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South African bonds as an alternative diversification asset for developed bond markets

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Orientation: Globalisation of financial markets has made it progressively more difficult for effective diversification to exist, and as a result portfolio managers are in need of alternative diversification opportunities.

Research purpose: Developed financial markets are more likely to be integrated with one another, and better diversification opportunities may be found in emerging markets.

Research motivation: Limited research focuses on bond market diversification, and most research does not include South Africa as a diversification destination. This research examines whether developed bond market investors could use South African bonds to diversify their portfolios.

Research design, approach and method: This article follows a quantitative research design with a causal-comparative or quasi-experimental approach. The econometric method used was primarily co-integration analysis establishing whether diversification opportunities exist between the South African bond market and five developed bond markets.

Main findings: Overall, the findings showed that there was no co-integrating relationship between the South African bond market and developed bond markets, indicating that diversification may be possible in the long term. Furthermore, it was found that the South African bonds were less affected by short-term shocks compared with the developed market bonds.

Practical/managerial implications: The results of this study indicated that South African bonds can be used to diversify a developed bond market investors portfolio. Developed bond market traders and fund managers should therefore consider holding South African bonds as a means of reducing their portfolio's overall risk.

Contribution/value-add: Holding South African bonds can be used to preserve a portfolio's long-term wealth. Additionally, the resistance of South African bonds to short-run shocks also provides investors with a cushion against sudden and unexpected crises.

Keywords: globalisation; financial market integration; diversification; developed bond markets; emerging bond markets; co-integration; causal relationships; innovation accounting.

Introduction

Staff (2013) explains that modern finance is plagued by a host of unrelenting, risk-promoting scenarios. Whether it is the introduction of new global risk factors or greater wealth accumulation expectations, investors are desperately attempting to find new ways to reduce financial risk (Staff 2013). A particular manner to do so, as highlighted by this study, is through diversification. Statman (1987) defined diversification as the reduction of one's risk by dispersing one's investments into unrelated securities.

This research is therefore based on the concept of risk reduction. The need for risk reduction methods has developed because of the massive increase in financial market integration. The past two decades have seen global financial markets becoming increasingly integrated with one another (Balli, Rana & Hu 2017). A number of explanations for this have been highlighted in a vast body of academic research. Studies by Harvey (2000), Wooldridge, Domanski and Cobau (2003) and Balli et al. (2017) explain that the dominant driving force behind this is the increased transfer of information as a result of sudden and exponential advancements in computing technology. The rise of information technologies has brought the world closer than ever before, allowing easy and effective access to financial markets that were once worlds apart. Turner and Holton (2015) agree with this, adding that the post-Cold War era saw a major shift in the

enhancement of financial systems with specific reference to economic computing technologies. The increased ability of information technology resulted in the increased interrelatedness of financial markets as cross-border trading volumes skyrocketed.

The increasing level to which global financial markets are integrated with one another has a number of benefits. Balli et al. (2017) suggest that greater economic growth has been promoted through the relaxation of cross-border capital controls and the inherent access to previously inaccessible financial platforms. De Gregorio (2016) supports this by explaining that global economic growth has thrived off the high level of investment efficiency that the increased global financial integration has provided. However, with all the benefits that the increased financial integration has provided, there are new risks that have evolved as a result. De Gregorio (2016) and Balli et al. (2017) agree that the recent financial crises of the past two decades are a clear indication that financial integration has left investors vulnerable. Investors who now look to maximise their wealth through investment into global markets are left exposed to financial and economic shocks that occur in those markets (Balli et al. 2017). The vulnerability stems directly from the ability of shocks in one market being able to spread into other international markets as a result of international markets becoming more integrated with one another. Investors' ability to access global markets, which brought about the possibility of earning higher returns, has now also resulted in risk spreading rapidly through these global markets.

The rapid increase in financial market integration because of globalisation has resulted in the transfer of risk across international borders becoming more prevalent. Furthermore, advances in modern technology have changed the way in which information travels. The widespread and timely transfer of information to all corners of the globe has created linkages between financial markets that never before existed. As a result, investors are finding it increasingly difficult to minimise the risk of their portfolios. This increase in globalisation has caused the need for investors to explore alternative avenues of investment that will aid in diversifying their risk.

Currently, there is a strong field of research documenting the level to which international equity markets are integrated. This poses an issue for fixed income investors looking to diversify their portfolios, as there is very limited research investigating the degree to which international bond markets are integrated. Furthermore, these studies focus predominantly on the linkages between developed markets, with little to no information investigating the linkages with emerging markets.

This article will therefore investigate if the South African bond market is an effective diversification alternative for developed bond market investors.

Literature review

Modern portfolio theory (MPT) is a world-renowned financial theory that is centred around the idea that investors who are risk-averse are able to construct portfolios that optimise their expected returns for a given level of risk, highlighting the fact that risk is a fundamental part of achieving higher reward. This theory was introduced by Markowitz in his seminal work published in 1952. The main concept from which MPT is built is investors' awareness, which results in them knowing the relationship between the risk and the return of a financial asset. Modern portfolio theory relies on the fact that it is common knowledge that the relationship between the expected return of a financial asset and the risk of that asset is positive. This implies that as the risk of a financial asset increases, its expected return also increases. Therefore, an investor willing to take on more risk is expected to be compensated for this additional risk with a higher return on his or her investment. Furthermore, if an investor is looking to maximise his or her expected return on his or her investment, he or she can do so by taking on a greater amount of risk.

