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Are there benefits to diversification across the largest African stock markets?

Research dissertation presented for the approval of the University of Cape Town Senate in partial fulfilment of the requirements for the degree of Masters of Commerce specialising in Financial Management

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ABSTRACT:

This study examines the co-movements of selected African stock exchanges, including Nigeria, Morocco, Egypt and South Africa, as well as the USA, in local currency and in USD terms, for the period January 2004 to June 2014. The study sheds light on African market cointegration before, during, and post the financial crises of 2007/2008 to identify whether there are benefits to diversification in stock exchanges across Africa and how this has changed over time. Only the four biggest exchanges are examined, to eliminate the effects of illiquidity and ensuring the size of indices used result in conclusions that are practical to investors. This study looks at short and long term relationships using correlation, cointegration, and the direction of the relationships using causality tests. It finds low correlations between all African exchanges and the USA, with the exception of South Africa, which did show significant correlation with the USA. We find no consistent cointegration relationships over the periods tested. There are no consistent causality relationships between the various countries. The implication of these results are that there are likely benefits to diversification across the four African exchanges examined.

Keywords:

Cointegration, African Exchanges, Diversification in Africa, Investment in Africa.

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ACRONYMS AND ABBREVIATIONS

CSE	Casablanca Stock Exchange
ECM	Error correction model
EGX	Egyptian Stock Exchange
EGX 30	Egyptian Exchange Top 30 Index
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
IRF	Impulse Response Function
JSE	Johannesburg Stock Exchange
JSE Top 40	Johannesburg Stock Exchange Top 40 Index
MENA	Middle East and North Africa region
MSCI	Morgan Stanley Capital International
NGSE	Nigerian Stock Exchange All Shares Index (NGSE)
NSE	Nigeria Stock Exchange
NSE Top 30	Nigeria Stock Exchange Top 30 Index
NYSE	New York Stock exchange
OLS	Ordinary Least Square
SADC	Southern African Development Community region
SACU	Southern African Customs Union
SACR	Southern African Customs Region
S&P 500	Standard and Poor's 500
SMF	Stock Exchange of Mauritius
USA	United States of America
USD	United States Dollar
VAR	Vector Autoregressions
VECM	Vector Error Correction Model
WFE	World Federation of Exchanges

1. INTRODUCTION

"The benefits of international diversification have been recognized for decades"
(French & Poterba, 1991:223)

Given the international benefits of diversification, the study of stock market integration has become of fundamental importance to investors around the world. This is because it is a useful tool to predict future co-movements of international stock exchanges, with the hope that "ex post patterns of co-movement may be useful proxies for the ex-ante co-movements" (Meric & Meric, 1989:627). Stock market integration can be defined as a condition in which stock markets move together and have the same expected risk adjusted returns (Sharma & Seth, 2012:84). The benefits of international diversification can only be realised if the markets do not move together. "However, if international stock market correlations are higher than normal in bear markets, then international diversification will fail to yield the promised gains just when they are most needed" (Butler & Joaquin, 2002:999).

Although market integration may be negative from a diversification perspective, Levine (2001:690) shows that decreasing restrictions on international portfolio flows tends to enhance stock market liquidity and integration, which in turn accelerates economic growth. This increasing level of integration has an effect on potential diversification options and therefore has an effect on investors' and fund managers' decisions. As will be discussed in the literature review below, often tests for integration are performed around crises, for example: the 1987s equities crisis (Arshanapalli & Doukas, 1993; Longin & Solnik, 1995; Butler & Joaquin, 2002; Meric & Meric, 1989) or the Asian crisis in 1997 (Ghosh, Johnson & Saidi, 1999; Kamin, 1999; Wang, Yang & Bessler, 2003), as this is when the main benefits from diversification are gained (Butler & Joaquin, 2002:999). Diversification aims to decrease variance of returns (Markowitz 1952:79), and during a crisis the market has a high variance from expected returns and thus benefits can be had from diversification.

Given the above, the objective of this paper is to shed light on whether a diversification benefit can be gained from investing across Africa, from a practical perspective. To do this this study aims to test the correlation, cointegration, and causality relationships among four of

Africa's largest and most liquid exchanges to determine whether there are diversification benefits to international and African investors investing across the continent.

The more specific objectives are to examine the long-term relationships between indices in the different markets, and the strengths of these interactions, as well as the direction of the relationships. The results of the tests performed will be useful for investors in the compilation of a diversified portfolio, specifically using exchanges within Africa. The outcome of this study should also increase our understanding of how the different large African markets react with respect to each other, especially in times of a global crisis, as this is when the benefits of diversification are most necessary.

As shown in the review of the literature in section 2, in past studies on this topic, researchers have looked at regional relationships. These have generally been relationships within the Southern African Development Community (SADC) (Piesse & Hearn, 2002; Jefferis & Okeahalam, 1999) or the Middle East and North Africa region (MENA) (Graham, Kiviaho, Nikkinen & Omran, 2013; Yu & Hassan, 2008). Other approaches have been to compare one or two African countries to international markets (Alagidede, Panagiotidis & Zhang, 2011; Chen, Chen & Lee, 2014; Collins & Biekpe, 2003), or to cover a large number of African countries (Adjasi & Biekpe, 2006; Agyei-Ampomah, 2011). One of the key areas of differentiation of this study from the past literature is the selection of exchanges.

This study examines four African stock markets, namely the Johannesburg Stock Exchange (JSE), Nigeria Stock Exchange (NSE), Casablanca Stock Exchange (CSG), and the Egyptian Stock Exchange. These are compared with US stock exchanges, represented by Standard & Poor's 500 index (S&P 500). This index includes stocks listed on both the New York Stock exchange (NYSE) and the NASDAQ. The objective is to establish where there are benefits to investing across Africa from a local perspective, examining the relationships among the African exchanges. We then look from an international perspective examining the relationships between the African exchanges and the S&P 500.

The four exchanges were selected because of their size and liquidity, which make them a viable investment option for large institutional and foreign investment. All four exchanges are also members of the World Federation of Exchanges (WFE). Being registered with the

WFE is significant as of the end of 2012 only four African stock exchanges have fulfilled the criteria entitling them to become members of this regulatory body (Riscura, 2013:7).

The reasons for the inclusion of the S&P 500 are twofold: Firstly, the USD is used as a proxy for relative value across the African exchanges, enabling us to see in USD terms if they are integrated. The USD was chosen because it is the "dominant medium for international transactions" (Goldberg, 2010:1), and is arguably the most obvious choice as a base for value movements. International investors needing to compare the performance of African stocks to other international investments would require the returns to have a relative value base, and in this case the USD is being used as that base. Raj and Dahl (2008:212) also test stock prices in local and USD terms, and find the currency denomination used affected their cointegration results. This could be of specific benefit to international investors.

According to Graham et al. (2013:90), "The diversification benefits, if any, may be contaminated by foreign exchange risk when returns from prices denominated in local currency are used". This study thus also attempts to remove the effects of currency depreciation and exchange rate changes, although imperfectly. Given African countries generally have higher borrowing rates than developed countries and, over time, have currency devaluation against the USD, the tests were run on the data in both local currency and USD terms in order to note the effects to both local and global investors. Looking at returns in USD allows the relationships to be viewed in relative terms.

A further benefit of this study, when compared to previous literature, is that this study has real-world application. The indices used in this study have the required size and liquidity to make them viable investment options, as they represent the largest and most liquid stocks. The aforementioned factors result in this study having application value to institutional and larger individual investors. In previous studies, Graham et al. (2013:89) use the Morgan Stanley Capital International (MSCI) indices, Collins and Biekpe (2003:291) use local benchmark indices, and Chen et al. (2014:89) use MSCI, Russell's' Frontier markets and the S&P indices.

Studying integration among stock markets will improve investor's decision-making strategies (Sharma & Seth, 2012:85). A potentially negative aspect of increased global integration is increased exposure to global crises. Economic crises usually have damaging effects on

economic growth and stability and therefore determining the extent of the interaction among the various countries is important from an economic policy standpoint too. Globalisation has been seen as a catalyst for the increasing interest in the study of inter-linkages among financial markets (Hasan, Saleem & Abdullah, 2008:54). The increasing occurrence of crises within equity markets, such as the 1987 equities crisis, 1997 Asian crisis, 2001 Dot-com bubble, and the financial crises of 2007/2008 (the primary crisis being looked at in this study), has increased interest in the benefits of international diversification. The period of this study is 1 January 2004 to 30 June 2014, which allows a view of the relationships and change in relationships before, during, and after the financial crises of 2007/8.

The research approach used in this study was to run a series of correlation tests to examine the strength of co-movements and the possibility of a predictive relationship. However as this statistic does not imply a causal relationship the initial test was then followed by running unit root, cointegration, and causality tests in order to establish the nature and significance of these relationships over time.

Previous studies have used a similar methodology to this study, in which tests were run on logged closing prices for cointegration, and on the returns of the logged closing prices for correlation and causality. The methodology in this study follows the most popular methods established by Sharma and Seth (2012), who analysed 105 research papers on stock market integration.

Correlation test results show very low correlations between the four African exchanges, and only South Africa[1] and the USA showed a correlation relationship above 0.5. It was also found that the relationships in local currency differed from the relationships in USD. There appeared to be a slight increase in correlations amongst the African exchanges during the crisis period (period 3). However the correlations were still very weak, implying that diversification benefits could have been gained in the crisis period.

[1] This study examines the prices and returns on indices used as a proxy for a country's exchange. The countries name is then used to describe the relationship between that country's exchange and another country's exchange. In this point the correlation between the Johannesburg Stock Exchange's Top 40 index and the S&P 500 index from the USA, is described as the correlation between South Africa and the USA. This method of describing relationships will be applied throughout the remainder of study.

Tests were run on logged daily and logged weekly data. As a further robustness check the tests were run on unlogged data, and the details of the robustness check are briefly discussed in the results section, and documented in Appendix 8.4. Raj and Dhal (2008) perform weekly as well as daily data analyses with a lag length of two. As mentioned, to gain more insight and make the results more relevant this paper examines the relationships in both local currency and in USD. This paper uses the USD as a fixed value point to compare respective movements in the indices. This has been done in previous studies, for example in Jefferis and Okeahalam (1999) and Agyei-Ampomah (2011).

The results of this study are similar to other African studies in that very few cointegration relationships are found between the various indices over the full period of testing. Numerous relationships are found when the full period is broken down into shorter periods, and these are discussed in more detail in the results section below. With logged daily data, using the Johansen cointegration tests, two cointegration relationships are found over the full period 1 January 2004 – 30 June 2014. The first is between the Egypt and Morocco, and the second is between Nigeria[2] and the USA. These relationship is found in both local currency and USD terms. The direction of the relationships was established from a Granger causality test. Egypt is found to lead Morocco over the full period in local currency, however in USD terms they are found to have a causality effect on each other. In both local currency and USD Nigeria and the USA are found to have a causality effect on each other.

