated (as given in Annexures 3 and 4) are also consistent with this. Signs for the relationship between the relative volatility and correlations are positive in cases where Australian volatility shows a stronger relationship with the correlations and not with the emerging market volatility.

Regression results show that in the markets of Chile, Korea, Malaysia and Mexico the adjusted R square is close to 0.1 or above, suggesting that some proportion of the variation in the correlations is explained by the independent variables (volatility of the emerging market or relative volatility of these markets). For the markets of Brazil, Greece, India, the Philippines, Sri Lanka and Turkey, adjusted R squared is lower than the former group of countries but significant enough to suggest a relationship between the independent variables (volatility of emerging market and the relative volatility of the two markets) and the dependent variable (correlations between the two markets). Results for Brazil, Chile, India, Korea, Malaysia, Mexico and the Philippines are significant at 1% for most independent variables and 5% for some independent variables in the respective markets. In general, results suggest that the volatility of the emerging market is important for the correlations between equity returns of Australia and emerging market pairs.

The regression results suggest that the volatility of the emerging market may have influenced the correlations between the emerging market equity returns and Australian equity returns. Relationship with emerging market volatility is significant in all at 1% level with zero lag or one lag (in the case of Malaysia, the Philippines and Chile; in the case of Chile it is significant with all lags) except Mexico. For relative volatility the results are weaker, with one or two lags. The last column of

Table 6.14 shows an overall significance level of 'F'. This can be interpreted as meaning that the chance that the results could be random is less than 1% (at a given confidence interval). Individual P values for each independent variable in regressions is low interpreting this together with the overall P value of the regression suggest that multicollinearity should not a reason for concern. A Bonferroni[111] correction for multiple regressions is a conservative test and is applied by dividing the test-wise significance level by the number of tests. This suggests that the results are significant at a 5% significance level for Brazil and at a 1% significance level for the rest of the markets. Durbin-Watson test for serial correlation suggests presence of serial correlations in all the markets at 5% level. Serial correlation is not expected to be of concern for the study as the lags of the explanatory variables have been included in the regression. Results for the excess kurtosis and Jarque-Bera statistic for the series are given in Annexure 5; these statistics show that some of the series are not normally distributed. In these markets (Brazil, Malaysia and Mexico) the outliers are identified and regressions are estimated with a dummy variable. Study finds similar results with the dummy variable.

The results for other regressions estimated are given in Annexures 2 to 4. Annexure 2 shows the regression results for correlations and volatility of emerging markets; Annexure 3 for correlations and the Australian market; Annexure 4 for correlations and the relative volatility between Australia and emerging market pairs. These results show that in most markets the correlations show a relationship with the volatility of

[111] Bonferroni correction at times has been criticised for being too conservative and testing each individual test to an unreasonably high standard of acceptability.

the emerging markets and the relative volatility and a weak relationship between the correlations and the volatility of the Australian market.

The time lag in this study represents the delay in transmission of volatility information (independent variable) to the correlations (dependent variable). The results show that lags of independent variables are important and the speed of transmission of information is different in different markets. Different information transmission speeds in different markets could be the result of stages of integration of these markets with the global markets in general and Australian market in particular. Another factor that can explain different speed of information transmission could be market efficiency of the individual stock markets. Most emerging stock markets are considered to be not weak form efficient and poor market efficiency could cause these markets to respond slower to changes in the market factors. However, test of these factors is beyond the scope of this study.

6.2.3 Summary results

This section addresses the changing correlations between the equity returns of Australia and emerging market pairs and tests for the factors that may cause the correlations to change over time. Study uses a computationally efficient DCC GARCH model for estimating time varying correlations. A significant contribution of this section is the relaxation of the condition of symmetry in the estimate of the GARCH model.

This study finds that the correlations of Australian equity returns with emerging market pairs change over time. Study also finds that the changes in correlations

between Australia and individual emerging market pairs are not uniform. Correlations with some emerging markets, e.g. Malaysia, fluctuate around the mean, while with India and Brazil the correlations in general have increased over the period of time and with Malaysia and the Philippines they are very volatile. Use of Asymmetric DCC GARCH model is theoretically recommended for estimating correlations as the model effectively captures the time varying nature of the correlations and gives more reliable estimate of correlations as compared with the unconditional estimate of correlations.

