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Comparative International Equity Portfolio Diversification:
A South African Investor Perspective

Rinhiel Deeplal

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Supervisor: Prof Imhotep Alagidede

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III. List of Abbreviations and Acronyms

ADF	Augmented Dickey Fuller
AR	Auto Regressive
ARCH	Autoregressive Conditional Heteroskedasticity
ASEAN	Association of Southeast Asian Nations
Asian EM	Asian Emerging Market Series
DCC	Dynamic Conditional Correlation
DF	Dickey Fuller
DWM	Developed Western Market/s
EAM	Emerging Asian Market/s
FDI	Foreign Direct Investment
GARCH	Generalised Autoregressive Conditional Heteroskedasticity
IRF	Impulse Response Function
LM	Lagrange Multiplier
MRR	Maximum risk-adjust return
MSR	Maximum Sharpe Ratio
MVP	Minimum-variance portfolio
NYSE	New York Stock Exchange
P-P	Phillips-Perron
SA	South Africa
SR	Sharpe Ratio
UK	United Kingdom
US	United States of America
VAR	Vector Autoregression
VD	Variance Decomposition
Western DM	Western Developed Market Series

IV. Abstract

This dissertation explores the potential international diversification benefits for a South African equity investor across the Developed Western Markets and Emerging Asian Markets. The step-down mean-variance spanning approach is employed to test the statistical significance of the diversification benefits across the two regional global markets. The empirical evidence suggests that international diversification of the local South African equity portfolio into Emerging Asian Markets completely dominate the diversification into Developed Western Markets. This diversification strategy has a superior tangency portfolio and minimum-variance portfolio. The Sharpe ratio is used to economically quantify the potential diversification benefits. The dominant strategy has a 28% increase in the Sharpe Ratio when compared to the diversification into Developed Western Markets. The Vector Autoregression model is used to study the integration between markets which may be a key driving factor in the different diversification benefits. The model deduces that there is higher integration between the Developed Western Markets and both the South African market and Emerging Asian Markets. The Developed Western Markets also have lower average returns in comparison to the Emerging Asian Markets. These factors penalise the diversification benefits into Developed Western Markets leading to diversification into Emerging Asian Markets being the favourable strategy. These results contribute to the limited body of knowledge which is available on diversification benefits from a South African investor perspective. This will assist to inform local investment policies and strategies in order to develop optimal portfolios in South Africa.

Key words: Diversification benefits; Optimal portfolio; Mean-Variance Spanning; Sharpe Ratio, Vector Autoregression; Diversification strategy.

Chapter 1: Introduction

1.1. Context

Even though significant research has been conducted in the field of portfolio diversification, the research is primarily focused from the perspective of a United States of America (US) investor. Having a limited perspective in a pioneering subject such as portfolio diversification poses a vexing challenge to South African Investors (Driessen & Laeven, 2007). The current research in portfolio diversification has been developed around a US centric market model thus rendering certain aspects of the research content redundant to a South African investor. This redundancy may prove fatal to a South African investor as it provides practical guiding principles which are negligible when developing international diversification strategies in the South African market. Information asymmetry is one of multiple reasons as to why South African investors have a home bias when investing in equity markets (Cooper et al., 2013). If the South African investor only holds local equities, it will mitigate the idiosyncratic risk posed to their portfolio (Goyal & Santa-Clara, 2003). To further immunise their portfolio, the local investor may reduce systematic risk by capitalising on the diversification opportunities presented within global markets. This is prevalent in the current investment environment as international markets are becoming easily accessible across developed and emerging economies.

The discovery of minerals in the 19th century promulgated Western interests in South Africa (SA) which accelerated the development of capital markets in the country. (Ruaben, 2022). This resulted in SA becoming a major financial power on the continent holding the largest stock exchange in Africa (Smith et al., 2002). This led to the Western markets being SA's dominant trading partners. This trading alliance could create challenges from an international diversification perspective due to the integrated dynamics of these markets. The resulting reduction of risk on the portfolio may be suboptimal compared to diversification opportunities which exist in differing global markets.

An interesting region for a South African investor to explore diversification opportunities is in the Emerging Asian Markets (EAM). During the 20th century, the Asian economies were stagnated because of unsophisticated financial markets and slow growth in the manufacturing sector (Bassino & Williamson, 2015). In the latter half of the 20th century, active economic policy reforms took place in the Asian markets causing a notable rise in manufacturing and commodity exports (Beeson, 2001), followed by an increase in Foreign Direct Investment (FDI), improved liquidity and in the development of financial markets (Purfield et al., 2008). Accordingly, these factors caused significant growth rates for Asian economies leading into the 21st century (Muhammad et al., 2016) which continues to present day. These growth rates have been, on average, more than three times faster than Latin America and the Caribbean countries for the last quarter of the past century (Talvi et al, 1997). Unlikely the Gulf Cooperation Countries (GCC) economies which are

primarily concentrated on oil production and tourism (Mansfeld & Winckler, 2007), the EAM growth is more diversified and sustainable in the long term. The predominant trading partners of Asian markets are local regional Asian countries as well as the Developed Western Markets (DWM) (Narayan et al., 2014). A South African investor may find that interesting diversification opportunities exist in the Asian markets due to the diversified economy, sustained growth rates and EAM weaker trade ties with SA.

The Mean-Variance framework provides the ability for an investor to investigate these potential diversification benefits. In 1952, the evolutionary work of Harry Markowitz shifted the paradigm in the selection of optimal portfolios and created a framework which enables rational investors to quantifiably maximize their returns for a given level of risk using a selected bundle of assets (Markowitz, 1952). This framework is based on the risk associated with the asset and subsequent return profiles as well as taking the investor's risk tolerance level into consideration.

Considering the above, further analysis and research are vigorously required on global portfolio diversification from a South African investor perspective. The DWM is considered as the first key regional global market in which to study diversification opportunities because of its global dominance and historic relationship with the South African market. The second key regional global market which is becoming more prevalent in society and is of interest are the EAM due to its reformed economic policies, sustained growth rates and limited trade relations with SA. These factors will highlight the international diversification differences and benefits across the regional global markets and help to inform local investment policies.

1.2. Research Question/Hypothesis

This dissertation aims to use existing portfolio diversification techniques to expand the body of knowledge from a South African investor's perspective. This dissertation will further focus on the optimal diversification approach for portfolios which is constructed using South African listed stocks in a basket of international equity markets.

Furthermore, this study aims to methodically answer two fundamental questions from the perspective of a South African investor, namely:

1. Is there greater benefit for a South African investor to diversify their equity portfolio into the DWM and/or EAM?

2. Can the integration between the South African equity market and the DWM and EAM explain how diversification benefits are realised?

1.3. Significance of the Study

The results obtained from this study will enable South African investors to make better informed decisions utilising a broader spectrum of research for their equity portfolios in terms of diversification into international markets. It will also allow the South African investor to take advantage of diversifying their equity portfolio into EAM, if any such benefits exist across the emerging markets. If no significant diversification benefit exists, the results will still be able to provide an understanding of how a South African investor's equity portfolio is impacted by investing in the different markets.

Another aim of this study is to provide valuable insights as to whether there are benefits for South African equity portfolio diversification in DWM or EAM. This analysis will be conducted through evaluating the integration between the various equity markets and studying how shocks from the different markets impact each other.

The approach of this dissertation is applied in nature in order to derive practical results so that readers would easily be able to use these results, in conjunction with their understanding of equity markets, to inform their current investment principles.

Chapter 2: Literature Review

2.1 Conceptual Portfolio Diversification Framework

Markowitz (1952) formalised the initial theoretical framework for portfolio diversification. This theory was built on the work of Williams (1938) who developed a portfolio selection rule in which an investor should aim to maximise their future returns. These returns are expected in nature as one cannot know the future with certainty. The second piece of work which contributed to Markowitz's theory was compiled by Hicks (1945), who introduced the idea of letting the rate at which we capitalise the expected returns from securities vary with risk.

Using the aforementioned works as a foundation, Markowitz (1952) theorised that investors should consider anticipate returns as favourable and the uncertainty associated with those returns as undesirable. This implies that the notion of an investor's primary objective is to select a portfolio that provides the highest expected return without considering the risk linked to that return can be rejected. The risks driven through market imperfections can be reduced through constructing a diversified portfolio of relatively uncorrelated securities. All variability cannot be eliminated through diversification as the securities are subjected to a certain level of overall market risk. Therefore, it is reasonable to assume that any rational investor would want to maximise their return with a minimum level of risk. These notions are fundamental to the Expected Returns-Variance of Returns (E-V) framework, which is analogous to the mean-variance framework, as developed by Markowitz. Markowitz also provides the theoretical tools required to construct such portfolios which is further discussed below.

For the sake of simplicity, the detailed mathematical rigour of the statistical concepts used below are not included in this paper as the aim is to derive a general understanding of the results and to develop the tools necessary for portfolio diversification. The proofs are available in any standard statistical text.

When constructing a portfolio, an investor has a pool of funds which they can utilise and invest into different assets. Let the percentage of an investment in asset i be represented by X_i , therefore the sum of the total proportions of investment must equal to 1 i.e. $\sum X_i = 1$. There is a condition that $X_i \geq 0$, which implies that there is no short selling of assets. Let the return from asset i be represented by μ_i . Therefore, the expected weighted return on the portfolio that consists of n assets is:

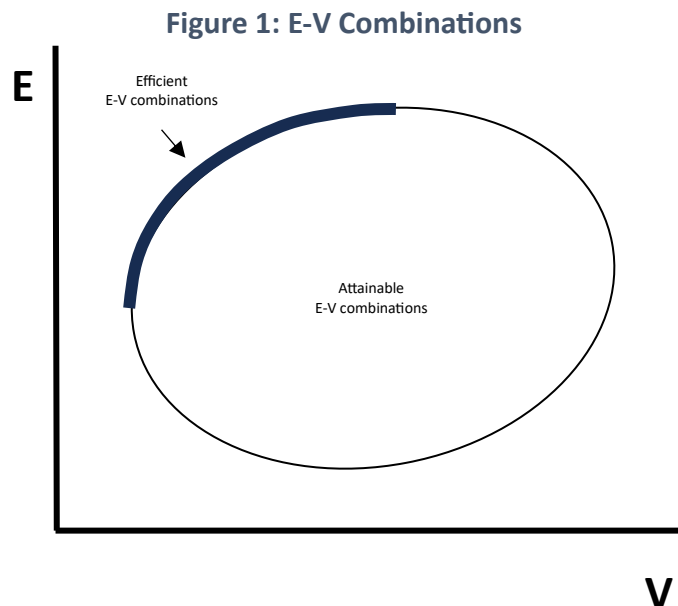
$$E = \sum_{i=1}^N X_i \mu_i$$

The variance of the portfolio is represented as follows:

$$V = \sum_{i=1}^N \sum_{j=1}^N \sigma_{ij} X_i X_j$$

Where σ_{ij} is the covariance between asset i and j .