Markowitz (1952) introduces the idea that investors' desire expected returns whilst at the same time finding variance undesirable. In understanding this, Markowitz (1952) explains that in order for investors to both achieve the desirable and minimise the undesirable, portfolio diversification is the most sensible option by which to do so. This involves an investor structuring his or her portfolio in such a way that it reduces the exposure to a specific asset. The basic goal behind diversification is to reduce the overall risk of a portfolio by investing in a variety of different assets instead of in a few common assets. This reduces the overall risk of the portfolio as the seemingly unrelated assets will not be affected by the same factors and the decrease in value of one asset will not see a similar decrease in the other assets and could, in fact, result in an increase in value of some of the other assets.

This is supported by Eun, Resnick and Sabherwal (2012) when they explain that the process of diversification is a method that reduces the exposure to any single asset or risk through the allocation of capital in a certain way. This method involves the decision to split an investment into a variety of assets that ultimately reduce the risk and volatility associated with only investing in a single asset (Eun et al. 2012). The premise of diversification is built around the notion that, according to Eun et al. (2012), security prices around the globe do not move in conjunction with one another, as seen by even extremely casual observations. Therefore, the ideology behind diversification as a concept stems from the time-honoured saying, 'do not put all your eggs in one basket'.

It has been a steep growth in the investment into international portfolios that have truly revealed the globalisation of financial markets across the world (Eun et al. 2012). The history of modern financial globalisation finds its roots in the fading days of the Second World War, a period that can only be described as an economic and political

nightmare (Mishkin 2005). With the allies becoming victorious and the world economy reduced to shambles, it was decided that a new international system was needed for the promotion of global trade; this resulted in the formation of the International Monetary Fund (IMF) and the World Bank (Mishkin 2005). According to Eun et al. (2012), globalisation of financial markets really came into fruition in the late 1970s when major economies began deregulating both foreign and capital markets.

It is this increase in international financial market integration that has led Solnik, Boucrelle and Le Fur (1996:17) to argue that 'international correlations for stocks and bonds fluctuate widely over time'. This fluctuation is a direct result of market integration, and Solnik et al. (1996) go on to explain that volatility appears to be contagious across international markets, with the correlation between international markets increasing during times of high volatility. As the globalisation of international markets increased, so has the growing concern amongst investors who are attempting to diversify, as the increasing level of international market integration is resulting in it becoming more and more difficult for weak or negative correlations to exist. Furthermore, because of diversification being most effective during times of financial distress, it is during these times of high volatility that the need for diversification becomes even more important. However, as previously discussed, the more integrated financial markets are, the harder it is to find effective diversification. It follows, then, that when volatility is high, in the period when diversification is most important, the less likely it becomes to find suitable diversification avenues (Solnik et al. 1996). Not only is volatility contagious, according to Solnik et al. (1996:17), but 'it has no discernible trend'.

International diversification

Having discussed the implications that globalisation has had on diversification, together with the relaxation of global capital controls over the past few decades, it is evident that the expected returns that investors desire are coming under threat as a result of the ever-increasing levels of financial market volatility (Duasa & Kassim 2009). The threat of diminishing expected returns, according to Duasa and Kassim (2009), has piqued the interest that global investors have in international diversification. It is therefore important to understand how and why diversification is an extremely important action taken by investors. According to Cappiello, Engle and Sheppard (2003), effective diversification is accomplished by two main approaches: firstly, through the investment in poorly or negatively correlated assets or, secondly, alternatively, through international investment of similar asset classes in multiple different markets.

Hunter and Simon (2004) build on these initial theories when they explain that fixed-income investors are constantly urged to look to international markets for possible fixed-income investment. As a result of the imperfect synchronisation of the business cycles of different countries, opportunities for greater returns exist through international investing, and investors are therefore able to reap the rewards that international diversification provides (Hunter & Simon 2004). Furthermore, according to Hunter and Simon (2004), portfolio managers typically construct globally diversified portfolios on the premise that foreign interest rate volatilities are different from their domestic interest rate volatilities and that their changes in volatility are not perfectly positively correlated. This has resulted in Hunter and Simon's (2004) finding that adding foreign government bonds on a currency-hedged basis to a diversified bond and equity portfolio significantly improves mean–variance efficiency. This is extremely attractive to international portfolio managers for many reasons. According to Hunter and Simon (2004), the improved mean–variance efficiency allows investors to predict, to some extent, the mean and volatility of government bond returns. Additionally, there has been little to no evidence found of the benefits of international portfolio diversification diminishing during periods of high stress because of the trade-off between risk and return moving implicitly over time (Hunter & Simon 2004). Lastly, even for an investor looking to hedge his or her portfolio in a market that is interdependent on his or her own market, interdependencies found in major international markets are still weaker than any interdependencies found in the same domestic markets (Hunter & Simon 2004).

Emerging markets as international diversification avenues

Having discussed the importance that diversification plays in today's world because of the increased level of globalisation and the thorough transmission of global information, this study aims at determining whether the South African bond market is a suitable avenue for diversification. Therefore, emerging markets as a whole will be discussed to gain a better understanding of what differentiates them from developed markets and how this results in emerging markets being less integrated with global markets. Furthermore, the South African market as a whole will then be compared with other African emerging markets to gain insight into South Africa's uniqueness as an emerging market, bolstering the South African bond market as an effective diversification avenue for developed market investors.