The regression results indicate a relationship between the independent variables (volatility of the emerging market equity returns, the relative volatility of the emerging markets equity returns and the Australian market equity returns) with the dependant variable (correlations) for Brazil, Chile, Greece, India, Korea, Malaysia, Mexico and the Philippines. The relationship for some markets is stronger than for others. For Sri Lanka and Turkey the relationship is very weak and for Pakistan the results show no relationship. The results also show that there is a time lag in the transmission of influence of volatility and/or relative volatility into the correlations. Findings of this section of the study have been published as Gupta and Mollik (2008).

Chapter 7

Conclusion

7.1 Thesis Conclusions

The review of the theoretical and empirical research into international diversification indicates that the correlations between equity returns are changing. Study of changes in correlations has an important bearing on the future of research on the benefits of international diversification. A multivariate GARCH model, e.g. Engle (2002), or a model that allows correlations to vary over time, will be more appropriate for the study of diversification benefits.

A review of the academic literature finds that despite increasing globalisation, there are still unrealised gains to be made by investors who hold internationally diversified portfolios of stocks. Based on this review of academic literature this study finds on theoretical grounds, emerging market investments should provide a vehicle by which an investor can achieve an improvement in the risk-adjusted returns for an internationally diversified portfolio. Empirical research indicates that investors can still benefit from international diversification, because world financial markets are still not fully integrated (i.e. globalised), (Schmukler 2004; Li, Sarkar and Wang 2003; and Karlsson and Norden 2007).

The issue of the benefits of international diversification from the standpoint of major equity markets has been well researched. The research has also looked into the specific benefits of investing into emerging markets because of the distinctive characteristics of the emerging markets. However, Madura and Soenen (1992) argued that there are differences in benefits of international diversification from the standpoint of investors from different countries, i.e. an investor from Canada

may gain different benefits from diversifying internationally as compared with an investor from Japan. As such, the benefits of international diversification for Australian investors may differ in size as compared with benefits for investors from other major equity markets, because of the nature of Australia's economic and financial markets. Moreover, the diversification benefits of investing in emerging markets specifically may also be different for Australian investors as compared with investors in other larger developed markets. This is because of the similarities and/or dissimilarities between the macroeconomic factors of the markets. This study has looked into these differences and tested if Australian investors can enhance portfolio returns by including emerging market into their portfolio mix. This study also looked at if the volatilities of the emerging markets or Australian market is expected to cause the changes to the correlations in equity returns and thus changes in the benefits of diversification into emerging markets for Australian investors.

Study of growth and expansion of world equity markets for the past three decades indicates that that emerging markets are important for equity portfolio investments of the investors from the developed world. As the fervour from the Asian crisis settles, the flow of portfolio investments is returning to the emerging markets. Since the financial deregulation and removal of exchange controls in Australia, the flow of equity capital to the emerging markets has been consistently rising. There was a small decline in the flow of equity to the emerging markets around the period of the Asian crisis; the crisis may have caused this reversal in the flow of equity investments to the emerging markets. Further, some researchers and

practitioners have expressed reservations about the flow of equity to the emerging markets, but this study finds that this flow of equity to the emerging markets is in Australia's interest. The growth in equity investments into emerging markets and improved sentiment towards investments into emerging markets will be reflected in portfolio strategies pursued by portfolio managers seeking international diversification.

Crisis in the East Asian markets has led many people to argue against investments in emerging markets on the basis that foreign investments may lead to increased volatility. The evidence does not support this argument; on the contrary, evidence in the published literature shows a smoothing effect in the equity market cycles after liberalisation.