When the Johansen and Engle-Granger cointegration test results were combined, the only cointegration and causality relationships found are as follows; Morocco causes South Africa in local currency during period 2, and the USA causes South Africa in local currency during period 4.

As with the daily data, numerous cointegration relationships are found using the Engle-Granger and Johansen tests over the shorter periods examined in this study. From the test results it does not appear that the amount of cointegration relationships are increasing over time.

[2] In this study two indices from Nigeria are used: The Nigerian Stock Exchange All Share index and the Nigerian Stock Exchange Top 30 index. When describing relationships with the other exchanges, the Nigerian Stock Exchange All Share index will be referred to as Nigeria, and, the Nigerian Stock Exchange Top 30 index as Nigeria Top 30.

When combining the test results from the Engle-Granger and Johansen cointegration tests, on the weekly logged data two relationships are found: Firstly, in local currency the USA is found to have a causality effect on the South Africa during period 3. Secondly, Nigeria Top 30 is found to have a causality effect on Nigeria during period 2.

When looking at weekly logged data using the Johansen Cointegration tests several cointegration relationships appear for the period January 2007 to June 2014. These are mainly in USD currency terms, and only one of these relationships is found in local currency terms. The cointegration and causality relationships for the period January 2007 to June 2014 are as follows: Egypt is found to have a causality effect on Morocco and vice versa, Nigeria Top 30 is found to lead Nigeria, South Africa is found to cause Nigeria, Nigeria and the USA are found to have a causality effect on each other, and, South Africa and Nigeria Top 30 are found to have a causality effect on either other. The only relationship in local currency terms is Nigeria Top 30 is found to lead Nigeria.

No relationships are found over the full period January 2004 to June 2014, using either the Johansen or Engle-Granger cointegration tests, and no cointegration relationships for longer than a single sub-period are found using the Engle-Granger test for cointegration.

Some of the findings in this study differ to those of studies done on similar countries over similar time periods and this is likely due to the choice of indices used in this research. The results in this study are consistent with those of Jefferis and Okeahalam (1999), Collins and Biekpe (2003), as well as Wang, Yang and Bessler (2003) but differ from those of Graham et al. (2013:98). The latter finds that when looking at the MENA region there are long term linkages with the USA, and Egypt was included in this sample. This differs from the results found in this paper, as cointegration between Egypt and the USA was only found in period 1.

Chen et al. (2014:99), find that there is integration, and the US market caused frontier market movements, and supported the leading market hypothesis. They also note that they expect leading markets to become more integrated with frontier markets in the future. South Africa and Egypt are classified as emerging markets for the purposes of this study. However it is not clear whether Morocco should be classified as an emerging or frontier market. If we use the definition adopted by Speidell (2011:1) Morocco would be classified as a frontier market, as

it is not included in the MSCI All Country World Index (Morgan Stanley Capital International [MSCI], 2016a). As noted by Speidell (2011:2), Morocco was included as an emerging market in 2011. However Morocco is no longer a member of the MSCI emerging markets index (MSCI, 2016a). Morocco was reclassified as a frontier market in November 2013 (MSCI, 2016b). Nigeria is considered a frontier market (Speidell, 2011:9).

The results of the Johansen cointegration test run on the weekly logged data in USD support Chen et al. (2014:99) in terms of the USA causing Nigeria during the period 1 January 2007 to 30 June 2014. However, findings using local currency, or those using both the Johansen and Engle-Granger tests do not support these conclusions as no relationships were found between Nigeria and the USA or between Morocco and the USA. As will be shown, there were also few relationships found between Nigeria Top 30 and Nigeria.

Graham, Kiviaho and Nikkinen (2012:36) find stock market integration is constantly changing over time. There has historically been more of a trend toward co-movements in the long term, but after 2006 there were more short term co-movements. Thus there were still benefits for US investors to invest in emerging markets, especially in the short-term. This finding is fairly consistent with our findings. Graham et al. (2013:98), and Yu and Hassan (2008:502), find some longer time relationships between MENA region markets, which is consistent with the results of this study.

The remainder of this study will be organised as follows. Section 2 provides a review of the literature relating to market integration in order to give the study the required context and background. Section 3 gives a brief review of the four stock exchange indices and their backgrounds. Sections 4 and 5 deal with the data collected in the study, as well as the research approach. Section 6 provides an analysis of the results found from the data, and Section 7 brings the information together in a summary of the outcomes of the research and a conclusion.

2. REVIEW OF RELATED LITERATURE

In our introduction we discussed the need for diversification when building an optimum portfolio. As stated by Markowitz (1952:77), "Diversification is both observed and sensible; a rule of behavior which does not imply the superiority of diversification must be rejected both as a hypothesis and as a maxim."

A number of studies have tested the relationships between stock markets. Our review of this literature first gives a brief overview of the significant findings on international developed markets. It then focuses on findings related to emerging and African markets. The early integration studies on international markets are of more interest as Africa has only emerged as a global investment opportunity, from an equity market perspective, in the last decade or so.

2.1 Integration of international stock markets

This study does not attempt to explain in detail the reasons for integration or lack of integration. It aims rather to discuss whether this relationship exists to clarify whether there are benefits from diversification within Africa, as well as to suggest potential reasons for the relationships found. In getting to this conclusion, we start by looking at how developed market integration has changed over time.

A seminal study investigating the inter-linkages between international stock markets was conducted by Grubel (1968:1299). In this study, Grubel (1968) examines stock markets in 11 geographically and economically diverse countries and finds that the return per certain level of standard deviation can be increased through diversification. Since Grubel (1968:1313) first examined the effects of international portfolio diversification, linkages among international stock markets have attracted substantial attention. As Sharma and Bodla, (2010:29) state: "Interaction of financial markets is one of the most extensively discussed topics of financial literature". This interest is mainly due to the above-mentioned potential benefits of diversification.

A review of the literature identifies a trend in research findings. A number of early studies conclude that the integration between stock exchanges is moderately low or inconclusive (Granger & Morgenstern as found in Lawson, 1971:642; Lessard, 1973:624; Ripley, 1973:361), implying one could gain from diversification between stock exchanges. In 1987 Swanson (1987) shows that integration between the USD yield and Euro Dollar yields increased for the period 1973 to 1983. Arshanapalli and Doukas (1993:202), using data for the period January 1980 to May 1990, also find that co-movements of international stock exchanges post the equities crisis in October 1987 increased substantially. There was no cointegration link between the US and the major European markets before October 1987. This finding, of cointegration post the 1987 equities crisis, did differ from the findings of past studies on developed markets. One of the main reasons for this was a change in the tests for cointegration, proposed by Engle and Granger (1987).

Longin and Solnik (1995) undertook the first long term study of market correlation, based on seven major markets over the period 1960-1990. Their findings suggest that correlation increased over the period tested. They also found that the correlation increases during times of large conditionally volatility (Longin & Solnik, 1995:19). By the late 1990s it was true to say that the major world stock markets had become more closely linked (Jefferis & Okeahalam, 1999:29).

Most research in the field of stock market integration has concentrated on the USA, UK, and Australia (Sharma & Seth, 2012:85). However, interest in the linkages of other countries has been increasing, as globalisation has affected the degree to which all countries react to and interact with each other in terms of their stock markets

Rangvid (2001:384) proposed the idea of increasing the number of cointegration relationships as an indicator for increasing market integration. Rangvid's (2001:388) paper could not reject that the European stock markets were becoming increasingly integrated throughout the 1980s and 1990s. Raj and Dhal (2008:214), in another study, discuss the integration of India's stock market with global and regional markets. They find that Indian stock market integration has strengthened since 2003, using unit root (Augmented Dickey-Fuller) tests and Johansen cointegration tests. Zhang (2009:35), similarly, explores the Asian markets and the USA, using correlation, cointegration, unit root tests, and Impulse Response Function (IRF), and find that the US markets had a significant effect on Asian markets, while China was the least affected of the Asian countries. The GARCH model and the Ljung Box statistic were used to

show that the domestic markets of Singapore were highly integrated with external markets, with Malaysia being the least integrated (Yi & Tan, 2009:218).

This same trend of increased international market integration was noted by Graham et al. (2012:44) in a more recent study. It should also be noted that the recent literature has not focused on whether stock exchanges are cointegrated, but rather on the extent of cointegration, and which countries and time period are relevant. This has been done primarily using the Wavelet analysis, with the aim of trying to identify long versus short term co-movements. This methodology has not been applied in this study, as evidence for cointegration of African markets is still not strong.

2.2 Integration of African stock markets

2.2.1 Why African stock markets?

Africa is regarded as a frontier market and the therefore thought of as a high growth area, and foreign investment and interest in the continent is growing. From 2011, Egypt, Morocco, and South Africa were members of the MSCI Emerging markets index (Speidell, 2011:2), with Nigeria forming part of the MSCI frontier markets index. (Speidell, 2011:9). Subsequently Morocco was removed from the MSCI Emerging markets index in November 2013 (MSCI, 2016b). Frontier markets account for the majority of the fastest growing economies in the world. This high growth attracts foreign direct investment (Speidell, 2011:22). Investing in a frontier market is associated with risk. Thus if the African frontier markets are cointegrated with emerging or developed markets it may be beneficial to invest in the less risky emerging or developed markets.

Market integration of developing African stock exchanges is fundamental to economic development (Jefferis, 1995:663; Kenny & Moss, 1998:829; Piesse & Hearn, 2002:1712; Bekaert, Harvey & Lumsdaine, 2002:2). The degree to which these African stock exchanges are globally integrated is important for this primary goal, as this attracts foreign direct investment (Kenny & Moss, 1998:830). The financial and economic reforms liberalizing African economies have further promoted international interaction (Bekaert et al., 2002:4; Piesse & Hearn, 2002:1712).

Financial development has also been proven to have a causal effect on the rate of economic growth (Irving, 2005:5). Financial integration also has implications for financial stability (Sharma & Bodla, 2010:29), with markets that are more integrated also being more financially stable. Consequently, such well-integrated stock exchanges can play an important role in the promotion of African economic growth. Research aimed at understanding the financial integration of African stock markets is therefore important for the future growth and success of Africa.

2.2.2 The effect of a crisis

With the world becoming more interlinked, it is not surprising, that global crises have also become more frequent, yet counterintuitively less severe (Bordo, Eichengreen, Klingebiel & Martinez-Peria, 2001:72). A financial crisis will inevitably have an effect on stock exchanges, more so in some countries than in others, depending on their degree of cointegration. Understanding the extent of stock market integration is advantageous for investors and investment advisors, as it means that local investments may suffer from a crisis, while international investments may be unaffected. For instance, although the Asian financial crisis of 1997-1998 had a drastic effect on the economies of Asian countries, it possibly had very little effect on smaller African stock exchanges. The effect of such crises on African stock markets and their integration over time has not been addressed thoroughly in the literature, nor has there been much research on the integration of African countries before or after a specific crisis period.