Following the literature presented by Grubel (1968) and Jorion (1985), highlighting the benefits of international diversification as opposed to domestic portfolio diversification, Levy and Lerman (1988) explain that the risk reduction that occurs from international diversification in stocks is well documented. This prompted Levy and Lerman (1988:56) to suggest that 'much less research has been devoted to bonds as a component of internationally diversified portfolios, despite their importance in the international capital market'. More recent work by Rabana (2009) confirms the findings of Levy and Lerman (1988) when he explains that even though the amount of literature examining the empirical linkages between emerging equity markets and developed equity markets is drastically increasing, empirical literature devoted specifically to the linkages between bond markets is almost non-existent.

It is therefore clear that international equities have been at the heart of research surrounding international diversification over the past couple of decades, which is further substantiated by Apergis, Christou and Miller (2012). According to Apergis et al. (2012), with global equities having been the focal point of international diversification, a global convergence of equity markets, caused by dramatic increases in capital flows between countries, is resulting in a major reduction in the diversification benefits of international equity market. With the recent shift to emerging market equities for international diversification, Aperigis et al. (2012) look at the degree to which global emerging equity markets are converging, not only amongst themselves, but with developed equity markets as well. Their findings indicate that global equity markets, both developed and emerging, are converging at a substantial rate and that stock markets around the world are now starting to reduce the individuality of a country's stock market and are reflecting the movements in the global industry as opposed to country-specific events.

This article therefore focuses on bonds as a financial asset class for developed market investors as opposed to equities for diversification purposes. Bekaert and Harvey (1997) already suggested in the late 90s that their research surrounding the distributional characteristics of emerging markets revealed substantial deviations from normality expectations. This is evident in the manner in which their research suggests that emerging markets are strongly characterised by skewness as well as kurtosis. According to Bekaert and Harvey (1997), this translates into basic investment perceptions that investors want products with strong positive skewness and are even prepared to accept lower expected returns to obtain these products. Therefore, in order for investors to be attracted to negative skewness, the expectation of significantly higher returns needs to be relatively high (Bekaert & Harvey 1997). This is where investors look to emerging market debt. According to Erb, Harvey and Viskanta (1999), emerging market debt has shown, through substantial evidence, that emerging bond markets exhibit strong negative skewness, which has been proved to reliably provide high expected returns.

Measures of effective bond market diversification

With research from Grubel (1968) following on from the work of Markowitz (1952), introducing international portfolio diversification as opposed to domestic diversification, a measure regarding the effectiveness of potential cross-border diversification was needed. Initially, it led to Levy and Sarnat (1970) suggesting that the degree to which diversification will be successful in reducing a portfolio's risk depends on the correlations that exist between securities. They explain that if two securities' returns are not correlated with one another, then by investing in both securities the risk of failure would decrease and in doing so diversification would be achieved. The other side of the coin also applies, as two securities that are strongly correlated would not reduce the amount of risk and diversification would not exist (Levy & Sarnat 1970).

With correlation of two items being defined as the mutual relationship that the two items share, past literature, as discussed previously, has described it as an accepted method of determining whether diversification is possible. Sudden advances in technology, specifically in computer and information technology systems, allowed technical analysis of this nature to be built upon by Engle and Granger (1987), who proposed the theory of co-integration analysis. According to Brooks (2008:336), 'a set of variables is defined as cointegrated if a linear combination of them is stationary'. This is seen in many time series, which are non-stationary but move in similar directions over time, implying that some influence exists between them (Brooks 2008). Furthermore, the existence of influence between the variables implies that there must be some sort of relationship between the variables in the long run. Brooks (2008) explains that:

> [*A*] cointegrating relationship may also be seen as a long-term or equilibrium phenomenon, since it is possible that cointegrating variables may deviate from their relationship in the short run, but their association may return in the long run. (p. 336)

Brooks (2008) expands on this and explains the link between co-integration and diversification when he discusses the important role co-integration plays between international bond markets. The existence of influence between the variables implies that there must be some sort of relationship between them in the long run. Furthermore, Brooks (2008) explains that a relationship that is proved through co-integration is also seen as a long-run or equilibrium phenomenon. This is, according to Brooks (2008), because of the possibility that co-integrating variables may stray from their relationship over the short term but return to their association in the long run.

South Africa: Breaking the emerging market mould

The South African financial market has established itself as a developed financial system within an emerging market economy because of its superior market size, growth potential and economic transparency. It is, however, South Africa's ability to strongly regulate financial markets that allows it to maintain these points of superiority and in turn maintain financial stability. Rossouw and West (2009) explain that African countries differ greatly from the rest of the world with regard to their governance practices. According to Rossouw and West (2009), the demands and needs faced by emerging markets are different when compared with their counterparts in the developed world, and as a result it can be expected that their structures within their institutions will differ. This is because emerging markets are synonymous with political uncertainty, social unrest and economic volatility. This has resulted in the governance of these markets being built around the premise of attracting international investment and enhancing economic growth through the appearance of economic stability in an attempt to bolster investor confidence (Rossouw & West 2005). Even though South Africa falls into this category, it has been able to maintain a sound financial and corporate environment since the ending of apartheid.