Australian portfolio managers seeking diversification into emerging markets may be concerned about changing correlations and erosion of potential benefits in diversifying into emerging markets. This study finds that the correlations between Australian equity returns and emerging market pairs are changing and in general have increased over time. This study also finds that the changes in correlations between Australia and individual emerging market pairs are not uniform. Correlations with some emerging markets, e.g. Malaysia, stay around the mean, with India and Brazil the correlations have increased over the period, and with Malaysia and the Philippines the correlations are very volatile. Notwithstanding the general increase in correlations over time, these correlations are still lower and Australian investors can still benefit from including emerging markets in their portfolios.

Regression results indicate that the volatility of the emerging market equity returns has a relationship with the correlations for Brazil, Chile, Greece, India, Korea, Malaysia, Mexico and the Philippines. The relationship for some markets is stronger than for others. The results show a very weak relationship for Sri Lanka and Turkey and no relationship for Pakistan. The results also show that this relationship between volatility and/or relative volatility and the correlations is not contemporaneous and there is a time lag in the transmission of the influence of the volatility and/or relative volatility. Investors who seek to use emerging markets for diversification purposes and are aware of the fact that the correlations change may be concerned about the factors that may influence these changes in correlations. This study shows that there is a weak link between the volatility of the emerging markets and the correlations of Australian returns with emerging markets.

My study finds that correlations within emerging market pairs and with Australia are low and that despite increasing globalisation, Australian investors can continue to benefit by investing into emerging markets. Relatively higher expected returns in the emerging markets and low correlations with Australian equity returns offer better diversification benefits, while high volatility in the equity returns of these markets require better econometric models to capture the true nature of the correlations. The use of the Asymmetric DCC GARCH model in estimating correlations improves the estimate of correlations. Thus, portfolios constructed using this model will represent the potential benefits of diversifying into emerging markets more accurately. Based on the results, this study recommends investing

into emerging markets to improve the risk-return relationship for an Australian portfolio manager.

Some emerging markets have restrictions on short sales and these restrictions limit the benefits of portfolio optimisation. Despite the restrictions on short sales, the results show significant benefits in diversifying into emerging markets. The thesis also looked at restricting investments into emerging markets to the maximum of 50% of the available funds and a further restriction of not investing more than 10% in a single market; the benefits are significant despite these restrictions.

7.2 Contributions

My study makes important theoretical and empirical contributions to existing knowledge. First contribution of the study is in using a computationally efficient model that captures the variation in correlations over time and can be used in practical applications because of its computational ease. Model used in the study is theoretically sound.

Second contribution of the study is that it tests if volatilities of emerging markets are expected to cause correlations to change over time. Investors who seek to benefit from diversification into emerging markets may be concerned about the changes in correlations over time. The understanding of the reasons that influence changes in correlations has important implications for fund managers.

The third contribution of this study is to quantify the benefits of diversifying into emerging markets for an Australian investor. Testing the benefits for a new and

smaller market, i.e. Australia is another important contribution of this study. The market tested is different in its financial and economic structures from other larger markets, thus theoretically would be expected to have different diversification benefits because of the differences in its financial and economic structures as compared with other developed markets. This study does not make a direct comparison of the diversification benefits for Australia with other major markets.

Higher volatility of emerging market returns has been of concern for academics and practitioners, who suggest inclusion of emerging markets for exploiting benefits of international diversification. This study contributes to existing knowledge by addressing this issue in terms of the overall diversification benefits of investing into emerging markets and finds that despite higher volatility there are benefits in diversifying into emerging markets. In addition, this study uses an efficient model that is theoretically sound, for estimating correlations more accurately in the presence of higher volatility. This understanding has important implications for portfolio managers seeking to benefit by using emerging markets in their portfolio selection process in order to diversify their portfolios internationally as well as for researchers seeking to identify the potential benefits of diversification into emerging markets.

The robustness of the analysis has been assessed by calculating the correlations using different methods; testing different portfolios on the efficient frontier and using different risk-free rates. This study uses a longer time series as compared with other studies and includes a full business cycle. Inclusion of the boom period

of the equity markets in the study removes the bias that might otherwise have influenced the results.