If the probability beliefs for (μ_i, σ_{ij}) are fixed, which can be computed by using historic values of the assets, then an investor can choose different portfolios of assets X_1, \dots, X_N which will result in different combinations of E and V. If one assumes that all possible sets of (E, V) are attainable from the different portfolio combinations, this will give rise to below surface in Figure 1.



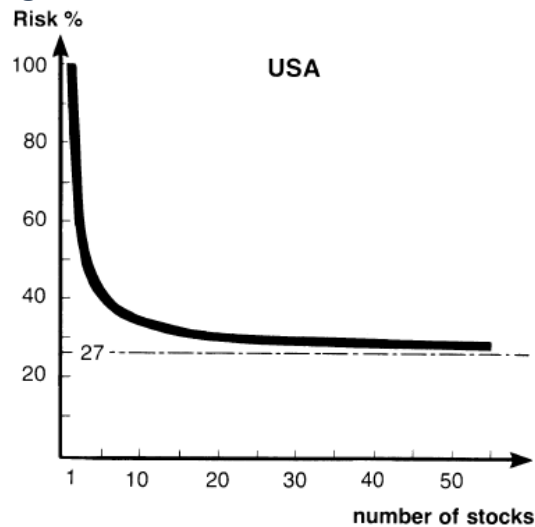
Applying the E-V rule to Figure 1, an investor would want to select a portfolio for which they can achieve the maximum return for the minimum variance possible. This will give rise to the dark bold part of the circumference on the surface, as these portfolio combinations will allow the investor to maximise their return for the minimum achievable variance. If the investors select a portfolio that give rise to an E-V combination on the interior of the surface, then another portfolio will exist which would dominate the selected portfolio as a higher return can be achieved for the given level of variance, else a lower variance can be achieved for the given level of return. Therefore, the dark bold part of the circumference dominates the rest of the portfolio combinations and would be the most efficient set of portfolios given the investors' propensity for risk.

Diversification is not solely adequate based on the volume of different securities held in a portfolio. If the portfolio is concentrated on a single economy, then it is exposed to macro-economic risk encountered by the economy which can be prevented through international diversification. Therefore, the E-V hypothesis implies the “right kind” of diversification for the “right reason”.

2.2 Diversification Reducing Risk in Developed Western Market Portfolios

Holding a well-diversified portfolio of stocks can reduce the total risk afforded by the portfolio. This is due to the variability of the portfolio’s returns being less than the individual stocks which constitute the portfolio. Several studies (Evans & Archer, 1968; Wagner & Lau, 1971) have focused on the relationship between the reduction in the riskiness of a portfolio and the increasing number of stocks held from the US stock exchange. Solonik (1974) conducted a specific study which monitored weekly price movement on the New York Stock Exchange (NYSE) for the period of 1966 to 1971 using a method of randomly selecting securities for the different size portfolios and calculating the average variability in the returns. This study is particularly noteworthy as it indicated the reduction in variability of the portfolio as the number of stocks increased.

Figure 2: US Local Portfolio Diversification



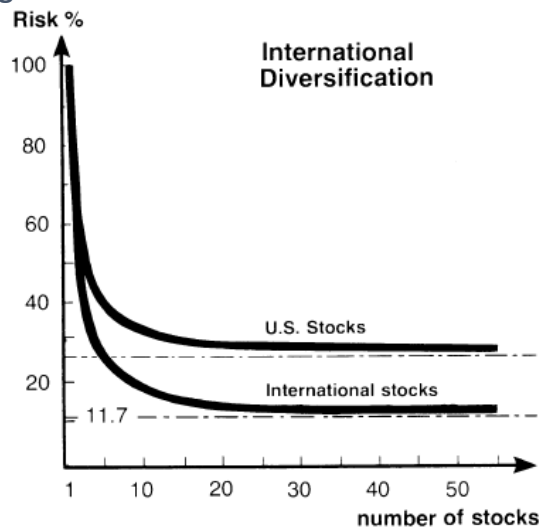
The vertical axis in Figure 2 shows the risk of the portfolio relative to the typical stock on the NYSE and the horizontal axis shows the number of stocks in the relevant portfolios. The empirical study indicates that a portfolio constructed of 20 stocks from the NYSE rapidly reduces the risk of the portfolio to 30%. If a US investor added another 50 securities to their portfolio, they would

only experience a marginal reduction in risk of 3%. For the US equity market, a portfolio consisting of 20 stocks may be considered well diversified.

The results also indicate that 27% of the typical risk of an individual US security cannot be diversified, while the non-diversifiable risk experienced on the German stock exchange is 44%. This result can be attributed to the market structure of the various countries. Most large US corporations offer publicly listed stocks whereas most large European firms are privately owned. This creates a lack of diversification opportunities in local European markets in comparison to the US. Thus, the constraints experienced by both markets in terms of non-diversifiable risk may be addressed by investing in international equity markets.

Multiple studies (Grubel, 1968; Levy & Sarnat, 1970) have examined the results of movements in stock prices across different countries which are almost uncorrelated. Stock price changes on the Financial Times Stock Exchange (FTSE) in the United Kingdom (UK) appears to be independent of stock price changes on the NYSE. When securities of one country is performing poorly, another country's securities may be performing on a higher standard thus offsetting any losses. Using the same period as per Figure 2, Solnik (1974), extended the study to identify the reduction of risk in a US equity portfolio by including international stocks from UK, Germany, France, Switzerland, Italy, Belgium and Netherlands. The study uses a method similar to the abovementioned with only one amendment namely that the portfolios are constructed with an equal chance of holding stocks from any of the aforementioned countries.

Figure 3: International Portfolio Diversification



As depicted in Figure 3, there is substantial risk reduction that can be achieved by diversifying internationally compared to only holding US stocks. A well-diversified international portfolio is

50% less risky than a well-diversified US portfolio and 90% less risky compared to a typical US stock.

Solnik (1974) further discusses the risk reduction benefits of inter-industry diversification. The study follows a similar logic of international diversification as not all industries will be performing poorly at the same time. Considering this logic in conjunction with the above-mentioned local and international diversification results, Solnik (1974) provides a practical framework to achieve a well-diversified and reasonably sized portfolio. Solnik's framework states that the first selection procedure is to ensure reasonable geographical diversification across countries. The second selection criteria is to select stocks from varying industries. The third and final selection criteria is a combination of the first and second rules, which states that one must consciously select a combination of international stocks from differing industries. This will help in achieving the maximum reduction in risk for the portfolio.

2.3 Emerging Asian Markets Portfolio Diversification Benefits

The literature on portfolio diversification of Asian markets consisted primarily of diversifying developed market portfolios into the Asian markets (Li et al., 2003; Fletcher & Marshall, 2005). Zhang (2011) concerted one of the earliest works of portfolio diversification from the perspective of a local Asian investor. The primary focus of the study was to identify whether regional or global diversification has more benefits for an Asian investor. The measures are founded on the Maximum risk-adjust return (MRR) and Minimum-variance portfolio (MVP) which are based on Chiou et al. (2009) and Jiang et al. (2010). In both instances, irrespective of whether an investor is concerned with maximising returns or minimising variance, diversification into regional Asian markets outperformed diversification into global markets.

The second key focus for Zhang (2011) was to evaluate whether there is benefit for a local Asian investor holding a diversified regional portfolio to further globally diversify. The method employed to determine this was the mean-variance spanning technique as developed by Huberman & Kandel (1987). The test results overwhelming indicated that the addition of global assets could improve the mean-variance efficient frontier and improve the overall optimal portfolio for the local Asian investor.

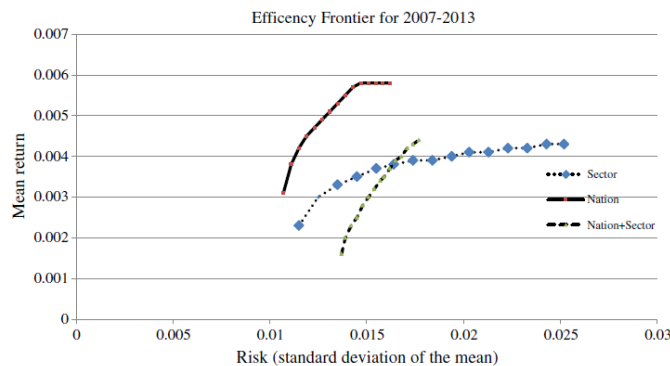
Mensah & Premaratne (2016) further built on the above body of knowledge by Zhang (2011) and extended the research by using a more advanced step-down mean-variance spanning technique (Kan & Zhou, 2008). This approach addresses certain deficiencies of the traditional mean-variance spanning method by identifying the source of rejection of the spanning hypothesis and allowing for greater assessment of the test's power. Mensah & Premaratne construct three different regional

Asian sectorial and global stock indexes comprising of high, moderate and low performers using the relative ranking technique (Levy, 1967). It is found that a local investor can substantially benefit from regional and global diversification compared to only holding their domestic Asian portfolio.

The increase in the Sharpe Ratios (SR) was also analysed by Mensah & Premaratne (2016). This analysis was conducted in order to determine whether regional or global diversification had a greater benefit. The results of said analysis dictated that regional diversification among the Asian countries has a significantly higher diversification benefit.

Another interesting study in the literature was compiled by Ballie et al. (2014). This study comprised of identifying whether a greater benefit exists by diversifying a local Asian stock portfolio within Association of Southeast Asian Nations (ASEAN) national equities or by diversifying across the respective sectors. The efficiency frontiers for the two different portfolios as well as the combination of national and sector equities were constructed for the period 2007-2013.

Figure 4: ASEAN Efficiency Frontiers



As per Figure 4, Ballie et al. (2014) was able to demonstrate that portfolios diversification across national equities dominates the portfolios diversified across ASEAN-wide sector equities and as well as across portfolios consisting of both sector and national equities.

Ballie et al. (2014) use the Generalized Auto Regressive Conditional Heteroskedasticity model, GARCH(1,1), and variance ratios to investigate the volatile spillovers which form part of the driving forces behind the disparity in investment benefits between the portfolios. For the ASEAN-sector equities, it was that the volatility of the returns was largely driven by local shocks. The instability of the ASEAN national returns has a high dependency on its own turbulence which

contrasts the ASEAN-wide sector stock returns when comparing their respective variance ratios. Accordingly, this notion explains some of the driving forces behind the optimal portfolios for the two differing diversification strategies.