Furthermore, according to Vaughn and Ryan (2006), the history and economic development history of South Africa differ greatly from those of other African countries. Vaughn and Ryan (2006) go on to explain that the standard and complexity of South Africa's financial infrastructure is extremely similar to that of many developed countries, and as a result South Africa is able to maintain an active and efficient capital market. This is supported by Rossouw and West (2009), who explain that for many African countries, the need for economic development takes priority over any deliberations of governance. In South Africa's case, its sufficiently sophisticated markets and concrete regulatory frameworks have resulted in a lot of similarity being shown between South Africa's and many developed European countries' governance structures (Rossouw & West 2009).

This has helped highlight the South African bond market as the ideal diversification avenue for developed market investors. On the account of South Africa falling into an emerging market status, the growth potential within South Africa is enormous. This, coupled with the potential of South Africa not being highly integrated with international markets like many other African markets, its developed and mature financial system, sizeable market structure and strong governance systems, has led the authors of this study to believe that South Africa may provide the best possibility for effective diversification.

Research methodology

This research incorporates a deductive mode of reasoning as data from five different international bond markets will be analysed. The results from the various analyses will be observed and objectively discussed to draw a conclusion on whether the South African bond market is co-integrated with the five other international bond markets.

A quantitative research design is predominantly used in research where the problem is identifying certain factors that may influence an outcome (Creswell 2013). Furthermore, quantitative data are explained to be the measurement of the factors that influence an outcome through the means of numerical data, where the relationships can be quantified. This study will therefore use a quantitative research design when attempting to determine the relationship between the South African bond market and other international bond markets.

Unit root test: Stationarity

Rabana (2009) suggests that the first step of co-integration analysis is to test the series for stationarity. Therefore, in order for one to test whether a series is stationary or non-stationary, one must test whether the series contains a unit root. This is done through the use of an augmented Dickey–Fuller (ADF) test (Rabana 2009). This will be done on the raw data series with a constant but no trend in the test equation as prescribed by Brooks (2008).

The early work completed by Dickey and Fuller (1979) for testing a time series for a unit root resulted in a set of null and alternative hypothesis being specified; these are detailed as follows.

Null hypothesis (H_0):

The series has a unit root and is non-stationary on the level where $\varphi = 0$ in:

$$\Delta Y_t = \varphi Y_{t-1} + \mu_t \quad \text{[Eqn 1]}$$

Alternative hypothesis (H_1):

The series does not have a unit root and is stationary on the level where $\varphi < 1$ in:

$$\Delta Y_t = \varphi Y_{t-1} + \mu_t \quad \text{[Eqn 2]}$$

Granger causality test

Having tested the series for the presence of a unit root to test whether they are stationary on the level, a Granger causality test will be performed as a preliminary test of the relationships between the bond markets.

The model estimation as described by Brooks (2008) is detailed as follows:

$$X(t) = \sum_{r=1}^{L} A_r X(t-r) + \varepsilon_t \quad \text{[Eqn 3]}$$

This causal relationship is an important early indication of whether effective diversification is at all possible (Brooks 2008). If it is found that the South African bond market does not share bi-directional causal relationships with the developed bond markets, it is a good indication that diversification in the South African bond market could be possible.

Vector autoregressive model

After the preliminary analysis has been completed, assuming it promotes further investigation into the bond market relationships, the level of co-integration between these bond markets will be analysed. Therefore, having already tested for stationarity with the ADF test, the next step in the co-integration analysis will be the construction of a vector autoregressive (VAR) model.

Brooks (2008) explains that VARs were made popular by Sims (1980). The model estimation developed by Sims (1980) is detailed as follows:

$$Y\,t = c + A_1 Y_{t-1} + A_2 Y_{t-2} + \ldots + A_p Y_{t-p} + \varepsilon_t \quad \text{[Eqn 4]}$$

Johansen co-integration test

Brooks (2008) supports Kremers, Ericsson and Dolado (1992) in the use of the Johansen co-integration test when he explains that the Johansen test is, by far, the most superior

procedure when attempting to test for possible co-integrating relationships. Maggiora and Skerman (2009:18) who, in a later study, use the Johansen co-integration test to test for co-integration, explain that 'the Johansen process is a maximum likelihood method that determines the number of cointegrating vectors in a non-stationary time series VAR'. They go on to employ the model estimation as described by Brooks (2008), which will also be used in the context of this study and has been detailed as follows:

$$\Delta X_t = \mu + \sum_{i=1}^{n} r_i \Delta X_{t-1} + \alpha\beta^{\wedge} X_{t-1} + \varepsilon_t \quad \text{[Eqn 5]}$$

The model is then analysed with regard to the two different test statistics. These are the trace test and maximum eigenvalue test statistics, where co-integration is deemed to be present when there is at least one co-integrating vector (Brooks 2008). The model estimations for these trace and maximum eigenvalue test statistics, as described by Brooks (2008), are detailed as follows:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{g} \ln\left(1-\hat{\lambda}_i\right) \quad \text{[Eqn 6]}$$

$$\lambda_{\max}(r, r+1) = -T \ln\left(1-\hat{\lambda}_{r+1}\right) \quad \text{[Eqn 7]}$$