Finally, this study has some practical implications for the portfolio manager, as the use of a computationally efficient model, and the findings that there are potential benefits for an Australian investor by diversifying into emerging markets, can provide opportunities for the portfolio manager to enhance the risk-return profile of his/her portfolio by including emerging market assets. The results of the study can be extended to identify the markets that may have higher diversification benefits because of lower correlations. This knowledge can assist the portfolio manager in making better investment decisions. The evidence that investments into emerging markets are not expected to cause increased volatility in these markets provides increased confidence for investors and analysts who seek to include emerging market assets in their portfolios.

7.3 Limitations of the study

Reliability of the data, poor liquidity in the stock markets, dominance of a few companies in the stock market indexes, and market impact costs are some of the limitations that the research in the emerging markets is generally exposed to. The major limitation of this study is the limited availability of data for emerging markets. The emerging markets started relaxing controls on foreign investments from the beginning of the 1980s. For some of the markets this data is available from a much later date. An out of sample study was not possible because of short data series.

The second limitation is the assumption that there are no transactions costs in investing into emerging markets. Study uses 1.1% transactions costs on the basis of previous studies in the emerging markets to see if there still are benefits after providing for 1.1% transactions costs. Accurate estimate of transactions costs is difficult and is beyond the scope of this study. It is important to consider the direct and indirect costs of investing into emerging markets and these costs.

The third limitation of the study is the absence of an out-of-sample analysis. Out-of-sample analysis is not feasible because of limitations of the data for the emerging markets. To perform an out-of-sample analysis using the multivariate GARCH model one needs a large number of observations which is not possible with the emerging markets as the data for these markets are available from a later date. An out-of-sample study can be feasible when a longer data series is available for these markets.

In general differentiating factors that distinguish emerging markets from the rest of the developed markets and provide the diversification benefits also prove to be limitations in investing into these markets. The presence of discriminatory taxation may influence negatively for foreign investors thus diminishing the benefits of diversification for these investors. Capital flow restriction that restrict free market entry and exit may erode the benefits of diversification as foreign investors may not be able exit from the market at the time the fundamentals suggest selling a particular emerging market investment. Thin trading in some of the emerging markets is another limiting factor in realising the benefits of diversification in the emerging markets. Low turnover and the small market size also influence the

foreign investors as the cost of investing in the merging markets for foreign investors increase. These problems are further accentuated by the economic culture and the language barriers that may exist in the emerging markets.