Most prior research on emerging market cointegration revolves around various crises. The majority of the above studies have focused on the 1997-1998 Asian crisis, while the extent of the 2007-2008 financial crisis on stock market integration has yet to be fully researched. This is especially as it pertains to Africa, although the MENA region was examined by Graham et al. (2013:98), using Wavelet analysis.

2.2.3 Findings from previous literature on emerging markets

Since the early 1990s emerging markets have become a more viable asset class, leading to a growing interest in African market integration. During the 1990s several significant events occurred, including the Mexican peso crisis, the Asian crisis, and the Russian and Brazilian

bond defaults. These have provided data and spurred further interest in the integration of emerging and global markets (Collins & Biekpe, 2003:285). Harvey argues that emerging markets are segmented from world markets because their returns are influenced by local rather than international factors (Harvey, 1995:787). The same study finds that including emerging market equities in a portfolio can increase returns and decrease volatility (Harvey, 1995:811).

Alagidede, Panagiotidis and Zhang (2011:7) explore the implications of integration among African economies and stock exchanges to assess the effectiveness of portfolio diversification. They find few long term relationships between African countries and even between African countries and the rest of the world. They conclude that investors could diversify their portfolios by including African stocks, because international stock market shocks would have little effect on African stock markets because of this lack of integration. Alagidede et al. (2011:7) also show the relevance of research in deciding whether African shares should be used to diversify an investment portfolio. However, much research still needs to be done in terms of African stock market integration.

Previous studies seem to focus on specific regions rather than Africa as a continent, thus this study is relevant for global investors looking to invest in Africa.

2.2.4 Previous literature on African market cointegration

Research which has influenced this study includes an examination of international stock market linkages in Southern Africa by Jefferis and Okeahalam (1999). This research was also spurred by the effects of two significant crises: The 1987 equities collapse, and the Asian and emerging market crises of 1997/1998. Jefferis and Okeahalam (1999) investigate the extent of linkages in Southern Africa, focusing on the neighbouring countries of Botswana, Zimbabwe, and South Africa. Correlation analysis, unit root tests and cointegration tests were used to ascertain the linkages. The methodology used in their paper was also used in this study. This is because this methodology had been used frequently in similar research and because the results can be easily interpreted. The cointegration results of Jefferis and Okeahalam (1999:45) shows that Botswana and South Africa are linked in the long term, whereas the correlation results illustrate a relationship between the countries in the short term.

Piesse and Hearn (2002:1722) provide evidence in support of integration among countries in the Southern African Customs Region (SACR), illustrating that the geographical location of each country has relevance for integration. Using the Johansen cointegration and Granger causality tests, they find that the monthly stock indices of the Southern African Customs Union (SACU) equity markets are cointegrated. A surprising finding was that causality runs from the Namibian to the South African stock market. They attribute this to the presence of common regional factors that tend to affect Namibia more than South Africa, which then spill over to the more open South African equity market (Piesse & Hearn, 2002:1722).

Collins and Biekpe (2003:290) use changes in correlations following the Asian crisis in 1997 to examine the interdependencies of African markets. They use seven stock exchanges across Africa and test for contagion from Hong Kong in 1997. They find that, with the exception of South Africa and Egypt, the evidence does not support integration with global emerging markets. They acknowledge that this is intuitive as South Africa and Egypt are the two largest stock exchanges in Africa (Collins & Biekpe, 2003:297). They also note that relationships between African exchanges are mainly based on region. However there was a lack of causal relationships, except between South Africa and Zimbabwe. The results they find are not necessarily consistent with studies on larger countries. They thus conclude that their methodology for determining the effect of contagion was incomplete. In this study we aim to obtain more conclusive results.

Wang et al. (2003:527) were the first to address the before and after effects of the 1997-1998 Asian crisis on stock market integration in African stock exchanges. This crisis is seen as the first stock market crisis to have a global impact (Kamin, 1999:501). Wang et al. (2003:530) furthermore shows that the crisis had an effect on the degree of integration between several African stock exchanges. Morocco had strong interactions with other countries on the continent prior to the crisis period, but almost none after the crisis period. South Africa was shown to be very unresponsive to shocks from other African markets, but showed a noticeable response to markets in the USA. Wang et al. (2003:531) divided the time into the period before the crisis and the period after the crisis, and found that, with the exception of South Africa, the degree of integration of African stock markets was limited.

Adjasi and Biekpe (2006:115) show that long term relationships exist between several African stock markets. South Africa was shown to be affected in the long term by reactions

from other markets, such as Egypt, Kenya, Mauritius, Nigeria, and Ghana. The South African market must regularly monitor developments in these other markets, due to their long run impacts. They also showed that South Africa, being the larger market, was helping to correct any disequilibrium and that the country had a significant effect on the relatively inactive Ghanaian market. This study brings to light not only the presence of South Africa as a major influence in Africa, but also the extent to which economies affect each other. Egypt, in particular, has been shown to have a long running effect on South Africa. This study will ascertain whether this long term effect still exists.

Graham et al. (2012:34) tests the strength of co-movements between the US and 22 Emerging markets, including Egypt, Morocco, and South Africa, using the Wavelet analysis tool. The key findings from the study were as follows: Stock market integration is constantly changing over time and there is more of a trend of co-movements over the long term, and more short term co-movements after 2006. Thus there are still benefits to American investors to investing in emerging markets, but more so in the short-term.

MENA market integration has been tested by Yu and Hassan (2008), and Graham et al. (2013). Yu and Hassan (2008:502) compare MENA stock exchanges to those in the USA, UK, and France to see if the market returns are cointegrated, for the period 1 January 1999 to 31 December 2005. They find cointegration between the Gulf Cooperation Council (GCC) and Non-GCC markets tested, and well as the US stock market exhibiting Granger causality with non-GCC markets.

The study by Graham et al. (2013:86) is similar to this study, in that it looks at co-movements with the USA and co-movements within the MENA region. Using data from June 2002 to June 2010, this study finds there are co-movements with the USA (S&P 500) in the long term. However, the relationship does not exist in the short term, implying the benefits of diversification in the short term (Graham et al., 2013:98). This study by Graham et al. (2013:98) also finds a rise in co-movements after the onset of the financial crisis in 2008. This is consistent with other research on increased cointegration in times of greater volatility. In terms of co-movements within the MENA region, they find again generally longer term co-movements. However after 2008, they begin to see short term relationships emerging (Graham et al., 2013:98). This supports the findings by Yu and Hassan (2008).

3. STOCK EXCHANGE INDICES BACKGROUND

There are 22 stock exchanges in Africa, though only 17 of these exchanges are operational (Riscura, 2013:7). Selecting the four in this study was necessary as there are several constraints with regard to the remaining 18 stock exchanges, such as illiquidity, not trading daily, or limited data (Hearn, Piesse & Strange, 2010:490). The size of the exchanges was also an important factor: Other than the four in this study, the exchanges are too small to be invested in by most mainstream funds, and thus using them would lead to questionable results. Given that the majority of international investors would only be investing in these four exchanges, we have performed the relevant tests on only these stock exchanges.

The Stock Exchange of Mauritius (SMF) is also a member of the WFE. However it has been left out of this study because of its small size. The SMF market capitalisation at year end 2012 was 7.18 billion USD (World Federation of Exchanges [WFE], 2015). This is significantly smaller than the countries included in this study. This would affect both the liquidity of the stocks listed on this exchange, and whether they are practically investable. This would influence the ability for this exchange to be used for diversification benefits.

A brief overview of the African exchanges is provided below, followed by more detail on the indices used as proxies for these markets.

The Johannesburg Stock Exchange (JSE) was established in 1887. By 2003, the JSE had an estimated 472 listed companies, as well as an average monthly traded value of 6.399 billion USD (€5.5 billion) (Johannesburg Stock Exchange [JSE], 2013). The JSE holds an influential position, as it is one of the top 20 stock exchanges in the world in terms of market capitalisation. On the 31 December 2012, the market capitalisation of the JSE stood at 907 billion USD (WFE, 2015). These rankings illustrate that the JSE, the largest stock exchange in Africa, is a giant in comparison to the other exchanges on the African continent (Norton Rose Fulbright, 2009).

The Egyptian Exchange (EGX) was established in 1883 as the Alexandria Stock Exchange. The name was changed to the Cairo Stock Exchange in 1903. It is one of the oldest stock

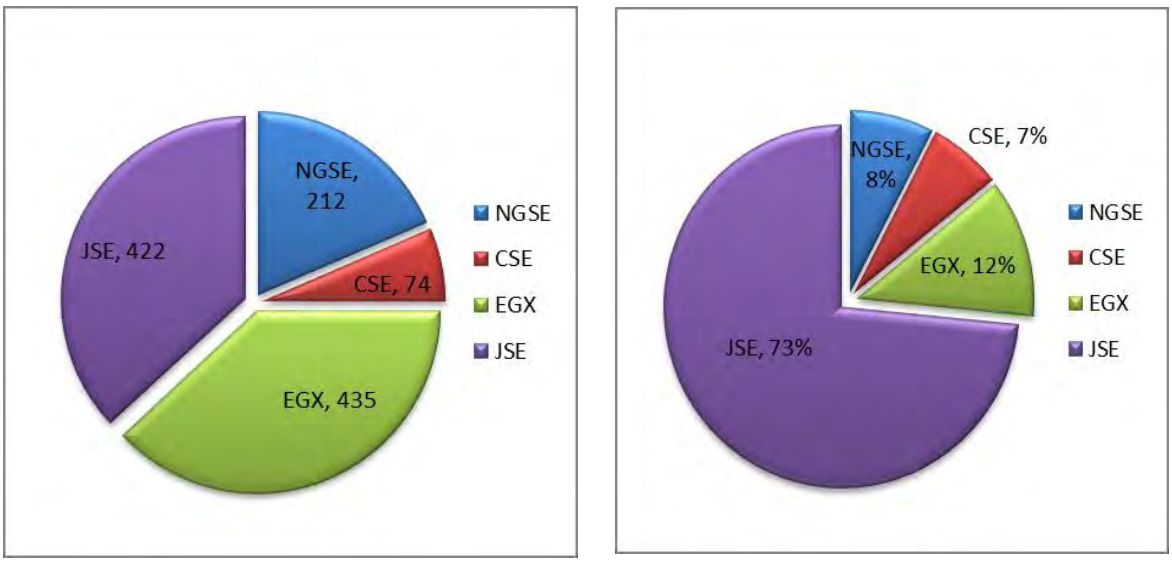
exchanges in the Middle East, and the second largest in Africa. On the 31 December 2012, the Egyptian Exchange had a market capitalisation of 59.2 billion USD (WFE, 2015).
The Casablanca Stock Exchange (CSE) is based in Casablanca, Morocco. Established in 1929, it currently has 16 members and 77 listed securities. The CSE modernised its trading systems in the late 1990s and early 2000s. (Casablanca Stock Exchange [CSE], 2008) On 31 December 2012, the market capitalisation of Morocco was 52.48 billion USD. (WFE, 2015)

The Nigerian Stock Exchange (NSE) was established in 1960 as the Lagos Stock Exchange. The NSE hosts approximately 200 listed companies in 12 diverse sectors, including several global brands (The Nigerian Stock Exchange [NSE], 2013). The NSE is the third largest stock exchange in Africa by market capitalisation and is the leading exchange in West Africa. On 31 December 2012, the market capitalisation of the NSE stood at 54.9 billion USD (WFE, 2015). In 2014, after rebasing its GDP (which was previously done in 1990), Nigeria became the largest economy in Africa (BBC, 2014). As discussed, these stock exchanges were chosen based on their liquidity, market capitalisation and availability of closing price data.