If none of the trace/max statistics are greater than their critical values, it is safe to assume that no long-run relationship exists between the variables (Brooks 2008). The next step in the analysis, according to Brooks (2008) and Rabana (2009), is the specification of the vector error correction model (VECM). The VECM models the short-run dynamics by imposing certain restrictions on each international bond market variable to ascertain whether each of the included variables significantly impacts the co-integration calculation (Maggiora & Skerman 2009). Brooks (2008) provides a model specification for the VECM, which is as follows:

$$\Delta y_t = \Pi y_{t-k} + \Gamma_{k-1} \Delta y_{t-(k-1)} + \varepsilon_t \quad \text{[Eqn 8]}$$

Innovation accounting

Having modelled the long-run relationships via the use of the Johansen co-integration test and the subsequent short-run relationships with the VECM, further analysis into the short-run dynamics is necessary (Rabana 2009). Innovation accounting is a combination of two tools that enable this (Brooks 2008). According to Brooks (2008), innovation accounting is made up of the impulse response and variance decomposition models. In the case of at least one co-integrating vector being present, the innovation accounting models will be specified within the VECM framework. If, however, there is a lack of co-integration, innovation accounting will be done on the differenced VAR model.

Therefore, the final step in the analysis will be to examine the transmission of shocks between the different bond markets. This will be achieved by means of an impulse response and variance decomposition model. These are graphical illustrations that should support the causality testing and provide an indication of how each bond market will react to shocks that occur in a particular bond market (Brooks 2008).

Data and analysis

Mills and Mills (1991) explain their use of high-frequency data within their models and justify this as a necessity. This is done to encapsulate the globalisation of the financial markets that has continued apace in recent years. This study will therefore incorporate daily data in line with the study by Mills and Mills (1991). The government bond market yields over the 15 years from 1998 to 2013, for the South African bond market as well as for the five developed bond markets, will be incorporated in line with Petrov (2011). According to Petrov (2011), this will encompass the entire duration of each bond. Furthermore, it will also ensure that a sufficient time period is used that will encompass the rise in globalisation that has been prevalent over the past decade. A summary of the intended variables and their sources is provided in Table 1.

This study will therefore make use of the IRESS database to obtain the required data as it is a well-known and extremely reliable database that is accessible to postgraduate students at the University of Johannesburg and has therefore been deemed an appropriate data source for this study.

Results and findings

The null hypothesis (H_0) of the ADF test is that the series contains a unit root and is non-stationary (Brooks 2008). The alternative hypothesis (H_1) is therefore that the series does not contain a unit root and is stationary on the level (Brooks 2008). Rejection of the H_0 or H_1 is based on the ADF test statistic as well as the probability. In the case that the test statistic is more negative than the critical value at the 5% confidence interval and the probability is less than 0.05, then the H_0 will be rejected and the H_1 will be accepted. In order for co-integration analysis to be possible, the H_0 should be accepted and each series should be integrated to the first order of I(1).

The probabilities of each bond market's test statistics are not significant at the 99%, 95% and 90% confidence intervals, therefore accepting the null hypothesis of a unit root (Table 2). The bond markets are therefore

TABLE 1: Data summary.

Bond market	Variable type	Source
South Africa	Government bond market yields	IRESS
Germany	Government bond market yields	IRESS
Norway	Government bond market yields	IRESS
Sweden	Government bond market yields	IRESS
United Kingdom (UK)	Government bond market yields	IRESS
United States of America (USA)	Government bond market yields	IRESS

TABLE 2: Augmented Dickey–Fuller test: Level.

Bond market	South Africa	Germany	Norway	Sweden	United Kingdom	United States of America
Augmented Dickey–Fuller test statistic	-2.3943	-0.4786	-0.8166	-0.9327	-0.8699	-1.9895
Probability	0.1448	0.8912	0.8117	0.7760	0.7959	0.2913

*, **, ***, Significant on 90%, 95%, 99% confidence intervals, respectively.

TABLE 3: Augmented Dickey–Fuller test: I(1).

Bond market	South Africa	Germany	Norway	Sweden	United Kingdom	United States of America
Augmented Dickey–Fuller test statistic	-10.7042	-9.9414	-9.8750	-9.6416	-9.4233	-10.9478
Probability	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***

*, **, ***, Significant on 90%, 95%, 99% confidence intervals, respectively.

TABLE 4: Granger causality test (South Africa).

Granger causality (South Africa)	Probability
Germany does not Granger cause South Africa	0.6764
South Africa does not Granger cause Germany	0.3376
Norway does not Granger cause South Africa	0.8626
South Africa does not Granger cause Norway	0.5461
Sweden does not Granger cause South Africa	0.7841
South Africa does not Granger cause Sweden	0.4139
United Kingdom does not Granger cause South Africa	0.3802
South Africa does not Granger cause United Kingdom	0.6967
United States of America does not Granger cause South Africa	0.7606
South Africa does not Granger cause United States of America	0.2352

*, **, ***, Significant on 90%, 95%, 99% confidence intervals, respectively.

TABLE 5: Granger causality test (others).