2.4 Benefits of Portfolio Diversification for a South African Investor

The body of published knowledge on portfolio diversification cannot by any means be considered extensive for a South African investor holding a local equity portfolio and realising benefits from international markets. Bhana (1986) conducted one of the earliest studies on international portfolio diversification. This study explored the diversification benefits for a South African investor in international markets which satisfied the following three criteria: (i) historically stable political countries (ii) sufficient data availability and (iii) an important trading partner with SA. Bhana further allowed for adjustments in foreign exchange movements which resulted in the gains and losses being included in the risk and returns from the assets.

It must be noted that Bhana compiled the study during a period where SA residents were not allowed to invest in foreign securities from income derived in SA due to the prevailing political regime. At the time of the study, there were strong recommendations from the South African Commission to alleviate the exchange control rulings and to instead allow South African residents to participate in foreign portfolio investments. The South African Commission recommended that larger institutional investors should first be allowed a 10% foreign portfolio holding, thereafter corporate bodies and lastly it should extend to natural persons in SA.

During this period, goldmining was one of the largest operating industries in SA and subsequently the South African economy retained a significantly large proportion of goldmining shares. As part of the study, the goldmining shares were analysed separately compared to the industrial shares in SA. The study analyses the rates of return, the standard deviations and the correlation between the industrial and goldmining sectors in SA and the 18 selected countries for the period 1969 to 1983. The results of the study are summarised in table 1 below.

Table 1: Selected Countries Equity Summary

Rates of return, standard deviations, and coefficient of correlations of equity investments for 18 selected countries during 1969–1983

Country	Compound annual return %	Standard deviation %	Correlation (R) with South Africa	
			Industrial shares	goldmining shares
			(3)	(4)
Australia	10,84	20,06	0,7055	0,0795
Austria	9,19	14,63	0,0346	0,1471
Canada	14,07	18,48	0,6718	0,1589
Denmark	20,80	29,15	0,1445	-0,3204
France	7,24	21,24	0,3904	0,0021
Finland	20,54	20,45	0,1609	0,1304
Germany	15,14	17,07	0,0882	-0,5326
Italy	0,06	16,35	0,5606	0,2970
Japan	25,60	21,99	0,1432	-0,3562
Netherlands	11,97	14,91	0,1441	-0,4383
New Zealand	12,11	15,61	0,4385	-0,1048
Norway	12,77	24,25	0,3742	0,2774
South Africa industrial shares	11,17	21,43	1,0000	0,4800
South Africa goldmining shares	22,45	50,17	0,4800	1,0000
Spain	1,97	21,48	-0,1117	0,0773
Sweden	18,08	20,52	0,1534	0,0125
Switzerland	16,10	18,32	0,2698	-0,4242
United Kingdom	13,11	22,35	0,2127	-0,4548
U.S. of America	12,18	18,76	0,2195	-0,3329
Average	13,44	19,74	0,32	-0,02

The annual rates of return vary from country to country with Japan holding the largest return of 25.60% whilst Italy holds the lowest return of 0.06%. The risk also differed substantially with Austria offering the lowest variability of 14.63% and the goldmining shares affording a staggering variability of 50.17%. This clearly indicates that there are potential diversification benefits for South African investors as the average variability across countries is lower than both sectors of the South African equities markets. There is also an overall low correlation with the various international equity markets of 0.32 and -0.02 for industrial and goldmining share respectively.

Using the preliminary results above, Bhana (1986) constructed efficiency frontiers (Markowitz, 1952) using the following limitations on an investment in any specific country: No limit; 50% limit; 33% limit; 20% limit and 10% limit. Furthermore, the market equilibrium model developed by Sharpe (1964) and Lintner (1965) was used to achieve optimal portfolios. Using a risk-free rate of 10% (which was the average rate at the time of the study), the optimal unlevered portfolio is the tangency of the market opportunity line and the various efficiency frontiers. The optimal portfolios which contained the proportion of investment in each country were identified for the different investment scenarios.

Table 2: Optimal International Portfolios for an SA Investor

Composition of optimal international portfolios for various levels of maximum investment in specific countries 1969–1983 (risk-free rate of return = 10%)

Country	No limit	50% limit	33% limit	20% limit	10% limit
Australia					3,52
Austria		1,18		2,99	10,00
Denmark					5,34
Finland	17,03	16,20	18,77	15,74	10,00
Germany				9,82	10,00
Japan	40,84	39,80	33,00	20,00	10,00
New Zealand		1,05	0,62	7,56	10,00
Norway					1,14
South Africa (goldmining shares)	14,15	13,89	13,66	12,72	10,00
Sweden	11,59	11,50	12,61	11,17	10,00
Switzerland	16,39	16,38	21,34	20,00	10,00
United Kingdom					10,00
Portfolio return	21,90	21,58	21,16	19,12	16,86
Portfolio standard deviation	12,50	12,24	11,90	10,30	9,31

Table 2 summarises the results of the optimal portfolios. Twelve countries appear in at least one of the optimal portfolios with Norway's contribution being negligible. The trade-off made for a 2.5% reduction in the portfolio return for the no limit scenario compared to purely investing in SA goldmining share is accompanied by a 75% reduction in risk which is evident across the optimal portfolios. The optimal portfolios indicate a 40%-80% investment exposure to Japan, Finland, Switzerland and the goldmining share in SA. This is achieved through low correlations across the aforementioned markets with relatively decent returns. Therefore, the above study has empirically deduced that benefits for international diversification does indeed exist for South African investors.

The above analysis of the existing literature on international portfolio diversification indicates the focus from a US investor perspective. There is minimal research available for a SA investor which explores the current opportunities in global markets to assist with optimal equity portfolio formation.

Chapter 3: Methodology

3.1 Mean-Variance Spanning

The idea of mean-variance spanning was introduced by Huberman and Kandel (1987). This concept is considerably elegant in that it provides a framework which enables an investor to identify if the minimum-variance frontier of K risky assets is identical to the minimum-variance frontier of $K+N$ risky assets. The K risky assets are often referred to as the benchmark assets and the N assets are generally called the test assets.

If a risk-free asset exists in the market and accordingly an investor can borrow or lend unlimited amounts at the risk-free rate, then the focus shifts from being concerned about the minimum-variance frontier to the tangency portfolio of the risky assets. In this case, the outcome of interest for the investor is whether the tangency portfolio for the K benchmark risky assets is the same as the $K+N$ risky assets.

Huberman & Kandel (1987) developed the mean-variance spanning test in a regression framework specifically inclusive of statistical tests to derive the results. R_{1t} is defined as a K -vector of returns of the K benchmark risky assets and R_{2t} as a N -vector of returns of the N benchmark risky assets. $R_t = [R'_{1t}, R'_{2t}]'$ is the raw returns on the $N+K$ risky assets. The expected returns on the $N+K$ risky assets is defined as:

$$\mu = E[R_t] = \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix}.$$

The covariance matrix of the $N+K$ risky assets is defined as:

$$V = Var[R_t] = \begin{bmatrix} V_{11} & V_{12} \\ V_{12} & V_{22} \end{bmatrix},$$

where V is assumed to be non-singular.

By projecting R_{2t} on R_{1t} , the following regression equation is determined:

$$R_{2t} = \alpha + \beta R_{1t} + \epsilon_t \quad t = 1, 2, \dots, T,$$

where $E[\epsilon_t] = 0_N$ and $E[\epsilon_t R'_{1t}] = O_{N \times K}$. 0_N is an N vector of zeros and $O_{N \times K}$ is an N by K matrix of zeros.

α and β are defined as $\alpha = \mu_2 - \beta\mu_1$ and $\beta = V_{21}V_{11}^{-1}$. Let $\delta = 1_N - \beta 1_K$ where 1_N is a N vector of ones and 1_K is a K vector of ones. The hypothesis for spanning in terms of the restrictions on α and δ is:

$$H_0: \alpha = 0_N, \quad \delta = 0_N.$$

The likelihood ratio test under the exact distribution (Jobson & Korkie, 1989) is used to test the joint null hypothesis. If H_0 holds true, it implies that for the N risky test assets, a portfolio of the K risky benchmark assets may be constructed that has the same mean (due to $\alpha = 0_N$ and $\beta 1_K = 1_N$) but a lower variance than the test assets (since R_{1t} and ϵ_t are uncorrelated and $Var[\epsilon_t] \geq 0$). Therefore, it is beneficial for an investor to hold a portfolio containing only the K benchmark assets as it dominates the N test assets.

The above test is applicable but it has shortfalls, the test only able to analyse the joint null hypothesis. To mitigate these shortfalls, Kan & Zhou (2008) proposed an extended framework which allows for the testing of the individual components of the null hypothesis to identify the source of the rejection. This is a step-down procedure that is tested sequentially. First, we can test for $\alpha = 0_N$ and then test $\delta = 0_N$ conditional on $\alpha = 0_N$.

The first test is a F -test for testing $\alpha = 0_N$, it is defined as:

$$F_1 = \left(\frac{T - K - N}{N} \right) \left(\frac{|\bar{\Sigma}|}{|\hat{\Sigma}|} - 1 \right) = \left(\frac{T - K - N}{N} \right) \left(\frac{\hat{\alpha} - \hat{\alpha}_1}{1 + \hat{\alpha}_1} \right) \sim F_{N, T-K-N},$$

where $\hat{\Sigma}$ is the unconstrained estimate of Σ and $\bar{\Sigma}$ is the constrained estimate of Σ by imposing the only constraint of $\alpha = 0_N$. F_1 follows an F -distribution with N and $T - K - N$ degrees of freedom.

The second F -test for testing $\delta = 0_N$ conditional on $\alpha = 0_N$, is defined as:

$$F_2 = \left(\frac{T - K - N + 1}{N} \right) \left(\frac{|\tilde{\Sigma}|}{|\bar{\Sigma}|} - 1 \right) = \left(\frac{T - K - N}{N} \right) \left[\left(\frac{\hat{c} - \hat{d}}{\hat{c} + \hat{d}_1} \right) \left(\frac{1 + \hat{\alpha}_1}{1 + \hat{\alpha}} \right) - 1 \right] \sim F_{N, T-K-N-1},$$

where $\tilde{\Sigma}$ is the unconstrained estimate of Σ when both constraints $\alpha = 0_N$ and $\delta = 0_N$ have been imposed. F_2 follows a central F -distribution with N and $T - K - N + 1$ degrees of freedom and is independent of F_1 . The variables Σ , $\hat{\alpha}$, $\hat{\alpha}_1$, \hat{c} , \hat{d} and \hat{d}_1 are defined in the appendix A.