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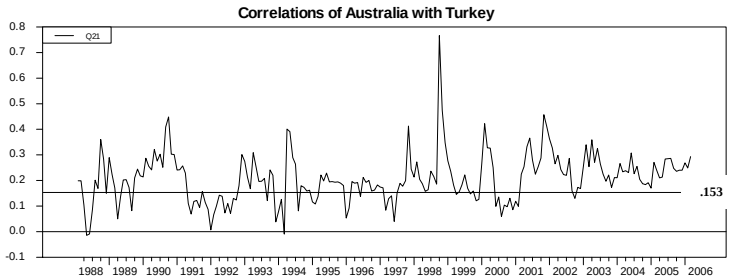
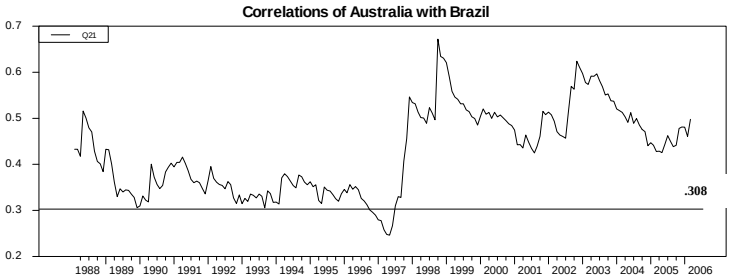
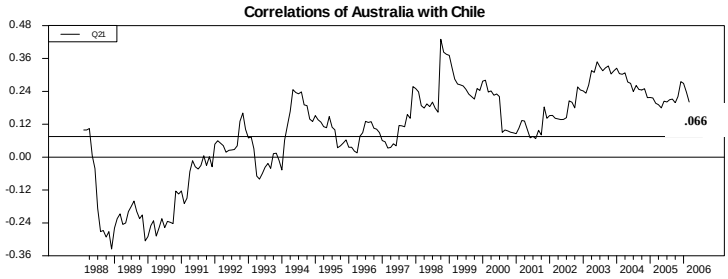
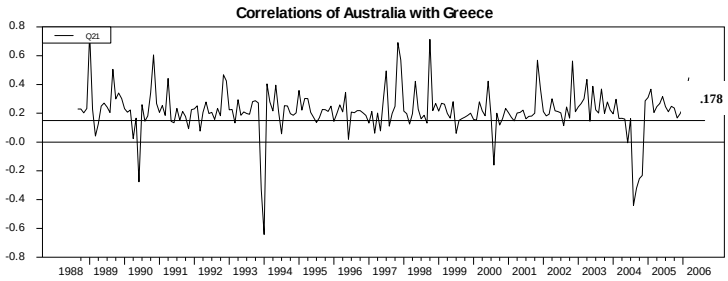
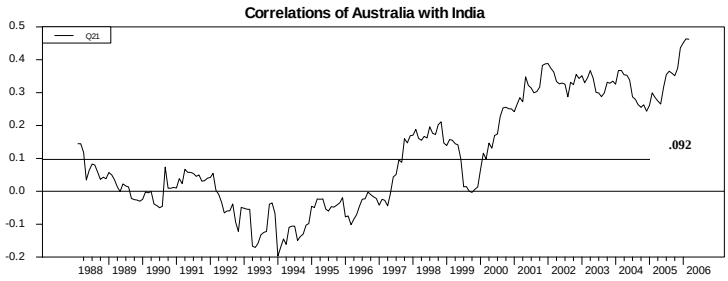
Annexure 1: Graphs of time varying correlations of Australia with emerging markets.