Granger causality (others)	Probability
United Kingdom does not Granger cause Germany	0.0290**
Germany does not Granger cause United Kingdom	0.1450
United Kingdom does not Granger cause Norway	0.0403**
Norway does not Granger cause United Kingdom	0.6880
United Kingdom does not Granger cause Sweden	0.0292**
Sweden does not Granger cause United Kingdom	0.2501
United States of America does not Granger cause United Kingdom	0.0446**
United Kingdom does not Granger cause United States of America	0.0022**

*, **, ***, Significant on 90%, 95%, 99% confidence intervals, respectively.

non-stationary on the level. The probabilities of each bond market's test statistics are all significant at the 99% confidence interval, therefore rejecting the null hypothesis (Table 3). This confirms the non-stationarity of the series on the level and indicates that co-integration testing may proceed (Brooks 2008).

Granger causality test

The Granger causality test, according to Brooks (2008), determines the causality of the series where all dependent variables are caused by significant independent variables. It is this causal relationship that will form a preliminary test for the purposes of this study, as an indication of the relationships shared will be provided through the presence or non-presence of causality.

Table 4 indicates that there are no significant causal relationships between the South African bond market and each of the other five international bond markets. Additionally, Table 5 indicates that there is only a single bi-directional significant causal relationship between the other five bond markets. This is between the United States of America (USA) and United Kingdom (UK) bond markets.

The lack of bi-directional causal relationships between the South African bond market and the five developed bond markets is an early indication that diversification opportunities in the South African bond market may exist. This is because of Hiemstra and Jones (1994) as well as Brooks (2008) explaining that the lack of causal relationships between variables suggests that no variable causes the other variable and that they could move independently of one another.

Vector autoregressive model

Following the Granger causality test, highlighting the causal relationships that exist between the different bond markets, the next step in the analysis is to do the co-integration analysis starting with the VAR specification. The first step in the estimation of a VAR model, having decided on the variables to be used, is to determine the optimal lag length (Brooks 2008). The Akaike, Schwartz and Hannan–Quinn information criteria indicated that a lag length of 2 will be used in the VAR specification.

Johansen co-integration test

The Johansen co-integration test will be employed to test the level of co-integration between the international bond markets. The null hypothesis (H_0) of the Johansen co-integration test is that there are no co-integrating equations present in the series, and therefore no co-integration is present (Brooks 2008). The alternative hypothesis (H_1) is that there is at least one co-integrating equation present in the series, and co-integration is present as a result (Brooks 2008). These will be analysed based on the trace statistic and maximum eigenvalue.

Examining Tables 6 and 7, none of the trace or maximum eigenvalue statistics is greater than the 0.05 critical value. Therefore, the H_0 is accepted and no co-integration is present at the 95% confidence interval. As the non-existence of any co-integrating equations has been identified, it is evident that there is a lack of a stable long-run relationship between the bond markets, and therefore only the short-run relationships are relevant. The Johansen co-integration test has therefore emphasised the potential for effective diversification between the international bond markets resulting from the lack of long-run relationships through the measurement of the levels of co-integration between the

TABLE 6: Johansen co-integration test – trace test: Unrestricted co-integration rank test (trace).

Hypothesised number of cointegrating equation(s)	Trace statistic	Critical value	Prob. **
None	94.95442	95.75366	0.0567
At most 1	61.64404	69.81889	0.1883
At most 2	37.37254	47.85613	0.3302
At most 3	20.81191	29.79707	0.3695
At most 4	8.705599	15.49471	0.3933
At most 5	0.462264	3.841466	0.4966

*, Denotes rejection of the H_0 at the 95% confidence interval; **, MacKinnon-Haug-Michelis (1999) *p*-values.

TABLE 7: Johansen co-integration test – maximum eigenvalue: Unrestricted co-integration rank test (maximum eigenvalue).

Hypothesised number of CE(s)	Max-eigen statistic	Critical value	Prob. **
None	33.31038	40.07757	0.2366
At most 1	24.27150	33.87687	0.4359
At most 2	16.56064	27.58434	0.6178
At most 3	12.10631	21.13162	0.5372
At most 4	8.243335	14.26460	0.3545
At most 5	0.462264	3.841466	0.4966

*, Denotes rejection of the H_0 at the 95% confidence interval; **, MacKinnon-Haug-Michelis (1999) *p*-values.

TABLE 8: Block exogeneity Wald test.

Dependent variable	Joint probability	Order
South Africa	0.5997	1st
Germany	0.1203	3rd
Norway	0.0500	4th
Sweden	0.0447	5th
United Kingdom	0.3246	2nd
United States of America	0.0424	6th

bond markets. These relationships will now be analysed individually to determine which bond markets react the most effectively over the short-run for diversification purposes.

Impulse response

The impulse response model visually indicates how a shock or innovation in one bond market is transferred to the other international bond markets (Brooks 2008). It is therefore able to identify both the responsiveness of the dependent variable to these shocks as well as the length of time for which the effect lasts (Brooks 2008). Each impulse response graph is measured as the standard deviation (y-axis) of shocks measured over a number of periods (x-axis) (Brooks 2008).

It is important to note that the ordering of the variables has a notable effect on the outcomes of the impulse response as well as on the variance decomposition (Brooks 2008). Therefore, before this analysis, a block exogeneity Wald test must be performed to determine the correct ordering of variables. The results of the block exogeneity test are provided in Table 8, indicating the order used.

Having determined the Cholesky ordering of the series, the impulse response model will therefore be constructed. The results of the impulse response are shown in Figure 1.