3.1 Comparison of the stock exchanges

The figures below represent the market capitalisation and the number of listed companies of the four stock exchanges. The JSE represents 73 percent of the total market capitalisation of these four exchanges in 2007, and this had increased to 83 percent by 2010. This emphasises the dominance of the JSE among African stock exchanges in terms of market capitalisation.

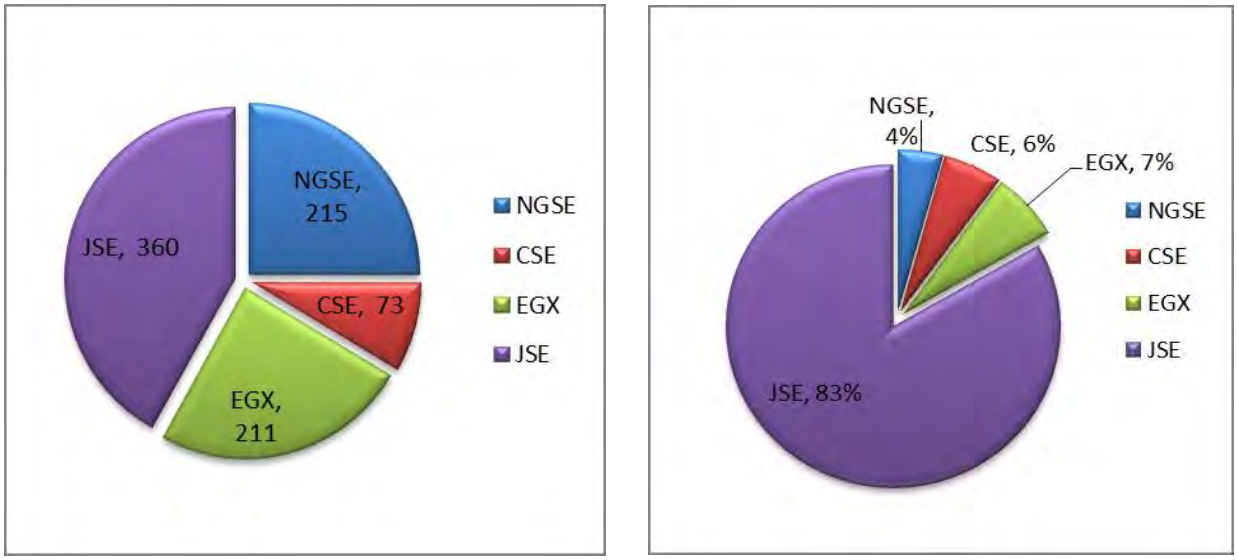
Figure 1: Number of listed stocks per exchange in 2007 (left) and market capitalisation per exchange in USD in 2007 (right)



Source: Compiled from Securities Exchange Commission [SEC] Nigerian statistical bulletin (2010:72).

Of the JSEs 422 listed companies, as shown in the Figure 1 above, 37 are foreign companies (WFE, 2015). It is expected that the 37 foreign companies will have a large influence on the effect that a global crisis would have on South Africa. In 2010 less than 45 of the companies were foreign**.** In the figure above, the CSE and the EGX had no foreign companies and the NSE only had 1 foreign company. Theoretically, these stock exchanges would be expected to be less affected by a global financial crisis. In 2010, the CSE and EGX had 1, and the NSE had 2 foreign companies.

Figure 2: Number of listed stocks per exchange in 2010 (left) and market capitalisation per exchange in USD in 2010



Source: Compiled from Securities Exchange Commission [SEC] Nigerian statistical bulletin (2010:72).

3.1.1 The Johannesburg Stock Exchange (JSE) – JSE Top 40 Index

The JSE Top 40 index was used as a proxy for South African stock movements. The JSE Top 40 takes the top 40 shares listed on the JSE in terms of market capitalisation and calculates a free-float weighted index. The JSE Top 40 index was developed with a base value of 10,399.53 as of June 21, 2002 (Bloomberg, 2015a).

3.1.2 The Nigerian Stock Exchange (NSE) – Nigeria All share and Top 30 indices

The NSE indices are based on market capitalization methodology so that each stock represented in the index contributes to the index proportionally to its market capitalization (NSE, 2013). All listings are included in the Nigerian Stock Exchange All Shares Index (NGSE) unfortunately this includes possibly illiquid or very small stocks. Weekly price data is available for the Nigerian Stock Exchange Top 30 (NSE 30), from 2 January 2007, with daily data being available from October 2009. The NSE 30 Index is a capitalization-weighted index. This index tracks the top 30 companies in terms of their market capitalization and liquidity. Unfortunately, there is no market capitalisation breakdown of stocks in the NGSE index and thus a NSE Top 30 could not be recreated for the period before 2009.

The NSE, like the JSE, over-represents certain sectors. For instance, the financials of Nigeria are over-emphasised in the stock exchange, compared to the contribution that this sector makes towards the country's GDP. Conversely, even though the energy sector is 40 percent of the GDP, it is barely represented on the listed market (Riscura, 2013:9).

3.1.3 The Egyptian Exchange (EGX) – EGX 30 Index

The CASE 30 Index, which was renamed the EGX 30 Index in 2009, was used as a proxy for Egyptian stock movements. The EGX 30 Index is a free-float capitalisation weighted index and consists of the 30 most highly capitalized and liquid stocks traded on the Egyptian Exchange. The EGX 30 index was calculated in local currency terms, but since 1998 has

been denominated in USD. EGX started publishing its dollar denominated index on the 1st of March 2009 (The Egyptian Exchange [EGX], 2013).

3.1.4 The Casablanca Stock Exchange (CSE) – CFG 25 Index

This exchange is relatively new, as it was reformed in 1993 (CSE, 2008). In 2004, the floating-weighted capitalisation method for calculating indices was introduced. The exchange has an electronic trading system and is one of the best performers in the Middle East and North African region. In this study the CFG 25 Index was used, as it is made up of 25 stocks from the top 35 stocks in terms of market capitalisation and top 30 stocks in terms of liquidity. The CFG 25 index covers more than 80 percent of the exchange market capitalisation, and is a "price-only market capitalisation weighted index" (Bloomberg, 2015b).

The indices discussed were used as proxies for the movements of the various exchanges for the cointegration and correlation analyses performed in this paper.

4. DATA

The data was divided into three different categories for testing. The first category was the daily closing prices for proxy indices of South Africa, Nigeria, Morocco, and Egypt. The second category was the logged version of the first set of daily data. The third and last category of data was the weekly closing prices of the respective indices. The weekly data had an additional index, the NSE 30. The reasons that the weekly data was used were twofold: Firstly, to see if a week's time lag affected the results, and secondly because the NSE 30 had limited data, which is discussed further under data issues. Thus, to achieve the goal of a practical investment study, weekly data was necessary to ensure the indices were investable in terms of size and liquidity. The primary reason for the weekly tests is because the NSE 30 is only available on a weekly basis from January 2007 until 2009, when it became available daily. Liquidity and the index being practically investable are key in this study and thus weekly tests were run to include the NSE 30 which best represents liquid and practically investable stocks.

The daily closing price and weekly closing price data for these indices were all obtained from Bloomberg. As discussed above, the JSE Top 40, NGSE, CFG 25 and the EGX 30, were the indices used for the daily analysis over the relevant period. For weekly analysis the same indices were used, with the addition of the NSE 30.

The logged closing prices were used for the cointegration tests, with the unlogged closing prices being used as a robustness check. For a cointegration test to be reliable the data cannot be stationary. As cointegration tests that two non-stationary data sets together become stationary (Engle & Granger, 1987:259). For the correlation tests and Granger causality tests where the data is required to be stationary, the returns of the daily closing and logged prices were used.

The period of analysis is from 1 January 2004 to 30 June 2014. This period is further divided into five sub-periods to address the potential impact of the global financial crisis on the African stock exchanges, as well as their integration with global markets. The crisis period for the purposes of this study is considered to run from October 2007 to the end of April 2009, with the post-crisis period starting at the beginning of May 2009. It is difficult to pinpoint the exact start and end of the crisis. However, using the S&P500 as a proxy for US stocks it can be seen that the decline in the S&P500 index started in October 2007 and the S&P 500 reached a low in March 2009. An examination of the indices being tested in this paper shows that the JSE Top 40 hit its closing high on 11 October 2007, the CASE index on 5 May 2008, CFG 25 Index on 13 March 2008, the NGSE on 5 March 2008, and the NSE 30 on 7 March 2008. The lows were found to be the JSE Top 40 in November 2008, which then declined again in March 2009, CASE index in February 2009, CFG 25 Index in January 2009, and the NGSE in March 2009.

Most of the benefits of diversification would be gained during the crisis period. For this study the crisis period begins in October 2007, as this is when the Top 40 and the S&P 500, the first of the proxies, start their decline and the benefits of diversification would be most important. The crisis period ends in March 2009 when the last of the proxies hit their respective lows. Analysis of the preceding and subsequent periods provides further insight into whether there has been a change in the relationship between the African exchanges, and those in the USA.

The periods for the daily data have been split as follows:

- Period 1: January 2004 – December 2005
- Period 2: January 2006 – September 2007
- Period 3: October 2007 – April 2009
- Period 4: May 2009 – June 2011
- Period 5: July 2011 – June 2014

Reason for five periods selected above is based on two main considerations. The crises period in the instance was determined by looking at the lows and highs from the closing price data. The other periods coincide, although not perfectly, with trends in the market movements. For example January 2006 – September 2007 one can see from the closing prices that this was a bull market, and the same can be said for May 2009 – June 2011. In the periods January 2004 – December 2005 and July 2011 – June 2014 the closing prices were quite stable. This allowed an analysis of the relationships in the varying market conditions.

For the weekly tests the data was split into three separate periods, as noted below. The reasons for having the longer periods are twofold. Firstly, the number of observations decreased substantially which required a longer period to get a statistically significant number of observations. Secondly, weekly data was only available for the NSE 30 from 1 January 2007, and daily data was not available in the required periods.

The periods for the weekly data have been split as follows:

- Period 1: January 2004 – December 2006
- Period 2: January 2007 – December 2010
- Period 3: January 2011 – June 2014

Ideally for the weekly data the same periods as per the daily data above would have been used, however as the number of data points decreases substantially from converting daily to weekly data and to keep the results statistically significant the range of dates needed to be expanded. It the originally period 3 was used only 78 observations would have been used. Given Nigeria Top 30 was only available from 1 January 2007 a single period could not span over this date.