For the spanning hypothesis to be considered valid, both tests (F_1 and F_2) are required to be accepted. If the spanning hypothesis is rejected by the first test, $\alpha = 0_N$, then it indicates that the two tangency portfolios are different. In this case, it indicates that the South African investors'

portfolio diversified into regional global markets is more efficient compared to holding only local stocks in their portfolio. If the rejection of the test is caused by $\delta = 0_N$, then the global MVPs are statistically different. This implies that the MVP of the South African portfolio diversified into regional global markets is superior compared to the local portfolio.

3.2 Maximum Sharpe Ratio Measurement

The goal of diversifying the South African portfolio with global equities from different sectors of the world is to maximise the risk-adjusted return while maintaining or reducing the risk incurred by the portfolio. The SR method allows one to measure the increase (Sharpe, 1966) in benefit from international diversification.

An investment opportunity can be characterised as $\mathbf{R}^T = [r_1, r_2, \dots, r_N]$, which is the realised return of N assets available to the investor and $\bar{\mathbf{R}}$ is the vector of mean returns. Let $\boldsymbol{\mu}^T$ be the vector of expected returns above the risk-free rate (i.e., risk premium) and \mathbf{V} be a positive definite variance-covariance matrix of the asset returns. Let S be the set of all real vectors $\mathbf{w}^T = [w_1, w_2, \dots, w_N]$ that define the weight of each asset such that $\mathbf{w}^T \mathbf{1} = w_1 + w_2 + \dots + w_N = 1$, where $\mathbf{1}$ is an N -vector of ones. The objective of the investor is to form a portfolio that minimises the variance for a given level of return by computing the appropriate investment weights for each risky asset. This is done within the $E-V$ framework of Markowitz (1952) by forming the global efficient frontier. A Lagrangian is developed which combines the objective function as well as the restrictions to provide a solution to enable the selection of optimal portfolios:

$$\min_{\{w, \phi, \eta\}} L = \frac{1}{2} \mathbf{w}^T \mathbf{V} \mathbf{w} + \phi (\mu_p - \mathbf{w}^T \boldsymbol{\mu}) + \eta (1 - \mathbf{w}^T \mathbf{1}),$$

where μ_p is the expected return on the portfolio, and ϕ and η are positive constraints. The investment weights, w_p are obtained by the first order condition of the quadratic program. The above setting allows for negative portfolio weights which is an indication of short selling.

Assuming a rational investor will select a portfolio that provides the MRR, they will want to maximise the SR on the portfolio. The mechanism, following Chiou et al. (2009), to maximise the measure without any investment constraints is:

$$MSR = \max_{\{w_p\}} \left\{ \frac{(\mathbf{w}_p^T \boldsymbol{\mu})}{(\mathbf{w}_p^T \mathbf{V} \mathbf{w}_p)^{1/2}} \mid \mathbf{w}_p^T \in S \right\}.$$

For an investor holding a domestic portfolio, the benefit of the inclusion of regional global securities can be measured by:

$$\gamma_i = MSR_i - SR,$$

where SR is the Sharpe ratio of the K benchmark South African portfolio. MSR_i are the maximum SRs of the diversified South African portfolios into the DWM and EAM. Where MSR_i is greater than SR , γ_i assumes a positive value which implies a greater benefit from global diversification. The γ_i also enables one to directly compare the diversification benefits from the two regional global markets. The greatest diversification benefit is derived from the diversified portfolio that produces the largest γ_i .

3.3 Vector Autoregression

The final analysis conducted in this research identifies the integration between the South African equity market and the regional global markets. The aim is to explain some of the variations in diversification benefits across the different markets.

The Vector Autoregression (VAR) approach is used to test integration between the markets as proposed by Sims (1980). This model allows for dynamic analysis of a system wherein changes in one variable are affected by changes in another variable, as well as on its own lags and on lags in other variables. The model consists of a m -dimensional and p -order VAR model, which is as follows:

$$y_n = a_0 + \sum_{i=1}^p \Phi_i y_{n-i} + u_t, \quad t = 1, 2, \dots, T$$

where $y_n = (y_{1t}, y_{2t}, \dots, y_{mt})$ is a $m \times 1$ vector of endogenous variables, a_0 is $1 \times m$ vector of fixed effects and u_t is a $m \times 1$ vector of independent disturbance terms (shocks). Φ_i are $m \times m$ coefficient matrices of the form:

$$\Phi_i = \begin{bmatrix} \phi_{11}^{(i)} & \dots & \phi_{1m}^{(i)} \\ \vdots & \ddots & \vdots \\ \phi_{m1}^{(i)} & \dots & \phi_{mm}^{(i)} \end{bmatrix}, i = 1, 2, \dots, p.$$

The above model provides insights into the integration between the various equity markets and assists in identifying whether the markets drive each other. It also indicates the lag time for shocks to spill over between markets.

The Impulse Response Function (IRF) method is utilised to understand the output of the above model. This method allows a unit increase in the error of one variable while holding the other

errors in the VAR model constant. This creates impulse responses and proves the impact of these changes on current and future values of all the variables in the model (Stock & Watson, 2001). The estimated impulse responses display patterns of repeated common variations. A ± 1 standard error bands are provided which indicates a 66% confidence interval for each of the traced out impulse responses.

Variance Decomposition (VD) is another tool used to analyse the VAR results. This method identifies the error variance percentage that is determined when forecasting a variable over time (Stock and Watson, 2001). In this context, the percentage explains the amount variability in the South African market because of its own shocks compared to shocks in the regional global markets. This is computed by determining how much of the current and future forecast error variance of a given variable is explained innovations of each explanatory variable in the VAR system. Both the IRF and VD employs the Cholesky Decomposition for identification purposes (Inoue & Kilian, 2013).

Chapter 4: Market Data Analysis

4.1 Data Overview

The data used in this study consists of returns from national stock market indices. The primary K benchmark portfolio used in this study are the South African stock market index returns. The next 2 data sets represent the respective N test asset portfolios which is the EAM and the DWM. The EAM consists of 8 countries namely China, Hong Kong, India, Malaysia, Pakistan, Philippines, Sri Lanka and Thailand. The DWM also consists of 8 countries which are Canada, France, Germany, Italy, Netherlands, Spain, UK and US. These markets are considered for the study based on their trading volume, market size, geographical location as well as data availability. The study featured these factors to ensure every effort is made to construct representative samples for both regional markets. The global markets selected are also accessible for investment by South African investors. The 91-day Treasury bill rate from the South African market is used as the risk-free rate for this study.

Due to the number of markets used in this study, the VAR dimensionality will be cumbersome due to the nature of the model. Thus, resulting in the output from the model, which indicates the integration across markets, becoming challenging to interpret in a concise manner. To overcome this challenge, 2 series are derived from the data to best represent each of the regional global markets. The series are constructed by taking the average across all the stock returns in the 2 respective regions, therefore resulting in an equally weighted contribution from each country for the regional series. The series are named Asian EM and Western DM for the EAM and DWM respectively.

All asset price data are extracted from Bloomberg Terminal and is denominated in ZAR. The returns are calculated in Excel using the change of price divided by the previous months price. The South African Treasury Bill rate is retrieved from Datastream. Monthly closing returns data for the period October 2003 to September 2023 are used from the various markets. This consists of 240 data points over a 20-year period which forms a balanced panel dataset. This period includes 2 significant global events, namely, the 2008 to 2012 Global Mortgage Crisis and Covid-19 which started in late 2019 and lasted for 3 years. These events had a significant financial impact on the global markets due to liquidity constraints and supply chain disruptions (Tong & Wei, 2011; Moosavi et al., 2022). The length of time considered for the study allows for a full 20-year business cycle as well as policy regimes to dynamically evolve the markets (Stock & Watson, 2003).

4.2 Descriptive Statistics

From table 3, it is evident that all the monthly returns across the markets are positive with EAM tending to yield higher returns when compared to the South African market and the DWM. The highest average monthly return of 1.56% is achieved by India and Italy achieves the lowest monthly return of 0.65%. The South African returns of 0.97% is amongst the median return in the set of assets. The standard deviation which is a measure of volatility in the returns ranges from 4,25% to 8,73% which relates to the US and Philippines respectively. From a regional perspective, the EAM tends to display higher volatility than the DWM with SA presented on the lower end of volatility across the various assets. Although the Asian markets tend to show higher returns and volatility, the markets do not follow the standard risk-return trade-off. The US has the lowest standard deviation but only has the 7th lowest return and Thailand has the second high standard deviation but only has the 5th highest return. The combined regional market representative assets Asian EM appears to outperform the Western DM assets by producing a higher combined return as well as an overall lower variance.

Markets that display negative skewness from table 3 are SA, Philippines, Thailand, Germany and Netherlands. The rest of the markets display positive skewness. The extent of the skewness is due to stock capitalisation (Hashmi & Tay, 2012). Negative skewness relates to abnormally high returns over previous period and relatively high turnover. The kurtosis coefficient indicates the degree of thickness in tails of the return distributions. The Philippines has the highest kurtosis coefficient which is an indication that its return distribution has a fat-tail whilst the UK has the lowest kurtosis coefficient which is proof that its return distribution tail is not as thick relative to other countries. Investors preferences are generally to invest in assets with lower negative skewness and low kurtosis (Kim & White, 2014).

The next important statistic which is in column 6 of table 3 is the Phillips-Perron (P-P) test. This is used to test for stationarity in the return series of the assets. The null hypothesis of the test assumes that the series have unit roots (which is an indication of non-stationarity) and the p-values of the test statistics are displayed below. There are other methods to check for stationarity such as the Dickey Fuller (DF) and Augmented Dickey Fuller (ADF) tests. The challenge with the DF test is that it requires residuals to not be auto-correlated for the test to be valid. The ADF tries to overcome this challenge by augmenting the DF test and adding lags of the dependent variable, however, there is no clear procedure in determining the optimal lag length. This leads to the P-P test being the most suitable as it incorporates an automatic correction to the DF test to allow for autocorrelated residuals (Herranz, 2017). This is considered a key outcome as the stationarity assumption is required for the spanning test (Driessen & Laeven, 2007) and the VAR models (Sims, 1980) to produce valid results. All the asset return series, including the Asian EM and the Western DM series, have a p-value of 0.0000. Therefore, one can reject the null hypothesis of the P-P test and conclude that all the asset return series do not have unit roots and are stationary at a 1% significance level.