Figure 1 shows that a 1 standard deviation shock to the German bond market causes an initial negative ± 0.02 standard deviation shock in the South African bond market over a 1-month period. Thereafter, a positive shock peaking at 0.05 standard deviations is evident over the next 2 months, dissipating in the sixth month. The flat and unresponsive curve further supports the lack of a causal relationship between the German and South African bond markets.

Figure 1 shows that a 1 standard deviation shock to the Norwegian bond market causes an initial positive ± 0.01 standard deviation shock in the South African bond market after the first month. Thereafter, a negative shock peaking at about 0.008 standard deviations is evident over the next month, dissipating in the fourth month. The flat and unresponsive curve further supports the lack of a causal relationship between the Norwegian and South African bond markets.

Figure 1 shows that a 1 standard deviation shock to the Swedish bond market causes an initial negative about – 0.025 standard deviation shock in the South African bond market over a 2-month period. Thereafter, a positive shock peaking at ± 0.02 standard deviations is evident over the next 2 months, dissipating in the third month. The flat and unresponsive curve further supports the lack of a causal relationship between the Swedish and South African bond markets.

Figure 1 shows that a 1 standard deviation shock to the UK bond market causes an initial positive ± 0.05 standard deviation shock in the South African bond market starting halfway through the first month and dissipating in the third month. Thereafter, a small negative shock of –0.01 standard deviations is experienced over a 2-month period, which dissipates in the fifth month. The flat and unresponsive curve further supports the lack of a causal relationship between the UK and South African bond markets.

Figure 1 shows that a 1 standard deviation shock to the USA bond market causes a negative ± 0.015 standard deviation shock in the South African bond market, starting in the second month and dissipating in the fourth month. The flat and unresponsive curve further supports the lack of a causal relationship between the USA and South African bond markets.

Variance decomposition

An alternative measure of the responsiveness of a particular bond market to shocks that occur in other international bond markets is that of the variance decomposition. According to Brooks (2008), the variance decomposition is a useful tool in assessing how shocks could potentially reverberate through a system. Where the impulse response model graphically represents the response to a 1 standard deviation shock in a particular bond market, the variance decomposition measures the degree to which a variation in one market can be explained by variations in other markets.