4.1 Data Issues

A number of issues must be considered with regard to the choice of data frequency. Daily data are preferred over lower frequency data, as they capture the dynamic interactions occurring over each day (Chinzara & Aziakpono, 2009:76). Moreover, the stock exchanges react promptly to new information. These quick responses are not accurately captured or fully encapsulated when using monthly, weekly or yearly data. The cointegration and correlation tests will thus be more relevant, and the results more applicable, if more frequent observations are used.

However, there are also problems with the use of daily data. This is predominantly because African markets are less liquid than developed markets. Agyei-Ampomah (2011:246) stated that the use of monthly returns addresses the many microstructural biases that may occur with daily data, such as nonsynchronous trading and stale pricing. In this study liquidity was addressed by using indices for only the largest and most liquid stocks, on the four biggest exchanges across Africa. Unfortunately this information was not available for Nigeria. The NSE 30 could be recreated. However this would need individual research on the companies traded over the period and their ranking based on market capitalisation. The market capitalisations of the individual shares were not available during the time period. We would have had to check the number of shares in issue and multiply that by the closing price in order to get the market capitalisations. This was not done in this study.

The different African indices are not easy to compare because of their infancy. The method used to calculate their indices, and the type of indices available, are sometimes not clear and not perfectly comparable. However the main issues of liquidity and tradability are addressed in this study. The JSE Top 40, CFG 25, and the EGX 30 Index were used, as they have higher liquidity than the All Share indices for the respective countries. They furthermore have similar trading characteristics, which makes for better comparison.

The NSE All Share index was used for comparison with the other stock exchanges. The NSE 30 Index would have been a better comparison to the JSE Top 40, CFG 25, and EGX 30. As noted above unfortunately the data are not readily available and, as previously stated, the NSE 30 was only initiated in January 2007, however daily data is not available from this starting date, and is only available from 2009, which is too late for the purposes of this study.

There are also problems with daily prices, due to non-trading holidays and noise trading. Using the most liquid indices and largest stocks should remove the majority of the issues noted above. Given the large sample size because we use daily data, it is unlikely that non-trading holidays will have major effects on the empirical findings. In an attempt to control for this further, days where none of the exchanges were open were excluded. When an exchange was not open on a day, but some or all of the other exchanges where open, the closed exchange index price was given the previous day's closing price, and this is consistent with previous studies done by Arshanapalli & Doukas (1992:197). This was felt to be more accurate than not recording an observation, as it would not lead to an accurate comparison.

The tests were run with Eviews, and the program automatically removes observations of the other exchanges when an observation for one exchange is not present. Therefore, adding a closing price from the previous days would mean more observations are compared over time and would lead to a more accurate result.

4.1.1 Issues with using indices

It is important to note than in using an index, there is always the issue of "capping". As with most indices, the maximum weighting of a stock in an index is limited. This means by using an index we are not capturing the complete movement of stocks in the movement of the index. This affects the cointegration relationships, as well as the correlations between various exchanges.

African countries have a tendency to be unstable due to political and economic unrest. This instability translates into volatile share prices and, therefore, when analysing the indices, it is difficult to draw valid conclusions. For example, the Zimbabwean stock exchange was originally included in this study as it is one of Africa's leading equity exchanges. However, because of hyperinflation, the stock exchange was closed on 18 November 2008 and the USD was adopted as the legal tender for trading in 19 February 2009 when trading reopened (Chowa, Nyanhete & Mhlanga, 2014:273). In 2011 the Egyptian stock market struggled, largely due to political unrest in the country. The market capitalisation dropped from approximately 500 billion at the beginning of January 2011 to 374 billion in March 2011 and

291 billion in December 2011 (EGX, 2013). This instability in Egypt could have further implications for the correct interpretation of the tests.

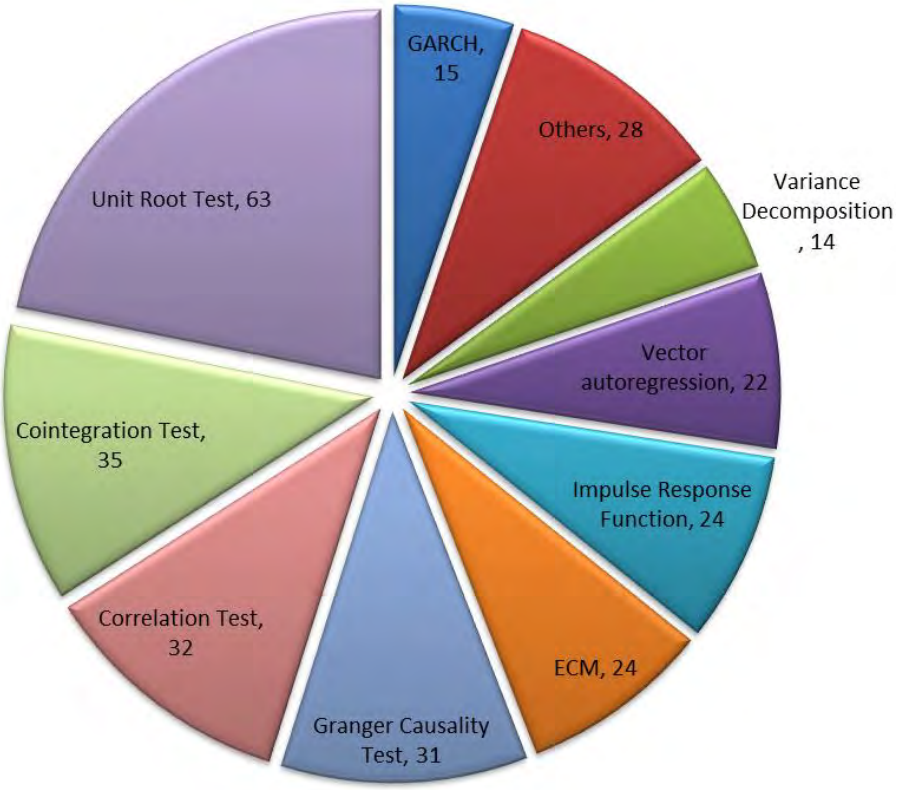
Two potential issues should be noted in relation to the daily closing prices. The first to note is that during the Egyptian revolution of 2011, from 27 January to 23 March 2011, the CASE index did not trade. In 2004, the NGSE did not trade from 4 - 15 November and from 17 -30 March 2005. There were also a couple of instances where the NGSE did not trade for five or six consecutive days during the period 2004-2006. Our analysis shows that the Egyptian revolution did have an effect on the Stationary tests run on the weekly data.

In this study the closing prices and the log of the closing prices were used to help with this lack of comparability between the indices. Previously it was noted that the log price and the closing price reveal the same results because the log is a compressed version of the time series (Alexander, 2008:141). In this study differences were found between the closing price data results and the logged data results, these are discussed in the results section.

5. RESEARCH APPROACH

The research approach used here follows the most common approach for researching stock exchange integration and its effect on diversification. Sharma and Seth (2012:109), who analysed 105 research papers on stock market integration, identified the econometric tools used most frequently in this type of research. Figure 3 below shows that the majority of the studies examined used the unit root test to test for stationarity, followed by Johansen's cointegration test, the correlation test, the Granger causality test, followed by other tests (Sharma & Seth, 2012:109).

Figure 3: Frequency of econometric tools used for data analysis



(Source: Sharma & Seth, 2012:109)

Based on their findings, the following methods of analysis, discussed below, were employed in this study: The unit root tests for stationarity, the cointegration tests (Both Engle-Granger and Johansen), the correlation tests and Granger pairwise causality tests. The tests were run on the three different data-sets. Both the Augmented Dickey-Fuller test and the Phillips-Perron unit root test were run on the weekly data. This was because there was an increased risk of stationarity because of fewer observations. The Augmented Dickey-Fuller test was run on the daily data.

5.1 Correlation

Correlation is used to test the co-movements of different indices returns in relation to each other (Alagidede et al., 2011:1334), this gives an indication of the strength and direction of the movements between the two indices. Johansen (2007:3) discuss the fact that correlation does not always mean there is a causal relationship, and thus further testing in the form of cointegration and causality is required to assess the relationship correctly.

5.2 Unit root tests for stationarity

A unit root test looks at whether a time series, such as a stock exchange index, is stationary, using an autoregressive model. The time series is stationary if the roots of its characteristic polynomial lie strictly inside the unit circle (Alexander, 2008:136). Testing for a unit root and cointegration can also determine market efficiency (Arshanapalli & Doukas, 1993:196).

The null hypothesis implies that the data need to be differenced to make it stationary, while the alternative hypothesis states that the data is stationary. We should then perform another unit root test and difference the data. If we reject the above null hypothesis, we can conclude that the series is indeed integrated of order 1, rather than having a higher order of integration (Alexander, 2008:136).

The Augmented Dickey-Fuller test and the Phillips-Perron unit root test are performed in this study. The Augmented Dickey-Fuller was performed on all data sets. If the null could not be rejected at a 10 percent level of significance a further Phillips-Perron test was run. If both found that there was stationarity, additional stationarity tests were performed.

The Augmented Dickey-Fuller test's regression includes lags to help account for serial correlation. The non-parametric Phillips-Perron test statistics can be viewed as Dickey-Fuller statistics that have been made more robust compared to serial correlation, by using the Newey-West (1987) heteroskedasticity and autocorrelation-consistent covariance matrix estimator.

5.3 Cointegration and causality

If indices are cointegration this reduces the benefits of diversification (Jefferis & Okeahalam, 1999:35). Cointegration is a measure of long term dependency between two stock exchange indices or other financial assets and is used to examine the co-movement of index prices in this paper. The null hypothesis for the cointegration tests is that the two indices are not cointegrated. Cointegration models are then constructed in two phases: The first phase examines the association of long term equilibrium between the prices of a set of indices.

The Engle-Granger methodology performs an ordinary least square (OLS) regression of one integrated variable on the other integrated variables, and is used in this study to determine the extent of cointegration. A set of integrated indices are cointegrated if there is a linear combination of these series that is stationary (Engle & Granger, 1987:251); (Alexander, 2008:136), even though the individual indices are non-stationary (Ashanapalli & Doukas, 1993:196). The Johansen test is a vector autoregression (VAR) based cointegration test using the methodology developed in Johansen (IHS Global Inc., 2013:849).

The second phase of the Engle-Granger cointegration model is called an error correction model (ECM) which is based on linear regression analysis of returns (Alexander, 2008). The Johansen cointegration test applies the same principle using a Vector ECM (VECM) (Piesse & Hearn, 2002:1715). Correlation informs us about any lead-lag behaviour between returns, and is a short term measure of these returns. The ECM or VECM can be interpreted as the movement in one index is due to the movement from another index, and a prior period error, which is a proxy for a long run movement due to past disequilibrium (Ashanapalli & Doukas, 1993:196).