Table 3: Descriptive Statistics of Returns for Selected Market Assets

	Mean Return	Std. Dev.	Skewness	Kurtosis	Phillips- Perron	ARCH LM Test (3)
South Africa	0.0097	0.0446	-0.0704	3.5652	0.0000***	0.0001***
Asian Emerging Markets						
China	0.0109	0.0754	0.3798	4.1997	0.0000***	0.0993*
Hong Kong	0.0074	0.0517	0.1802	3.1049	0.0000***	0.0225**
India	0.0156	0.0714	0.1603	5.6197	0.0000***	0.6526
Malaysia	0.0074	0.0448	0.1997	3.3284	0.0000***	0.3811
Pakistan	0.0115	0.0532	0.0880	3.4143	0.0000***	0.9982
Philippines	0.0128	0.0873	-0.5374	8.0029	0.0000***	0.0267**
Sri Lanka	0.0101	0.0577	0.2476	5.4953	0.0000***	0.5540
Thailand	0.0111	0.0783	-0.4493	5.7915	0.0000***	0.8718
Western Developed Markes						
Canada	0.0094	0.0479	0.1200	3.6905	0.0000***	0.0093***
France	0.0089	0.0524	0.2264	3.0953	0.0000***	0.9736
Germany	0.0118	0.0549	-0.0338	3.2054	0.0000***	0.8806
Italy	0.0065	0.0610	0.0126	3.4537	0.0000***	0.8618
Netherlands	0.0088	0.0523	-0.1241	3.4877	0.0000***	0.2002
Spain	0.0070	0.0608	0.2650	4.0284	0.0000***	0.0376**
UK	0.0069	0.0449	0.0997	2.9661	0.0000***	0.5310
US	0.0093	0.0425	0.4548	3.6264	0.0000***	0.8857
Market Representation						
Asian EM	0.0109	0.0379	-0.0245	3.5022	0.0000***	0.6187
Western DM	0.0086	0.0475	0.1718	3.2171	0.0000***	0.9560

*** 1% significance level

** 5% significance level

* 10% significance level

Integration between markets can be studied through multiple techniques, such as the standard correlation measure and cointegration method. When working with timeseries data, these methods have certain shortfalls, namely they assume the variables have a static relationship and do not capture the evolving nature of the financial integration. The cointegration methods are also not able to quantify the integration (Billio et al., 2017). A method which is able overcome the aforementioned challenges of simple correlation is the Dynamic Conditional Correlation (DCC) model. It can quantify the level of integration between markets, account for heteroscedasticity and trace out the dynamics of the integration between markets over a period of time (Engle, 2002). This method requires Autoregressive Conditional Heteroscedasticity (ARCH) effects (the variance

of the series being conditional on previous periods) to be present in the modelled markets. This characteristic is identified through the ARCH Lagrange Multiplier (LM) test, which has a null hypothesis of no presence of ARCH effects. The ARCH LM test of order 3 (testing for ARCH effects over 3 lags) is conducted and the p-value is the output in table 3. Most of the countries have a p-value of larger than 5% apart from SA, Hong Kong, Philippines, Canada and Spain. The market representation asset series do not show sign of ARCH effects. This provides justification that the DCC model is not appropriate for this study. To circumvent this challenge, the VAR model will be employed to investigate the integration between markets. Although this model presents the same challenge of the cointegration methods wherein it is unable to produce a numerical value for the integration (Engle, 2002), this model will still provide sufficient insights to derive an understanding of the integration across the various markets.

The following 3 tables have been constructed to understand the correlation between the individual markets at a high level. Due to the number of markets, a consolidated correlation matrix could not be displayed and the information is effectively conveyed through the individual tables.

Table 4: Correlation Between South African and Asian Markets

	South Africa	China	Hong Kong	India	Malaysia	Pakistan	Philippines	Sri Lanka	Thailand
South Africa	1.0000								
China	0.2249	1.0000							
Hong Kong	0.4830	0.5647	1.0000						
India	0.4523	0.2508	0.4433	1.0000					
Malaysia	0.3060	0.3996	0.4960	0.4303	1.0000				
Pakistan	0.3059	0.3481	0.4770	0.5236	0.6190	1.0000			
Philippines	-0.0834	-0.0032	-0.0252	-0.1081	-0.0299	-0.0554	1.0000		
Sri Lanka	0.4508	0.2388	0.4504	0.4883	0.4979	0.5301	-0.0678	1.0000	
Thailand	0.1107	0.2130	0.2207	0.2486	0.3282	0.3452	-0.0006	0.2263	1.0000

Table 5: Correlation Between South African and Western Markets

	South Africa	Canada	France	Germany	Italy	Netherlands	Spain	UK	US
South Africa	1.0000								
Canada	0.6077	1.0000							
France	0.5912	0.7126	1.0000						
Germany	0.5811	0.6834	0.9230	1.0000					
Italy	0.5406	0.6179	0.9186	0.8565	1.0000				
Netherlands	0.5862	0.7382	0.9162	0.8647	0.8418	1.0000			
Spain	0.4846	0.5736	0.8774	0.8056	0.8906	0.7936	1.0000		
UK	0.5677	0.7799	0.8859	0.8283	0.7988	0.8838	0.7698	1.0000	
US	0.4672	0.8255	0.8476	0.8228	0.7306	0.8424	0.6902	0.8855	1.0000

Table 6: Correlation Between Asian and Western Markets

	China	Hong Kong	India	Malaysia	Pakistan	Philippines	Sri Lanka	Thailand
Canada	0.3598	0.5128	0.4935	0.5089	0.5077	-0.1349	0.5535	0.2910
France	0.3039	0.5311	0.4971	0.5196	0.5078	-0.0799	0.4927	0.2955
Germany	0.3289	0.5433	0.5409	0.5159	0.5189	-0.0876	0.4983	0.2883
Italy	0.2797	0.4769	0.4753	0.4386	0.4234	-0.0866	0.4077	0.2716
Netherlands	0.3418	0.5853	0.5278	0.5650	0.5410	-0.0686	0.5295	0.2991
Spain	0.2601	0.4820	0.4701	0.4553	0.4522	-0.0768	0.4267	0.2499
UK	0.3973	0.6075	0.4836	0.5981	0.5703	-0.0890	0.5397	0.4186
US	0.3727	0.5278	0.4946	0.5971	0.5873	-0.1054	0.5257	0.4081

As per table 4 and 5, SA seems to have a lower average correlation across the EAM compared to the DWM. SA has a correlation coefficient of more than 0.5 with 6 out of the 8 DWM whilst the highest is Canada with 0.6077. Whereas none of the EAM have a correlation coefficient of above 0.5 with SA. This is an indication that the South African markets have high co-movements with the DWM when compared to the EAM. The EAM seem to have a lower correlation amongst itself when compared to the market integration in the DWM. This could be due to the development nature of these markets as the integration process between these markets are not yet fully developed and their proximity do not imply strong financial ties.

The correlation between the DWM and EAM, as displayed in table 6, appear to be in the middle of the correlation amongst its own regional markets as per table 4 and 5. This indicates that a high level of financial integration exists between the DWM and EAM when compared to the integration within the EAM. This indication supports existing literature which finds that global and regional markets are not fully integrated (Bekaert et al., 2005; De Jong & De Roon, 2005). The highest correlation coefficient across the markets is between Hong Kong and the UK of 0.6075. The Philippines is the only market that displays negative correlation across all the other markets. This negative correlation presents diversification opportunities for investors in the respective markets in order to protect their portfolios against adverse shocks in other markets.

Table 7: Correlation Between South Africa and Market Representation Series

	South Africa	Asian EM	Western DM
South Africa	1.0000		
Asian EM	0.4345	1.0000	
Western DM	0.6061	0.6602	1.0000

Table 7 illustrates the correlation between the South African market and the market representation series for the 2 regions. SA and the Asian EM series have the lowest correlation coefficient of 0.4345 with the Asian EM and Western DM having the highest correlation coefficient of 0.6602.

This is an indication of higher integration between the Asian and Western markets when compared to the South African and Western markets. This will be a factor for a South African investor to consider when selecting assets in the global markets.

All the above-mentioned coefficients are static and do not capture the time-varying nature of the financial integration between the markets. To understand the evolving dynamics of the correlation across the markets, the VAR model is applied in the empirical results section. The diversification benefits for a South African investor across the 2 regional markets is evaluated as well.

Chapter 5: Empirical Results

5.1 Step-down Mean-Variance Spanning Results

This section explores the diversification benefits for a South African investor across the 2 regional global markets. The results are derived using the step-down mean-variance spanning technique. This provides statistical evidence to conclude whether the K benchmark assets span the K + N assets which is the basis of the null hypothesis. For the test to be rejected, both the F_1 -test and F_2 -test needs to be rejected to conclusively arrive at the result of the K + N assets span the K benchmark assets. This will result in a meaningful inward shift of the mean-variance efficient frontier which is achieved by the addition of the N test assets. The rejection of either constituent of the null hypothesis provides information on the source of the rejection. If the F_1 -test is rejected, it indicates an improvement on the tangency portfolio and if the F_2 -test is rejected, it is an improvement of the MVP.

Table 8: Step-down Mean-Variance Spanning Results

Test Assets (N)	Benchmark Assets (K)			
	South Africa		South Africa + EAM	
	F1	F2	F1	F2
EAM	1.9593* (0.0525)	26.5750* (0.0000)		
DWM	1.6403 (0.1143)	19.3367* (0.0000)	1.1371 (0.3393)	2.2516* (0.0248)

* 10% significance level

Corresponding p-value represented in the brackets

The first step-down spanning test is between SA and the EAM. The degrees of freedom for the F_1 -test are 8 and 231 resulting in a 90th percentile statistic of 1.6970. The degrees of freedom for the F_2 -test are 8 and 230 which results in a 90th percentile statistic of 1.6971. As per table 8, both the F_1 and F_2 test statistics are larger than their corresponding 90th percentile F-distribution and are rejected at a 10% significance level. This provides evidence that the combined portfolio of the South African and EAM stocks spans the South African market portfolio. Therefore, the addition of the EAM assets provides benefit to the tangency portfolio and the MVP for the South African investor.

When looking at the diversification benefits of a South African portfolio into the DWM, the numbers of test assets (N) used are the same as the above which results in the same 90th percentile statistics for the F-distributions. As can be seen in table 8, the F_1 -test statistic is 1.6403 which is less than the corresponding 90th percentile F-statistic of 1.6970, thus resulting in the first test not

being rejected. The F_2 -test statistic is greater than the corresponding 90th percentile F-statistic which provides evidence to reject this test. Therefore, the DWM does not span the benchmark South African portfolio. Even though the null hypothesis failed to be rejected, the South African investor can still benefit from the addition of DWM assets as it assists in the improvement of the MVP, despite there being no benefit from a tangency portfolio perspective.