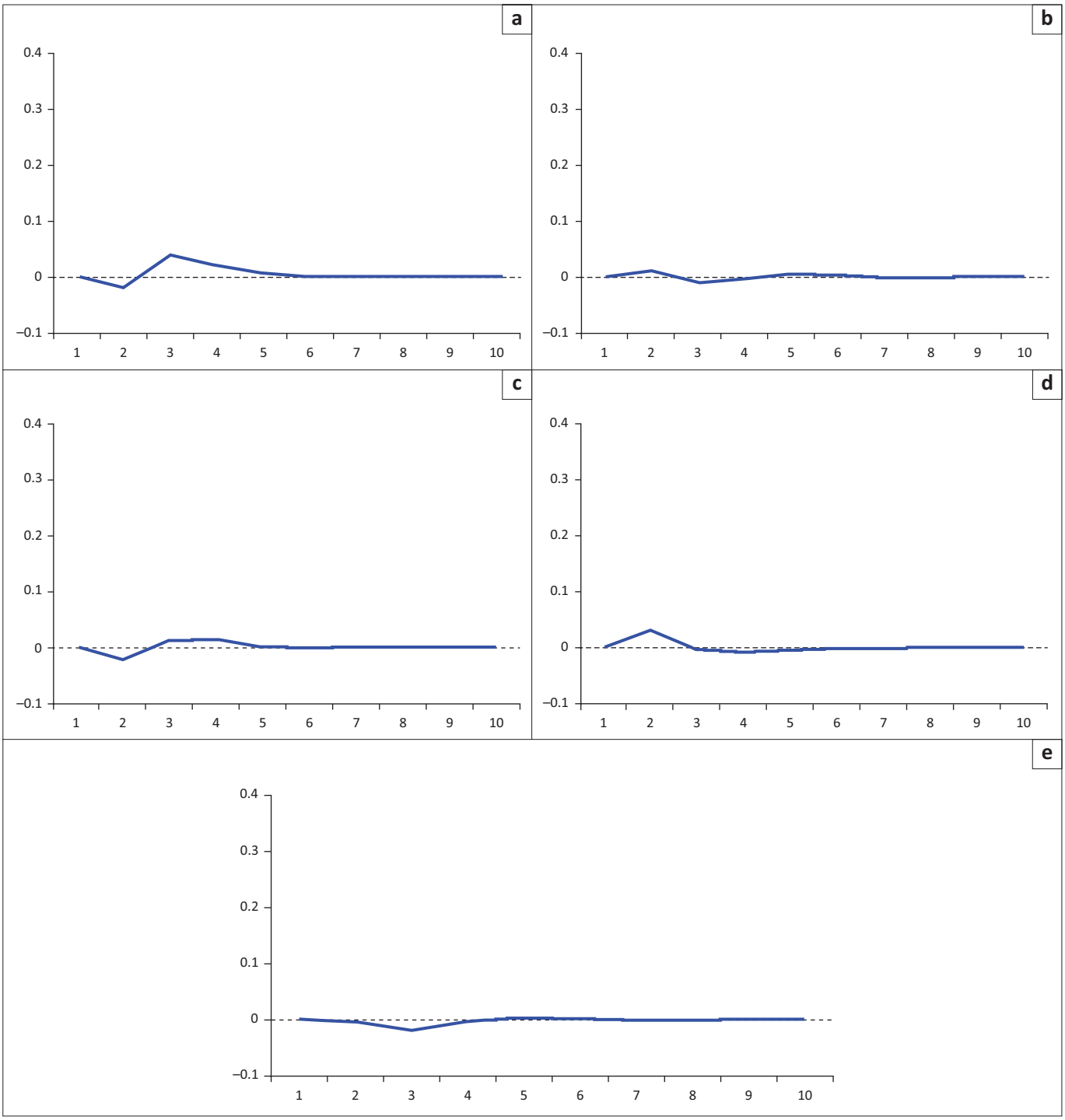

FIGURE 1: Impulse response of South Africa to a shock in each bond market response of South Africa to (a), Germany; (b), Norway; (c), Sweden; (d), United Kingdom and (e), United States of America.

Each variance decomposition table measures the percentage variance of shocks measured over a number of periods, in other words the percentage of the variance in a bond market as explained by a shock in another bond market measured over time. Having already completed the block exogeneity Wald test to determine the Cholesky ordering for the impulse response, the same order will be used when specifying the variance decomposition model.

From Table 9 it is evident that shocks to the German, Norwegian, Swedish, UK and USA bond markets do not cause any significant fluctuations in the South African bond market over all time periods. A shock in all five bond markets accounts for 0% of the variation in the South African bond market in the first period.

Summary

The results of the Granger causality test indicated that there are no bi-directional causal relationships between any of the six bond markets. The lack of causality was an early indication that diversification opportunities in the South African bond

TABLE 9: Variance decomposition of South Africa.

Variance period	Germany	Norway	Sweden	United Kingdom	United States of America
1	0.0000	0.0000	0.0000	0.0000	0.0000
5	2.1053	0.2270	0.7399	0.9440	0.3543
10	2.1073	0.2351	0.7406	0.9561	0.3580

market may exist. Subsequently, results from the co-integration testing indicated that the South African bond market is not co-integrated with the five developed bond markets and a long-run relationship does not exist. Additionally, the innovation accounting indicated that South African bonds have a lower reaction to shocks compared with the developed markets. Variations in the developed bond markets also account for very low variations in the South African bond market, both indicating the lack of short-run relationships.

Conclusion

The literature review of this study brought to light the seminal work on diversification by Markowitz (1952). Later works by Grubel (1968), Ibbotson, Carr and Robinson (1982) and Jorion (1985) then introduced the benefits of international diversification as a means of reducing the risk of a portfolio by investing in international securities, taking advantage of market imperfections that arise from cross-border relationships. The increase in market integration has resulted in these international diversification opportunities becoming more and more difficult to exist. The findings presented indicate that South Africa could, in fact, provide a potential diversification opportunity.

Initial testing of all bond market data, by means of a unit root test, including South Africa and five developed bond markets, indicated that co-integration analysis could take place. Thereafter, it was found that no significant causal relationships exist between the South African bond market and each of the other five developed bond markets. This indicated that diversification into the South African bond market may be possible through the understanding of the works by Levy and Sarnat (1970) and Mills and Mills (1991) who found that the lack of causal relationships is indicative of low levels of correlation, a major driver of effective diversification.

The causality testing gave a good indication of the South African bond market's ability to provide diversification benefits to developed bond markets. However, more recent economic theory prompted this study to use co-integration testing to determine if diversification opportunities are truly available. Both the maximum eigenvalue and trace statistic tests indicate that no co-integration is present at the 95% confidence interval. The lack of co-integration between the international bond markets is evident of the lack of a stable long-run relationship, supporting the lack of bi-directional causal relationships and further supportive of possible diversification (Brook 2008). Numerous studies, such as Gruber (1968), Levy and Sarnat (1970), Mills and Mills (1991), Clare, Maras and Thomas (1995), Ciner (2007) and Rabana (2009), agree with this by explaining that effective diversification is achieved in securities that are not co-integrated with each other. Effective diversification could therefore be achieved through investment into the South African bond market because of the lack of co-integration and the resulting lack of long-run relationships between the international bond markets.

The short-run analysis that followed added substance to these findings. The results of the impulse response indicate that the South African bond market had no significant or large reactions to shocks in all five developed bond markets. This is an indication that diversification into the South African bond market is possible not only over the long-run, but over the short-run as well. Furthermore, additional short-run analysis in the form of a variance decomposition indicated that 0% of the variation in the South African bond market can be attributed to variations in all five developed bond markets in the first period.

Through the investigation into the causal relationships and level of co-integration between the South African bond market and five developed bond markets, this study explored whether the South African bond market is a possible diversification avenue for developed bond market investors. Results, consistent with both one another as well as with existing literature, suggest that diversification is in fact possible, and that the South African bond market is a possible diversification avenue for developed bond market investors. South Africa's emerging market status and its strong position amongst emerging markets have resulted in low levels of co-integration between developed bond markets. Furthermore, South Africa's well-regulated financial market and well-developed bond market are what set it apart as an African investment and position it well within the set of leading choices for emerging market investment (Kahn 2005).

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Authors' contributions

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Ethical considerations

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Data availability

The data that support the findings of this study are available from the IRESS database. The software for this database is available on https://www.iress.com/.

Disclaimer

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