Finally, once the ECM has been defined, it may to be used to test the Granger causality flows. Granger causality measures the lead-lag relationship between the two indices (Alexander, 2008:246). The Granger causality test in essence runs two tests: The first checks whether there is a predictive relationship between the two indices and the second tests whether one index causes the movement in the other index (Collins & Biekpe, 2003:293).

5.4 Dollarization

This research aims to give insight into the benefits of diversification. Therefore, in addition to the normal test preformed, the tests have also been run using the various indices priced in USD, with the primary purpose of showing a real return from a USD perspective. We use the USD because, as a country's currency weakens, *ceteris paribus*, the value of stocks should increase as it has become cheaper to foreign investors, thus pushing up the value of the indices. By dollarizing these amounts, however, we remove this effect, because as the currency devalues and stocks go up, a dollarized index would remain constant. In the correlation results below, in period 5, there is a 46.6 percent correlation between South Africa and the USA. However, when the JSE Top 40 is dollarized, the correlation becomes 60.4

percent. In the weekly data there is also a significant difference, as the correlation in period 3 is 63.9 percent, while the dollarized JSE Top 40 has a 71.9 percent correlation.

A study by Dimson, Marsh and Staunton (2006) illustrates the importance of dollarization. In their study they find the annualised returns of South Africa and the USA to be 7.25 percent and 6.52 percent for the period 1900 to 2005 (Dimson, Marsh, & Staunton, 2006:48). However in the same study, when the effects of currency movements are taken into account in the annualised returns, the returns are adjusted to show South Africa and the USA to be 5.38 percent and 5.51 percent. From the above it can be seen that looking at annualised returns using different currencies seems to show that investing in South Africa offers a better return that investing in the USA. However, when they are displayed in the same currency, it appears investing in the USA offers a better return than investing in South Africa. Removing the currency effect is thus important when looking at the benefits of diversification. In the study by Graham et al. (2013:91) of global and regional co-movement of the MENA stock exchanges, they state that, given that the oil countries have forex reserves to counter currency fluctuations, exchange rate movements would not contaminate the co-movement results for the sample countries. Three out of the four countries being examined in this study do not try counter currency fluctuations. Nigeria, on the other hand, does not allow its currency to float freely. This should be considered when examining the cointegration results for Nigeria, but this should not affect the results from the other three countries.

The USD is currently the global reserve currency, and this makes it useful as an international measure of value. The USD is often used for pricing of resources and conducting of business across Africa. The main objective of this study is to test whether African exchanges move together in the short term (correlation), long term (cointegration), and in which order they move (causality). We do not go into detail about the various factors that could cause this movement. However, in an attempt to make our findings more relevant, we include an additional test measuring the indices prices in USD. The objective of this is to make the results more relevant to a potential investor wanting to diversify his portfolio across Africa, by using the USD as a fixed point of reference. It would be extremely difficult to make a conclusion about relative movements without having to look at the individual countries, their, inflation and interest rates, to determine a "real" movement. There are many factors in each country which could have an effect on the indexes and it would be naïve to think dollarizing could take all of these into account. However, given that currency movements are also

theoretically a function of interest rates and inflation, dollarizing the indices takes into account both inflation and interest rates, although imperfectly.

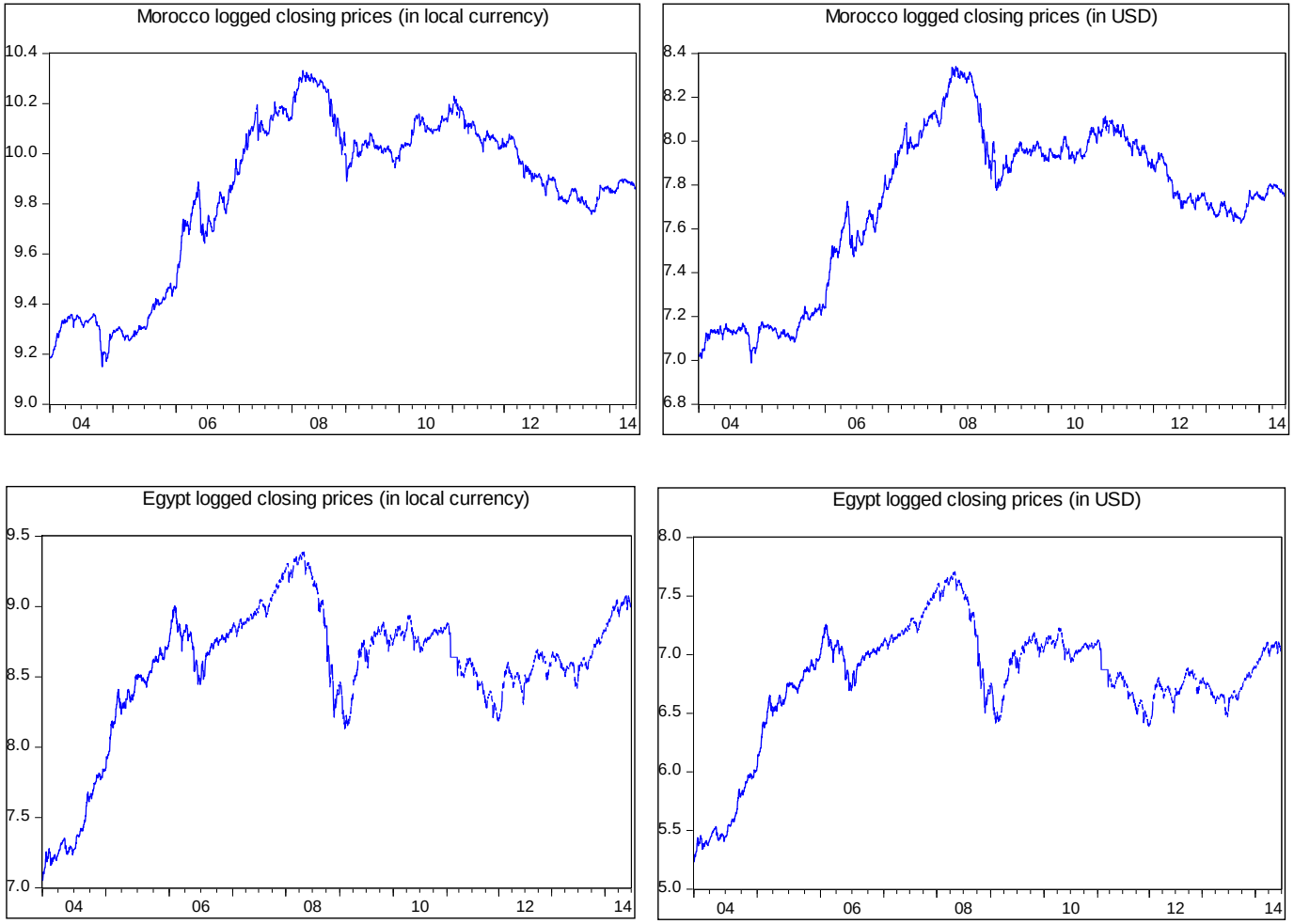
Over the medium to long term one would expect currency movements to be a fairly accurate reflection of interest and inflation. This is not a perfect strategy, as currency movements are often over-exaggerated and unpredictable, and, as noted in the case of Nigeria, might not float freely. Using dollarized prices would make the findings of this study more relevant and useful to foreign investors. In order to dollarize the data, we took the daily closing index prices quoted in USD. Monthly dollar prices have also been used in past studies, such as those by Alagidede et al. (2011), Agyei-Ampomah (2011), and, Jefferis and Okeahalam (1999).

6. RESULTS

Below see the results of this study, including graphical representations of the various indices, the results of correlation, unit root, cointegration, and causality tests run on the logged daily closing data in both local currency and USD, followed by the unit root, cointegration, and causality tests run on the weekly logged data in both local currency and USD.

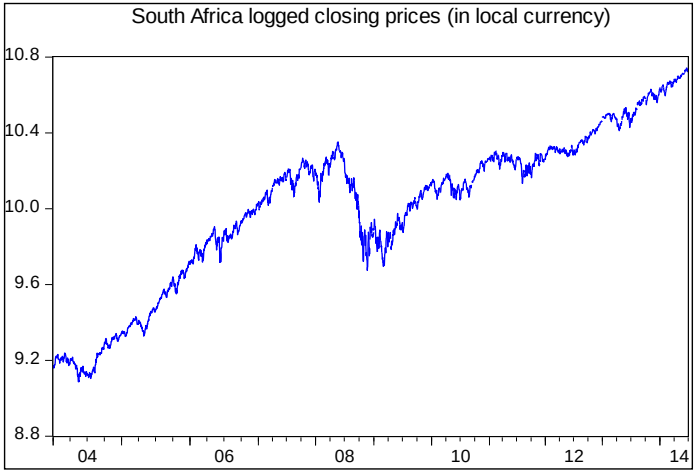
6.1 Logged closing prices

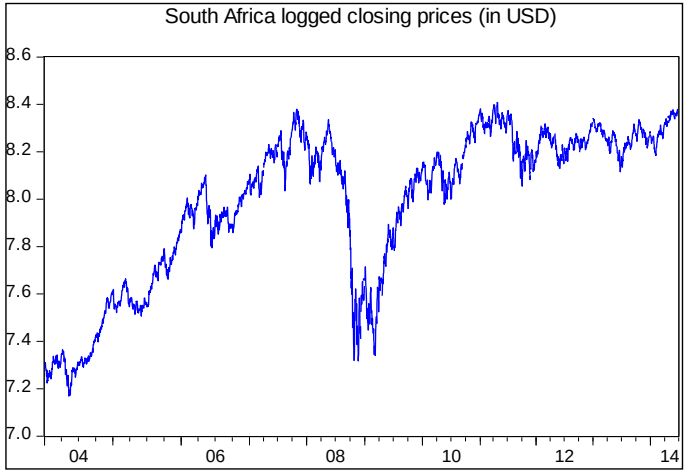
Figure 4: Below shows the logged closing prices of the indices in USD and local currency (y- axis); EGX 30, the CFG25, the NGSE, JSE Top 40 and the S&P 500 indices over time (x- axis).