The above results provide overwhelming evidence to answer the first hypothesis proposed in this study, wherein there is greater benefit for a South African investor to diversify their portfolio into EAM compared to DWM. The resulting South African portfolio diversified into EAM completely dominates the diversification into the DWM as both the tangency portfolio and MVPs are significantly improved. This enables a South African investor to materially increase their return while simultaneously reducing the risk sustained to their portfolio. Some of the factors substantiating these results are the higher average monthly returns in EAM over the period in comparison to DWM. This finding supports the research previously compiled by Radelet et al. (1997). This could be due to the growth opportunities presented in those markets and the economic policies that were implemented to help unlock opportunities in the developing markets. Another factor is that South African and EAM appear to be less correlated when compared to DWM, as indicated by tables 4, 5 and 6. An in-depth exploration of the integration between the markets is conducted further on in this study.

A final step-down mean-variance spanning test is conducted to identify whether there are any benefits in introducing test assets from DWM to benchmark portfolio which consist of both South African and EAM assets. The degrees of freedom for the F_1 -test are 8 and 223, for the F_2 -test it is 8 and 222 with the 90th percentile F-statistic being 1.6979 and 1.6980 respectively. The test statistics in table 8 shows that the F_1 -test is unable to be rejected at a 10% significance level and the F_2 -test is rejected at a 10% significance level. This implies that the null hypothesis cannot be rejected and the DWM test assets do not span the benchmark assets. There is a certain benefit to be gained by the addition of the DWM assets to the portfolio with regards to a slight improvement in the MVP, but this marginal benefit might not be considered viable as it may be outweighed by the highly insignificant tangency portfolio. The lower average returns from the DWM assets and the indicative higher correlation between EAM and DWM as per tables 5, 6 and 7 (which are explained further below) are key drivers leading to the results.

5.2 Increase in Sharpe Ratio

Section 5.1 provides statistical evidence of the benefits for a South African investor holding a domestic portfolio to diversify into the EAM in comparison to the DWM. Both the tangency portfolio and MVPs are dominated by the diversification into the Asian markets. These results are of notable importance, however, having statistical significance from a diversification perspective

does not automatically imply economic improvement (Glabadanidis, 2009). To identify whether the diversification benefits are economically significant, the improvement in the SRs across the portfolios is investigated in this section. This provides a quantitative measure that captures the combined benefits, and if any, the improvement in the tangency portfolio and MVPs.

Table 9: Sharpe Ratios Across the Portfolios

	South Africa	EAM	DWM	EAM + DWM
South Africa	0.0937	0.1317	0.1053	0.1314

Table 9 shows the SRs for the various portfolios. When a South African investor holds only a local portfolio, the SR is 0.0937. In contrast, when regional global assets are added to the portfolio, there is an increase in the SR across various diversified portfolios. When the South African portfolio is diversified into the DWM, the SR increases to 0.1053. The highest SR of 0.1317 is achieved when the local portfolio is diversified into the EAM.

Table 10: Increase in Sharpe Ratios

	EAM	DWM	EAM + DWM
South Africa	0.0379 (40.45%)	0.0116 (12.33%)	0.0376 (40.13%)

To illustrate the perspective of the SR differences in table 9, the increase in the ratios are calculated using the local South African portfolio as reference, the results of which are displayed in table 10. The increase in the SRs quantify the potential economic benefits of the different diversification strategies.

When the DWM assets are added to the local portfolio, there is a 0.0116 increase in the SR as per table 10. This leads to 12.33% increase in the SR when compared to the local portfolio. Even though the results in section 5.1 indicates that the DWM assets do not span the local portfolio, the F_2 -test proves to be significant. This result implied that the MVP is improved by the addition of these assets. The reduction in variance proves to have an economic impact on the portfolio as it leads to an increase in the SR.

The EAM assets span the local portfolio as proved in section 5.1. This is reflected in the increased SR of 0.0379. In the context of the local market, there is a 40.45% increase in the SR as per table 10. This result deduces that there is a significant economic improvement to the local portfolio when EAM assets are considered for diversification and provides a compelling argument for these assets to form part of the investment decisions. The benefits are driven 2-fold, namely that there is an improvement in the tangency portfolio and in the MVPs as indicated in table 8. When these 2

effects are combined, it creates a compounding impact and gives rise to the significant economic improvement of the portfolio. This outcome further provides evidence, in conjunction with the result in section 5.1, to answer the first question hypothesised in this paper. Not only is it beneficial for a South African investor to diversify into EAM when compared to DWM, but the magnitude of the diversification benefit depicts a 28% economic improvement in the portfolio.

The final analysis conducted in this section focuses on the economic diversification benefits of the local portfolio across both the regional global assets. When this is considered, there is an increase of 0.0376 in the SR which leads to a 40.13% economic increase in the portfolio. This is considerably larger than the diversification benefit of the local portfolio which is diversified only into the DWM of 12.33%. When looking at this benefit in terms of the local portfolio diversified across the EAM, it can be viewed as the addition of the DWM assets. In this context, when adding the DWM assets to the local portfolio diversified into the EAM, there is a decrease in the SR of 0.0003 with an overall economic benefit reduction of 0.23%. This is in accordance with the findings from section 5.1, wherein the MVP was notable, but the insignificance of the tangency portfolio outweighed this benefit. The addition of the DWM assets diminishes the value of the local portfolio diversified into the EAM. This further enforces the benefits of the local investor diversifying primarily into the EAM in comparison to the DWM.

This section provides insights into quantifying the economic benefits experienced through diversifying the local portfolio into the regional global markets. The results from section 5.1 assisted in understanding some of the driving factors of the differences in the economic benefits. The next section aims to explain the causes of the driving factors by studying the integration between the global markets.

5.3 VAR Model Results

In this section, we study the interconnectedness between the South African market and the regional global markets. This helps to understand the differences in the diversification benefits for a South African investor across the different markets. This is conducted using VAR models as it allows for a dynamic analysis of the markets over time. This means the effects of the South African market can be identified based upon its past value as well as on the past values of the other regional markets and vice versa.

The complexity of the VAR model increases with the number of variables. This study contains a total of 17 different variables which represent the individual global markets. The use of these variables creates a complex system of equations which leads to difficulty when interpreting the outcomes. As mentioned in section 4.1, the Asian EM and Western DM series are created using

the average of the respective regional market assets. These series capture the nature of the respective regional markets and limits the number of variables used in the model to 3. This allows for a concise study of the structural inference across the global markets which assists in achieving the desired integration understanding. The P-P unit root tests in Table 3 indicates that the derived series are stationary which justifies their use in the model.

The optimal lag length used for the VAR model is 12. This is derived from the monthly frequency of the data. At this specific lag length, it is possible to identify how shocks from regional global markets affect the South African market over an annual period and vice versa.

The above analysis on the complexity of the model leads to the VAR model being set-up as follows:

$$\begin{bmatrix} \text{Western } DM_t \\ \text{Asian } EM_t \\ \text{South Africa}_t \end{bmatrix} = \begin{bmatrix} a_{10} \\ a_{20} \\ a_{30} \end{bmatrix} + \sum_{i=1}^{12} \begin{bmatrix} \phi_{11}^{(i)} & \phi_{12}^{(i)} & \phi_{13}^{(i)} \\ \phi_{21}^{(i)} & \phi_{22}^{(i)} & \phi_{23}^{(i)} \\ \phi_{31}^{(i)} & \phi_{32}^{(i)} & \phi_{33}^{(i)} \end{bmatrix} \begin{bmatrix} \text{Western } DM_{t-i} \\ \text{Asian } EM_{t-i} \\ \text{South Africa}_{t-i} \end{bmatrix} + \begin{bmatrix} u_{1t} \\ u_{2t} \\ u_{3t} \end{bmatrix}, t = 1, 2, \dots, 240.$$

The VAR model uses only 3 variables and has a lag length of 12. Even with these few inputs, the substantial dimensionality of the model may be identified. This creates a significant number of coefficients estimates which provide limited information on the co-movements of the system. Due to this limitation, the output is not studied directly. The IRF and VD is used to provide an enhanced understanding of the VAR model output. These techniques help in interpreting the results of the VAR model in a logical manner which allows for an easier, more concise understanding of the markets' dynamic behaviour.

Although the coefficient estimates of the VAR model are not directly analysed, the underlying assumptions of the model are still required to be tested. This ensures that all the analysed results are valid and there are no spurious conclusions. . The model validation occurs next, followed by the analysis of the VAR results.

5.3.1 VAR Model Validation

The first assumption of the VAR model is the stationarity of the series used in the model. As shown in table 3, the South African index return series and the two derived regional market return series have a p-value of less than 0.000 for the P-P test which implies that the series are stationary.

The next validation requirement is the stability of the VAR system. This is referred to as the stationarity condition of the VAR model which is tested through the inverse roots of the Auto Regressive (AR) polynomial lying within a unit circle. If any of the roots lay outside the unit circle, it would cause the model to become unstable resulting in invalid forecast performance (Pesaran et al, 2009) and invalid impulse response standard errors (Braun and Mittnik, 1993).