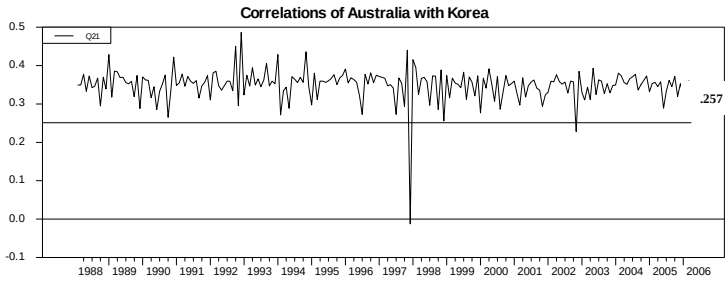


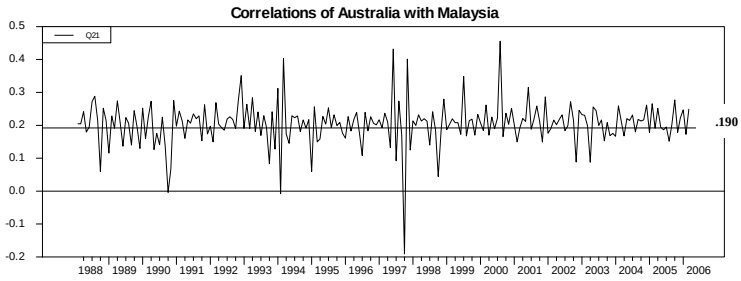


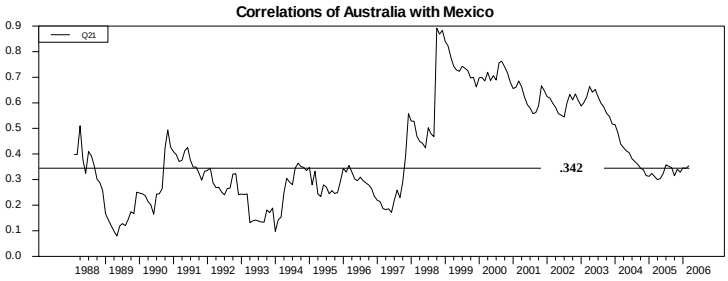


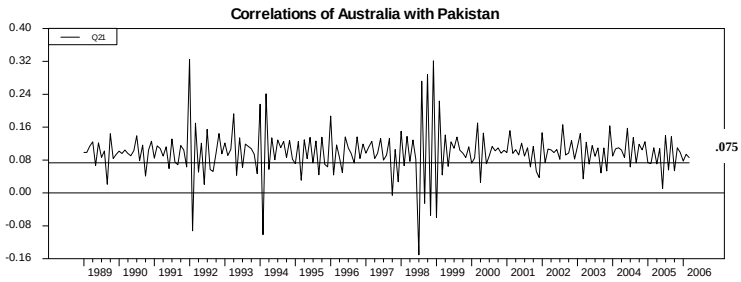


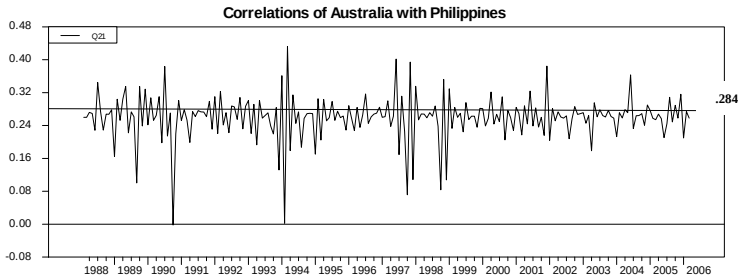

Correlations of Australia with India
Q21
.092

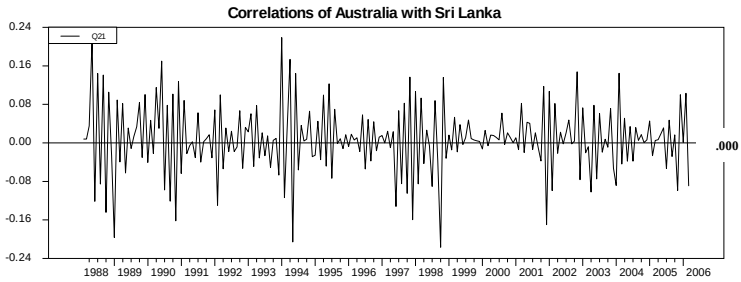

Correlations of Australia with Korea
Q21
.257


Correlations of Australia with Malaysia
Q21
.190


Correlations of Australia with Mexico
Q21
.342


Correlations of Australia with Pakistan
Q21
.075


Correlations of Australia with Philippines
Q21
0.48
0.40
0.32
0.24
0.16
0.08
0.00
-0.08
.284
1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006


Correlations of Australia with Sri Lanka
Q21
0.24
0.16
0.08
0.00
-0.08
-0.16
-0.24
.000
1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006

Annexure 2: Regression results of factors affecting the correlation between Australian returns and emerging market returns (Asymmetric DCC GARCH).

Regression equation: $\rho_{i,t} = \alpha_i + \beta_1 Volatility_E + \varepsilon_t$

Market	Variable(Lags)	Coefficients	T-stat	no. of observations	Adj. R^2	Significance level of F
Brazil	Brzvol	-0.7538	-3.3919*	213	0.0541	0.0008
Chile	Chivol Chivol(1) Chivoll(2)	-8.0515 -6.5499 -6.3105	-3.3819* -2.6751* -2.7832*	213	0.2070	0.0000
Korea	Korvol Korvol(2)	1.5097 1.5323	5.0881* 5.1542*	213	0.3505	0.0000
Malaysia	Malvol(1) Malvol(2)	-2.0701 1.0276	-4.4954* 2.2286**	213	0.0924	0.0000
Mexico	Mexvol(2)	0.9941	2.4856**	202	.02844	0.0137
Philippines	Phivol(2)	-3.2104	2.1126**	213	0.0207	0.0358

* significant at 1%, ** significant at 5% and *** significant at 10% level. Variables are: Brzvol means volatility of Brazil market (emerging market), Ratio means ratio of volatility of emerging market to Australian market volatility, terms in brackets represent the lags.