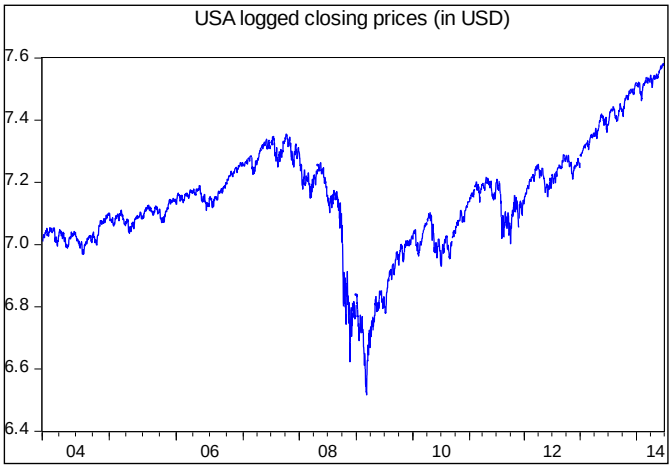



Nigeria logged closing prices (in local currency)
11.2
11.0
10.8
10.6
10.4
10.2
10.0
9.8
04
06
08
10
12
14


Nigeria logged closing prices (in USD)
6.4
6.0
5.6
5.2
4.8
4.4
04
06
08
10
12
14


South Africa logged closing prices (in local currency)
10.8
10.4
10.0
9.6
9.2
8.8
04
06
08
10
12
14


South Africa logged closing prices (in USD)
8.6
8.4
8.2
8.0
7.8
7.6
7.4
7.2
7.0
04
06
08
10
12
14



The sharp decrease in prices in 2008 shows that the 2007-2008 financial crisis had a major effect on all four African exchanges. Morocco's results seem to indicate that they fared better than the other African stock exchanges during the crises period, with a much smaller percentage decline in the index value. The primary reason for this could be that foreign investors accounted for a small proportion of the market (Samedi, 2009).

The crisis period was followed by periods of high volatility after the crisis, which is likely an effect of the general global economic instability after the crisis. It is also interesting to note that none of the countries have recovered in USD terms or in local currency terms to their highs, other than South Africa in local currency terms. One can also see the effect of the Egyptian revolution at the beginning of 2011. After its initial recovery, the Egyptian stock exchange plummeted in capitalisation from 504 billion on 13 January 2011 to 290 billion on 28 December 2011 (WFE, 2015). The EGX had to close on the 27 of January 2011 after the EGX 30 Index plunged 14.5 percent in the two preceding trading days. The exchange reopened on the 23 of March 2011, but the economic outlook of the country was still uncertain at that time.

As can be seen in Figure 4, above, recovery has been much more significant in the USA than in African countries. In 2009 and 2010, Egypt and South Africa recovered with an increasing trend, whereas Nigeria and Morocco did not make a healthy recovery. In 2009, the Moroccan stock exchange briefly surpassed that of Egypt to become the second largest on the continent during this period. In local currency the South African graph looks similar to that of the USA,

with a steady increase until the end of June 2014. The figures for the other countries in local currency look very similar to the USD graphs.

The stationarity tests in this study showed that in USD terms the JSE Top 40 was stationary for the period 1 July 2011 to 30 June 2014. The difference between the closing prices in USD and in local currency could possibly be explained by the devaluation of the Rand to the USD during this period, this has not been examined further in this study.

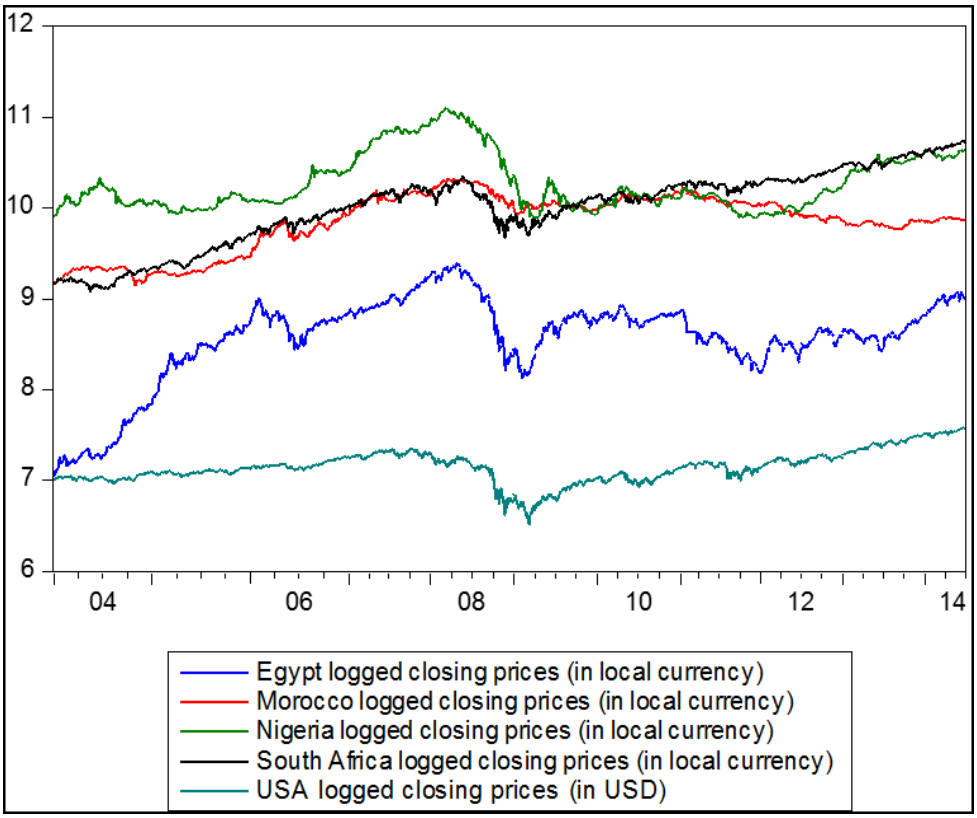
The unrest in North Africa and the Middle East also affected Morocco's economy, which showed a bull market until early 2011 and then went into a steady decline. The CSE dropped steadily as investors feared possible disruptions to the economy and the possibility of future violent protests.

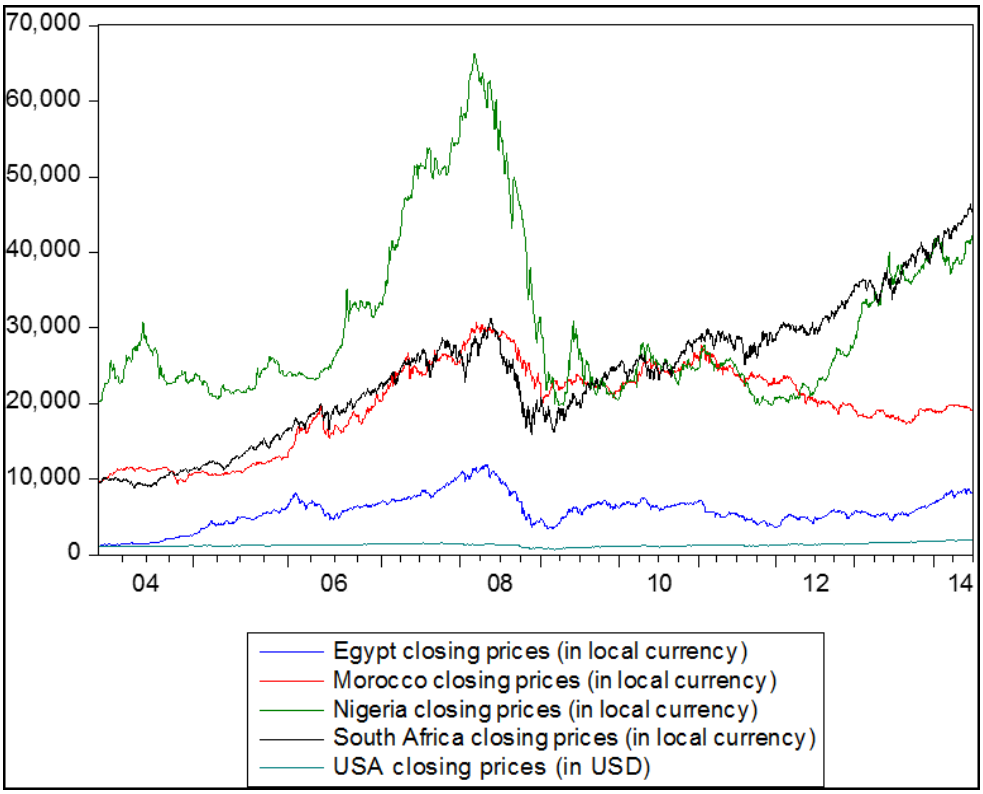
Nigeria seems to have taken the longest to recover from a financial crisis of the countries studied, and it remained highly volatile without sufficient recovery until the end of 2012. The NSE was not only affected by the global crisis but by other factors. These include ineffective market regulation, poor corporate governance and inefficiency. Another factor could have been the banking crisis in Nigeria from 2008 - 2009. By the end of 2009, 10 Nigerian banks, approximately a third of the banking system assets, were either underfunded or insolvent. The Nigerian banking sector represents approximately 53.6 percent of the country's GDP (International Monetary Fund [IMF], 2013:7).

In September 2011 Asset Management Corporation of Nigeria purchased all the non-performing loans (NPL's) to recapitalise the restructured banks. This seems to have marked the start of an improvement in investor confidence, as it coincided with the start of the upturn in the market shown on the graph above (IMF, 2013:4).

The remainder of this analysis separates findings on the logged and unlogged data. Logging the dataset compresses the respective movements in the indices into a narrow range, making datasets with different bases more comparable. This can clearly be seen Figure 5 below.
This figure shows all four indices in their local currency before and after being logged. One would expect that the cointegration relationships would not change significantly in this process. However, as discussed below, it is clear that logging the data does have an effect on the relationships found.

Figure 5: Logged and Unlogged Index closing prices (y-axis) in local currency over time (x-axis)





6.2 Stock Market Linkages – Correlation on logged daily closing price returns

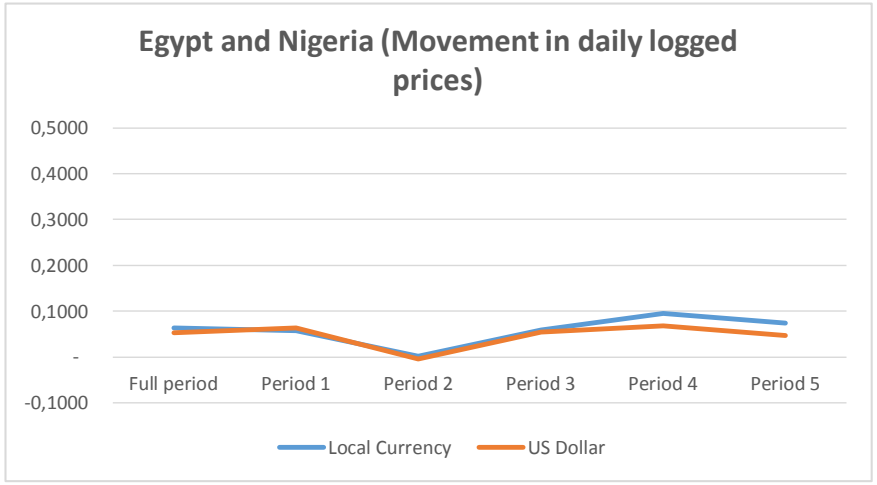
Starting with the logged data the correlation results between the different countries in this study have been shown in Appendix 8.2, in detail. The figures below show the correlations found between the four African countries and the USA over the periods under review. Correlation tests were run on the returns of the various indices. Each graph shows the correlation coefficients, firstly for the full period and secondly the periods of interest, periods 1 to 5.