Figure 5: Inverse Roots of AR Characteristic Polynomial

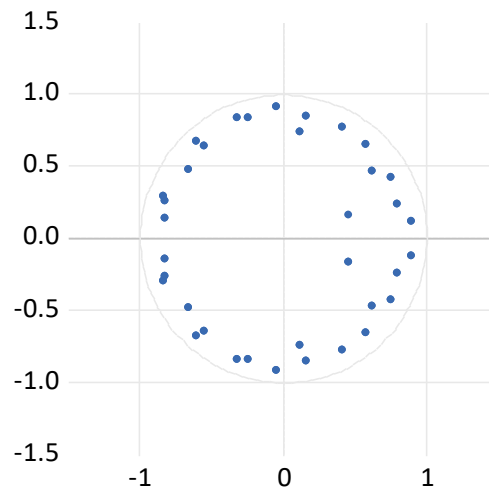


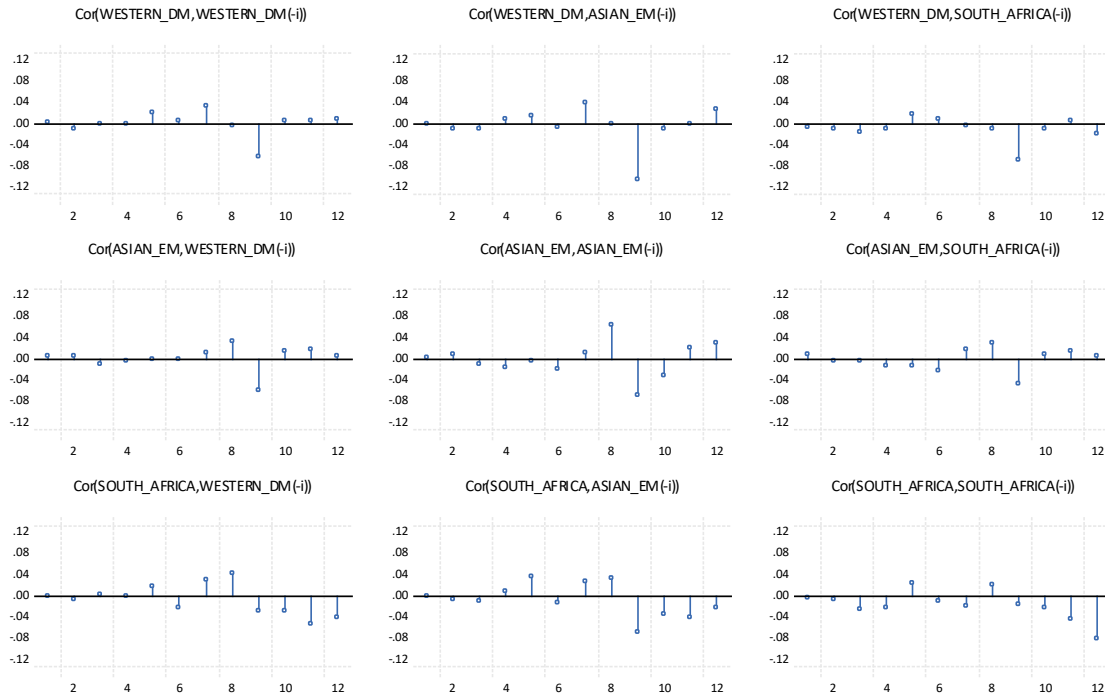
Figure 5 illustrates the unit roots of the AR characteristic polynomial. All the roots are dispersed around the unit circle and meets the stability requirement of having a modulus of less than one. The concerns of unreliable forecasts due to model stability are mitigated which enables the model validation to continue to the next set of requirements.

The next set of assumptions are in terms of residual diagnostics. The key requirement for these assumptions is to ensure no autocorrelation in the residuals. Time series data often display this behaviour as error terms in the model which can depend on each other for successive periods. If autocorrelation is present in the model, the ordinary least-squares estimators are not efficient (Hatemi, 2004) which will lead to the model producing suboptimal results.

Figure 6 is a correlogram showing the autocorrelations of the residuals within an approximate 2 standard error bound. If residuals are greater than the 2 standard error bounds, then they show signs of autocorrelation. From the below correlogram, the residuals are within the 2 standard error bounds for all lags across the combinations of modelled variables.

Figure 6: Correlogram of Residuals

Autocorrelations with Approximate 2 Std.Err. Bounds



The final residual test checks for serial correlation at the selected lag length of the model. This entails residuals displaying correlated behaviour at the intervals of the specified lag length. The LM test is used to determine serial correlation. The null hypothesis of the test is to assume no serial correlation at the select lag length (Evans & Patterson, 1985). Table 11 indicates the LM serial correlation test results. At the selected lag length of 12, the p-value for the test is 0.3515. This prevents the rejection of the null hypothesis at a 5% significance level, therefore there is no serial correlation at the selected lag length of 12 for the model.

Table 11: LM Serial Autocorrelation Test

Null hypothesis: No serial correlation at lag h						
Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	3.882352	9	0.9190	0.429890	(9, 452.8)	0.9190
2	4.110626	9	0.9040	0.455281	(9, 452.8)	0.9040
3	5.601157	9	0.7791	0.621383	(9, 452.8)	0.7791
4	4.480668	9	0.8770	0.496467	(9, 452.8)	0.8770
5	6.547335	9	0.6841	0.727106	(9, 452.8)	0.6841
6	7.031460	9	0.6338	0.781285	(9, 452.8)	0.6339
7	6.649692	9	0.6735	0.738556	(9, 452.8)	0.6736
8	14.14985	9	0.1171	1.584587	(9, 452.8)	0.1171
9	16.04016	9	0.0660	1.800021	(9, 452.8)	0.0661
10	6.603392	9	0.6783	0.733376	(9, 452.8)	0.6784
11	6.075033	9	0.7324	0.674305	(9, 452.8)	0.7324
12	9.987295	9	0.3515	1.113327	(9, 452.8)	0.3515
13	2.682250	9	0.9756	0.296613	(9, 452.8)	0.9756

All of the above results show that the VAR model is stable and the residuals are not autocorrelated which provides sufficient evidence that the model used in this study is valid. This indicates that the output from the model and any resulting conclusions from the model's results are credible.

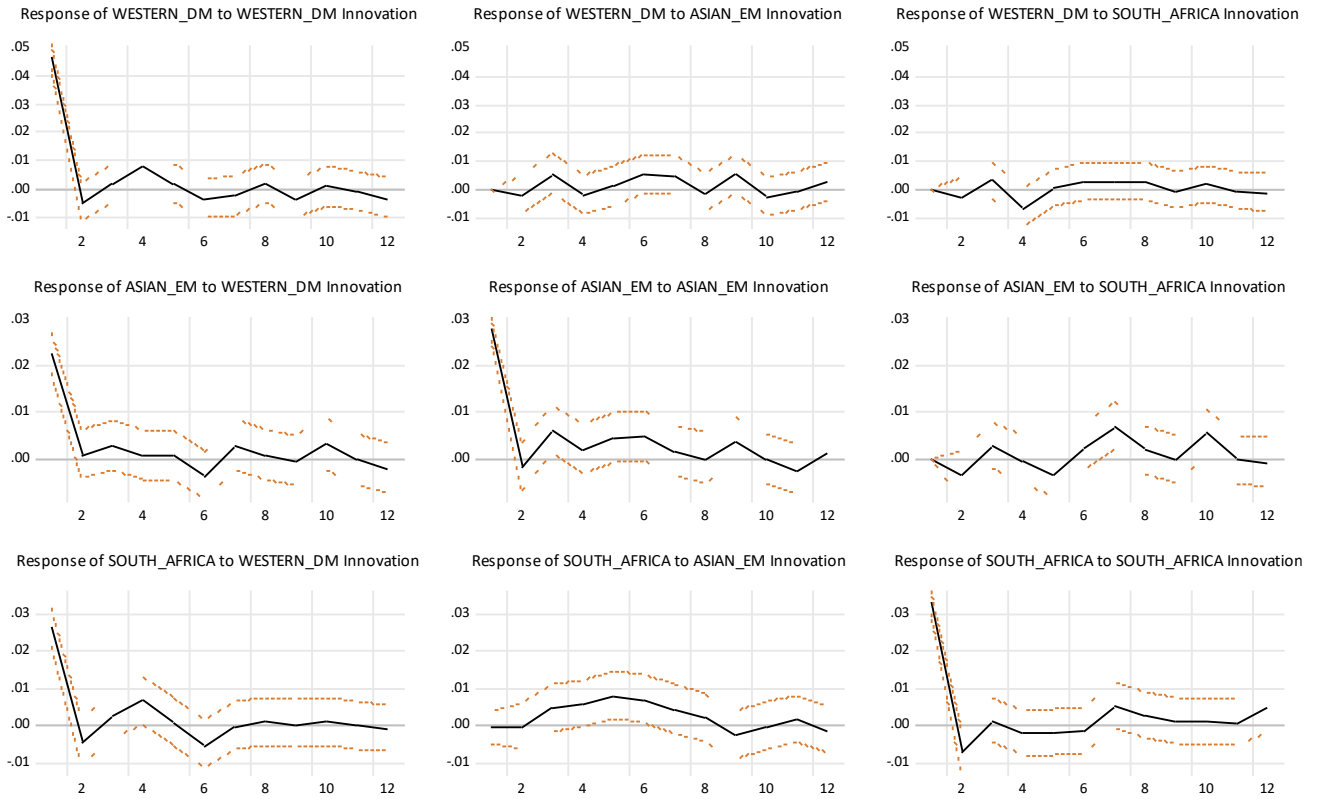
5.3.2 Impulse Response Function

The IRF disseminates the output from the VAR model in a concise manner. This is conducted through tracing the responsiveness of variables in the VAR model to a unit change in the error terms of each variable. The results of the impulse responses across the South African, DWM and EAM are displayed below.

Figure 7 illustrates the impulse responses across the different markets. The diagonal graphs compare the impulse responses of a unit shock in a market to itself. The top left graph indicates the impact on the DWM, a unit shock has an impact on the immediate next period. The shock is absorbed into the DWM over the next few periods and seems to stabilise between 6 to 8 months later. The centre and bottom right graphs show the respective responses of the EAM and the South African markets to shocks of itself. These markets follow a similar response pattern to the DWM, as the impact in next period is significant and the shock is absorbed over the next 8 months. This is a clear indication of markets being sensitive to its own shocks which justifies the need for diversification.

The 2nd and 3rd graphs in the 1st column of figure 7 display the impacts of a DWM shock on the EAM and South African markets respectively. For the DWM impact on the EAM, there is a significant shock overflow in the immediate next period. From the 2nd month to the 12th month, the impact is reduced but effects are still present over this period. For DWM impacts on the South African market, the shock is significant over the next period but is reduced over time. There is a slight positive increase in impact over month 4 and negative in month 6, but by month 7 the impact seems to have been completely absorbed by the South African market. This deduces that both the EAM and South African markets are impacted by shocks in the DWM. These effects are generally experienced for periods of up to a year. It is a clear sign of integration between the markets with the DWM displaying the characteristic of the leading market with the other 2 markets following accordingly.

Figure 7: Impulse Responses Across Markets



The 1st and 3rd graph in the 2nd column of figure 7 display the impact of a shock in the EAM across the DWM and South African markets respectively. The impact on the DWM to a shock in the EAM are not transferred immediately as there is a 3-month lag until these effects are experienced. Although there are effects which are experienced in the DWM, these effects are minor in nature and not as consequential when the impact is experience in the opposing direction. There is also a lagged effect on the South African market due to the impacts being noticed 3 months later and persists for a period of 9 months. The peak of the impact is experienced 6 months later, but these impacts are minor in nature.

The 1st and 2rd graph in the 3rd column of figure 7 display the impact of a South African market shock across the DWM and EAM. The shocks in the South African market seem to have almost no impact on the DWM as the impulse response barely deviate away from 0 with a minor negative lagged impact 4 months later. The impact on the EAM seems to have a lagged impact of 2 months but there positive and negative effects which persist over the commencing 12 months. The peak of the effects is experienced in month 7, but these affects are also inconsequential.

The above analysis provides evidence that there is significantly greater integration between the DWM and the other 2 markets compared to the integration between the EAM and South African

market. This is an extremely important finding as it shows that when a South African investor diversifies into the DWM, the MVP is penalised due to the higher levels of integration between these markets. This supports the results derived in section 5.1 and 5.2, meaning there is greater economic benefit for a South African investor to diversify their local portfolio into the EAM as the markets are less integrated, therefore materially reducing the variability on the diversified portfolio.