Annexure 3: Regression results of factors affecting the correlation between Australian returns and emerging market returns (Asymmetric DCC GARCH).

Regression equation: $\rho_{i,t} = \alpha_i + \beta_1 Volatility_{Aus} + \varepsilon_t$

Market	Variable(Lags)	Coefficients	T - stat	No. of observations	Adj. R^2	(Significance level of F)
Chile	Ausvol Ausvol(2)	-8.1648 -5.9109	-3.2119* -2.3934**	213	0.1757	0.0000
Greece	Ausvol(1) Ausvol(2)	4.3404 4.7052	2.0818** 2.2642**	213	0.0606	0.0006
India	Aus Ausvol(2)	-7.0626 -6.24355	-2.3169** -2.1300**	213	0.0615	0.0004
Malysia	Ausvol	-2.2901	-2.4317**	213	0.0226	0.0000
Mexico	Ausvol	-2.4546	-2.8326*	213	0.0320	0.0050
Philippines	Ausvol(2)	-7.1925	-2.5337**	213	0.0730	0.0001
Sri Lanka	Ausvol(2)	-0.0297	-1.9867**	213	0.0137	0.0482
Turkey	Ausvol	-11.4919	3.8636*	213	0.0616	0.0001

* significant at 1%, ** significant at 5% and *** significant at 10% level. Variables are: Brzvol means volatility of Brazil market (emerging market), Ratio means ratio of volatility of emerging market to Australian market volatility, terms in brackets represent the lags.

Annexure 4: Regression results of factors affecting the correlation between Australian returns and emerging market returns (Asymmetric DCC GARCH).

Regression equation: $\rho_{i,t} = \alpha_i + \beta_1 {Volatility_E}/{Volatility_{AUS}} + \varepsilon_t$

Market	Variable(Lags)	Coefficients	T-stat	No. of observations	Adj. R^2	(Significance level of F)
Brazil	RBrz RBrz(2)	-0.0048 -0.0040	-2.1721** -1.8230***	213	0.0450	0.0029
Greece	RGre(2)	-0.0195	-2.2847**	213	0.0202	0.0233
Korea	RKor RKor(1) RKor(2)	0.0134 0.0090 0.0070	4.2369* 2.5044** 2.2233**	213	0.3703	0.0000
Malaysia	RMal(1) RMal(2)	-0.0165 0.0115	3.4675* 2.4278**	213	0.0463	0.0025
Mexico	RMex RMex(2)	0.0093 0.0098	2.6625* 2.8072*	213	0.0815	0.0000
Philippines	RPhi(1)	0.0255	2.1212**	213	0.0162	0.0350
Sri Lanka	RSri(2)	0.0000	1.7227***	213	0.0091	0.0864

* significant at 1%, ** significant at 5% and *** significant at 10% level. Variables are: Brzvol means volatility of Brazil market (emerging market), Ratio means ratio of volatility of emerging market to Australian market volatility, terms in brackets represent the lags.

Annexure 5: Diagnostic tests for the normality.

Market	Excess kurtosis	Jarque-Bera
Brazil vol	26.8906	7200.0977
Ratio	21.3142	4613.7407
Correlations	-0.1196	14.3927
Chile	2.9764	150.5640
Ratio	0.7871	30.3245
Correlations	-0.3061	16.6694
India	4.1262	250.6325
Ratio	4.9530	356.1710
Correlations	-0.5773	2.9931
Malaysia	17.8284	3352.9937
Ratio	13.1193	1869.0568
Correlations	10.6086	1082.3449
Mexico	9.7744	1131.7245
Ratio	5.5255	427.7248
Correlations	-1.1489	18.1497
Philippines	4.6514	319.6645
Ratio	5.3948	382.2111
Correlations	-0.2503	8.6971

Annexure 6: Assumptions for the DCC model.