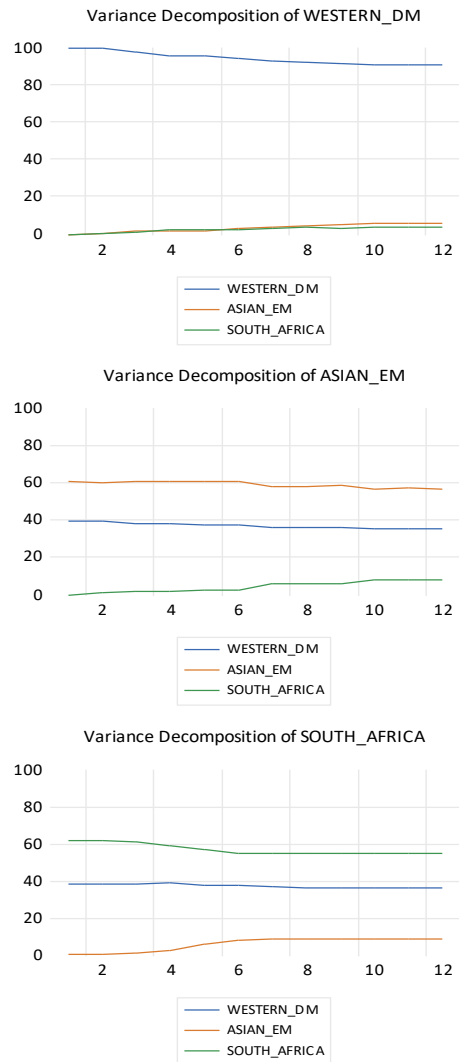
5.3.3 Variance Decomposition

The VD provides a framework of examining the VAR dynamics by understanding the variability in the dependent variable which is attributable to its own shocks compared to shocks in other variables of the system. This allows for the study of the movements in the South African market as explain by its own shocks and shocks in the regional global markets. This framework is multidirectional and is identified for all studied market series.

Graph 1 in figure 8 displays the VD for the DWM. Over the first 6 months, more than 95% of the movements in the DWM are driven by its own changes. Shocks from the EAM and South African market contribute less than 5% to variability in the DWM over the same period. Over the second 6 months, shocks from the EAM and South African markets are prevalent as it explains around 10% of the changes in the DWM. This indicates that the spill-over effects of the shocks in the emerging markets take more than half a year to be experienced in the DWM. Even after a year, 90% of the variability of the DWM are explained by its own shocks thus evident of emerging markets events which are not significantly impacting the DWM.

The VD of the EAM is shown in graph 2 of figure 8. Within the first 6 months, the DWM contributes around 40% of the EAM movements. This is evidence of DWM having significant influence over the changes in the EAM. The EAM in the same 6-month period, contribute to 60% of its own changes. The shocks of the South African market start to display minor effects after 6 months as it increases to 10% by month 10 and stays near that level until month 12. The EAM and DWM impacts decrease slightly from month 6 to 12, but the DWM impact is still around 4 times dominant than the South African market on the EAM. This result, in conjunction with graph 1 in figure 8, demonstrates that the DWM have a leading effect on the EAM. This leading effect is due to the EAM having a minimal impact on the DWM, however, the activities in the DWM account for a large proportion of the changes in the EAM. This shows the high level of integration between these markets when compared to the South African market and the EAM.

Figure 8: Variance Decomposition Across Markets



The final graph in figure 8 depicts the VD of the South African market. 60% of the changes in the South African can be explained by its own shocks within the first 6 months. The contribution of its own shocks decreases to slightly below a 60% level from month 6 and remains there until month 12. There are minimal shock effects from EAM which are experienced in the South African market during the first 6 months. The EAM impacts increase to 10% from month 6 and remains at that level till month 12. The DWM has a 40% contribution to changes in the South African market over the first 6 months, the impacts of which decrease marginally from month 6 to 12. As indicated with the VD between the DWM and EAM, the DWM displays the same leading market characteristics with the South African market. This leading market behaviour is attributable to the South African market having a lower VD percentage on the DWM across the 12-month period, but the opposite effects are observed for the DWM impacts on the South African market which is a leading indicator of integration between the South African and DWM. This contrasts with the South African market

and the EAM which shows a bidirectional lower VD and indicates a lower integration between these markets.

The results from the VD of the VAR model provide further evidence to support the findings from the IRF in section 5.3.2. This section depicts that around 35% to 40% of the changes in the South African market and the EAM which can be explained by movements in the DWM. In comparison, there are no immediate significant impacts on the DWM because of the changes in the South African market or EAM. These markets only have a combined impact of 10% on the DWM over 12 months. This finding provides concrete evidence that a high level of integration exists between the DWM and both the South African market and the EAM due to its influence over these markets. The same effects are not identified in the South African market and the EAM which supports the results from the IRF of marginal levels of integration between these markets.

The aforementioned results are key in answering the second research question in this study, namely the integration between the South African market and the DWM compared to the EAM is an important factor which contributes to the different realised diversification benefits. The higher integration between the South African and DWM leads to a lower F_2 -test statistic in Table 8 when compared to the EAM for the same degrees of freedom. This relates directly to the reduced benefit of the MVP of a South African investor diversifying into the DWM in comparison to the EAM. These results also explain why a South African portfolio which is diversified across EAM is penalised from a SR perspective, as illustrated in Table 10, when DWM assets are added to the portfolio. This is due to the higher integration levels which are prevalent between the DWM and both the South African and EAM as well as increases the MVP and decreases the diversification benefits. Therefore, the local South African portfolio that is diversified into the EAM dominates the diversification into the DWM.

Chapter 6: Summary and Conclusion

The evolution of the global markets over the past century has created complex dynamics in international markets. The rise of the Western markets has influenced the development of emerging markets such as Africa and Asia. This is due to the high levels of trade which exist between these markets. The dominance of the DWM provides interesting global diversification opportunities for the South African investor to optimise their equity portfolio into other regions of the world. The EAM is of particular interest for this study because of the reformed economic policies it had undergone in the 20th century and the low levels of trade with SA.

The aim of this study is to identify the potential international diversification benefits for a South African investor across the DWM and the EAM. Another key element of this study is to understand the dynamics between the markets in order to uncover the differences in the diversification benefits. The approach taken to achieve the aims set out in this study is to work within the conceptual mean-variance portfolio diversification framework. This framework formed the basis of the approach and made use of an advanced step-down mean-variance spanning technique in order to identify the diversification benefits. To quantify the economic benefits, the difference in the MSRs is calculated for the diversification across the two regional global markets. Due to the time series nature of the data, the VAR model is used to understand the evolving dynamics between the markets. The output of the VAR model is studied through the IRF and VD frameworks which provides a concise and logical understanding of the market interactions.

The step-down mean-variance spanning results provided overwhelming evidence that diversification of a South African equity portfolio into the EAM outperforms the diversification into the DWM. The test provided conclusive results that the EAM assets span the local portfolio. The DWM assets do not span the local portfolio as it failed to add value to the tangency portfolio but it did improve the MVP. The EAM dominated the diversification on both accounts of the tangency and MVP as both F-test statistics were more significant than the corresponding DWM test statistics. Even when considering the addition of DWM assets to local portfolio which is diversified into EAM, the results proved to not be viable. Therefore, proving that the optimal diversification strategy is for a South African investor to diversify their portfolio into the EAM.

The economic quantum of the diversification benefits closely reflect the strength of different diversification options. The diversification into the DWM provide a 12.33% increase in the SR of local portfolio. In contrast, diversification of the local portfolio into the EAM provides a 40.45% increase in the SR. This is a 28% increase in economic benefit for the South African investor. If the DWM assets is added to the optimal portfolio of the local and the EAM assets, there is a reduction in the SR and leads to an overall economic reduction of 0.32% on the portfolio.

The differences in the diversification benefits can be explained by the higher average returns in the EAM when compared to the DWM for the period studied. The integration of the global markets is the second factor which focuses substantially on the risk incurred by the portfolio. The IRF showed that all the markets are sensitive to shocks experienced by itself which indicates the requirement for international diversification. The shocks in the DWM overflowed into the South African market and the EAM within a month, the effects of which were still experienced for 6 months. Shocks from the South African market and EAM had an almost negligible effect on the DWM. The bidirectional shocks of the South African market and the EAM on each other were not immediate. These shocks took around 3 months to transfer between markets and the effects were minor in nature. The VD displayed the fact that more than 90% of the movements in the DWM are driven by its own changes. Whereas, for the South African market and the EAM, 40% of its movement are explained by changes in the DWM. The South African market and the EAM only explains an average of 10% of each other's market movements. This clearly indicates the high level of integration between the DWM and in both the South African market and the EAM. These results also provide evidence of the global market leader of the DWM. The level of integration between the South African market and the EAM is significantly lower with shocks between these markets being experienced at a lower extent.

Therefore, an optimal diversification strategy for a South African investor holding a local portfolio is to diversify solely into EAM. This is enforced by the higher rates of returns experienced in this market and the marginal level of integration between the South African market and the EAM. The lower level of returns from the DWM and the high levels of integration with the other two markets leads to suboptimal diversification strategy for the local portfolio.

The contribution of this study enhances the limited body of knowledge which is available to South African investors on the benefits of international diversification. These results have a direct impact on South African portfolio management as it provides information that can help optimise investment strategies and principles. This is greatly required in SA, especially at the time of this study, because of unstable local political regimes, failing infrastructure and high levels of continuous corruption which is experienced in the country. This study may be expanded by looking at other emerging regions (such as the Middle East) and by considering additional of other asset classes like property as well as by evaluating economies granularly through industry diversification.

Appendix

A. Mean-variance Spanning Formulas

$$\Sigma = V_{22} - V_{21}V_{11}^{-1}V_{12}$$

$$\hat{a} = \hat{\mu}'V^{-1}\hat{\mu}$$

$$\hat{a}_1 = \hat{\mu}'_1V_{11}^{-1}\hat{\mu}_1$$

$$\hat{c} = \mathbf{1}'_{N+K}V^{-1}\mathbf{1}_{N+K}$$

$$\hat{c}_1 = \mathbf{1}'_KV_{11}^{-1}\mathbf{1}_K$$

$$\hat{d} = \hat{a}\hat{c} - \hat{b}^2$$

$$\hat{d}_1 = \hat{a}_1\hat{c}_1 - \hat{b}_1^2$$

where,

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

$$\hat{b}_1 = \hat{\mu}'_1V_{11}^{-1}\mathbf{1}_K$$

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