The following set of assumptions is reproduced from Engle and Sheppard (2001). These assumptions are sufficient to establish the consistency of the parameters estimated using the two step DCC estimator as suggested by Engle (2002) and applied in this study.

Assumption 1

(i) For each $\emptyset$ in Φ, $E(logf_1(r_t, \emptyset))$ exists and is finite, t= 1, 2 …,

(ii) $\{logf_1(r_t, \emptyset)\}$ obeys strong uniform law of large numbers

(iii) For each $\theta = (\emptyset, \psi)\Theta = \Phi x \Psi, \mathrm{E}\left(\mathrm{logf}_2(\mathrm{r}_t\theta)\right)$ exists and is finite, t = 1, 2, …,

(iv) $\{logf_2(\mathrm{r}_t\theta)\}$ obeys the strong ULLN.

Assumption 2

(i) $\theta_0 = (\phi_0, \psi_0)$ is identifiably unique, interior in $\Theta = \Phi \times \Psi$ uniformly in n, Θ is compact, and $\theta_0$satisfies the conditions that univariate GARCH parameter restrictions are satisfied for all asset series.

(ii) $\{\bar{L}_{1T}(\phi) = E(T^{-1} \sum_{t=1}^{T} logf_1(r_t, \emptyset))\}\, is\ O(1) uniformly\ on\ \Phi$

(iii) $\{\bar{L}_{2T}(\theta) = E(T^{-1} \sum_{t=1}^{T} logf_2(r_t, \emptyset))\}\, is\ O(1) uniformly\ on\ \Theta$

Assumption 3

(i) For all $\phi\ in\ \Phi, \nabla\ \bar{L}_{1T}(\phi) =\ E(\nabla \bar{L}_{1T}(r^T, \phi)) < \infty, where\ r^T = (r_1, r_2, \ldots\ldots r_T)$, $the\ T -\ dimensional\ vector\ of\ observations.$

(ii) For all $\theta\ in\ \Theta, \nabla\bar{L}_{2T}(\theta) = E(\nabla\bar{L}_{2T}(r^T, \theta)) < \infty$

Assumption 4

(i) For all $\phi\ in\ \Phi, \nabla^2\bar{L}_{1T}(\phi) = E(\nabla^2 L_{1T}(r^T, \phi)) < \infty$

(ii) $E\left(\nabla^2 L_{1T}(r^T, .)\right) is\ continuous\ on\ \Phi\ uniformly\ in\ T = 1, 2, \ldots$

(iii) $\{\nabla^2 log f_1(r_t, \phi)\} obeys\ the\ strong\ ULLN.$

(iv) For all $\theta\ in\ \Theta, \nabla^2\bar{L}_{2T}(\theta) = E(\nabla^2 L_{2T}(r^T, \phi) < \infty$

(v) $\mathrm{E}(\nabla^2 L_{2T}(r^T, .))\ is\ continuous\ on\ \Theta\ uniformly\ in\ T = 1, 2, \ldots$

(vi) $\{\nabla^2 log f_2(r_t, \phi)\} obeys\ the\ strong\ ULLN$

Assumption 5

(i) $\left\{A_{11,T} = \nabla_{\emptyset\emptyset}\bar{L}_{1T}(\phi_0)\right\} is\ O(1) and\ uniformly\ negative\ definite.$

(ii) $\left\{A_{22,T} = \nabla_{\psi\psi}\bar{L}_{2T}(\theta_0)\right\} is\ O(1) and\ uniformly\ negative\ definite.$

Assumption 6

$\{T^{-1/2}\nabla'_{\phi} lnf_1(r_t, \phi_o), T^{-1/2}\nabla'_{\psi} lnf_2(r_t, \phi_o, \psi_o)\}$ obeys the central limit condition with co-variance matrix B_{OT}, and B_{OT} is O(1) and uniformly positive definite.

Using these assumptions from 1 to 6, DCC GARCH model establishes the asymptotic distribution of the two stage estimation process.

Note: In this annexure I have used the same notation as used in the Engle and Sheppard (2001), which is slightly different from the notation used in the methodology.