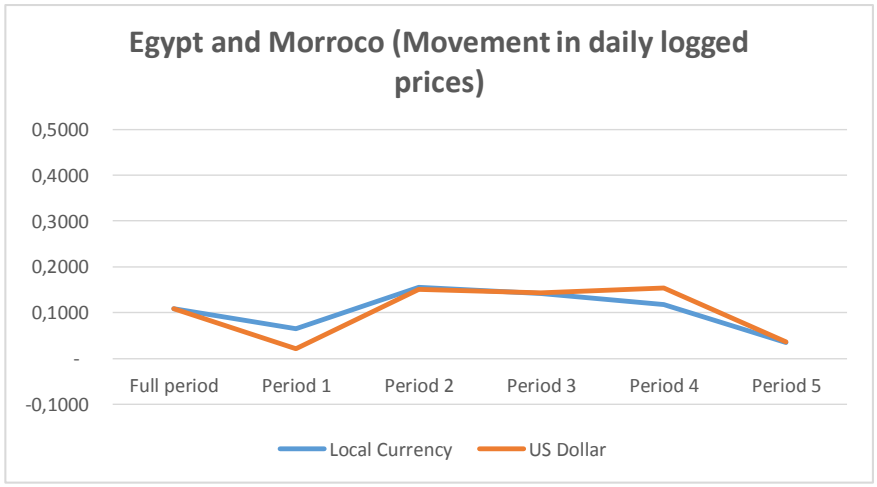
As can be seen below there is very little correlation between Egypt and the other African exchanges or the USA. The highest correlation is found between South Africa and Egypt in period 3 and even this is below 0.3. The graphs above would suggest there are significant potential benefits from investing in Egypt to reduce portfolio risk, even during the crisis period, period 3. The results do not show increasing correlation over time, although the highest correlation between Egypt and the other countries show in periods 3 and 4.

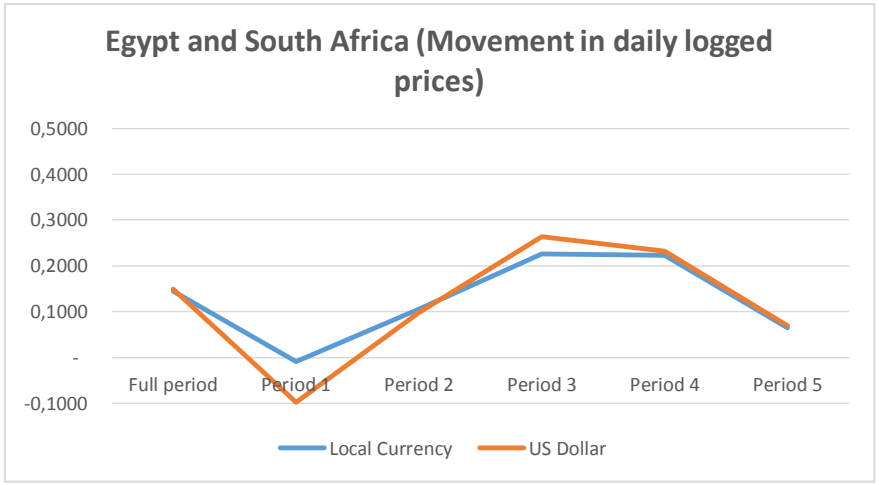
Morroco also presents such an opportunity for diversification, as one can see below in Figure 6. The correlation between Egypt and Morocco, and Egypt and Nigeria does not exceed 0.2, throughout the tested period in either local currency or USD terms. This finding supports the finding of Graham et al. (2012:44) and Graham et al. (2013:92).

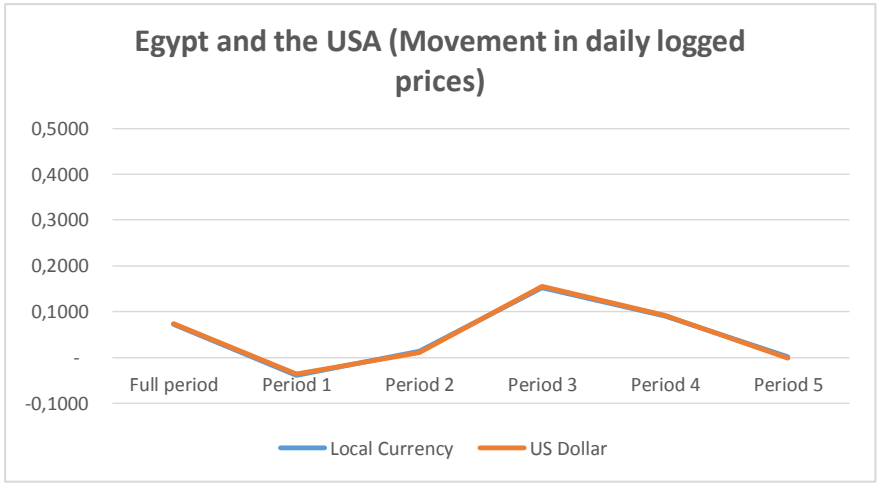
In local currency terms the correlation between Morocco and the USA or South Africa is also very low over the period tested. When exchange prices and thus price movements are converted to USD the relationship changes significantly, showing that the correlation increases in the later periods of the study, from the crisis period onwards. This could suggest that Morocco, as with South Africa and the USA, is considered more integrated with the global economy.

Figure 6: Correlation (y-axis) relationships between Egypt and the other indices over time (x-axis)



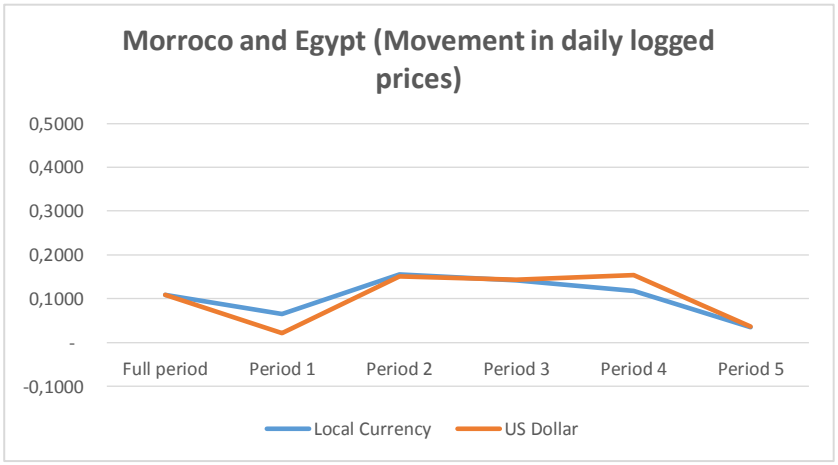


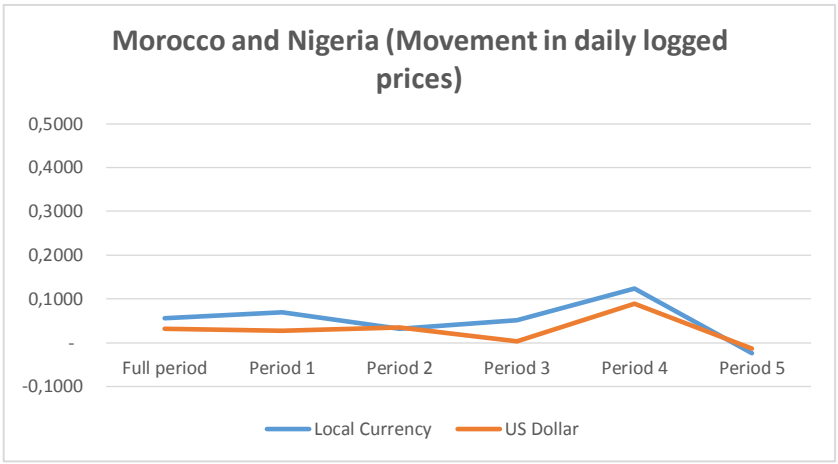


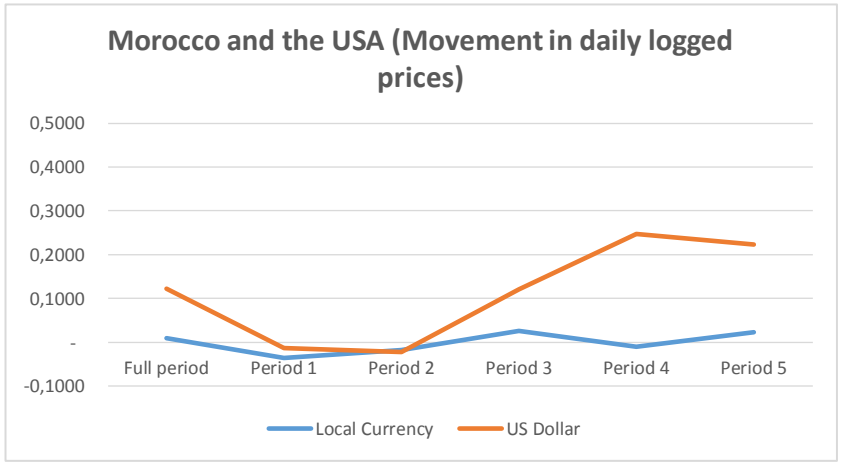


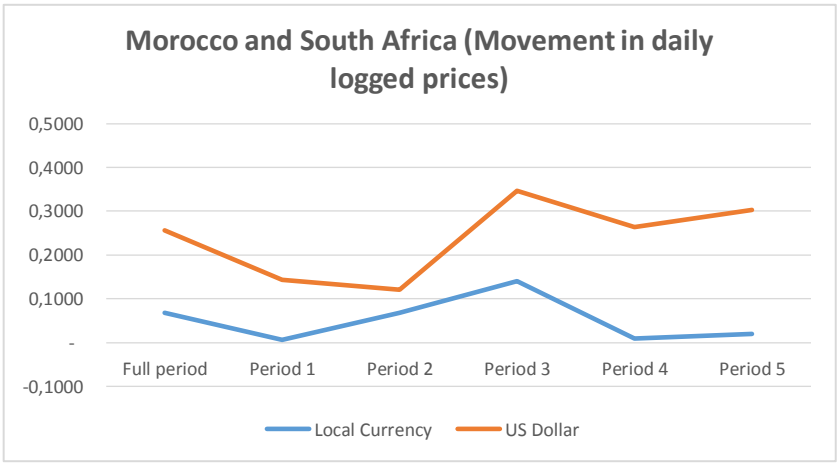
Period Key : Full period 1 Jan 2004 – 30 June 2014; Period 1: 1 Jan 2004 – 31 Dec 2005; Period 2: 1 Jan 2006 – 30 Sep 2007; Period 3: 1 Oct 2007 – 30 Apr 2009; Period 4: 1 May 2009 – 30 Jun 2011; Period 5: 1 Jul 2011 – 30 June 2014

Figure 7: Correlation (y-axis) relationships between Morroco and the other indices over time (x-axis)



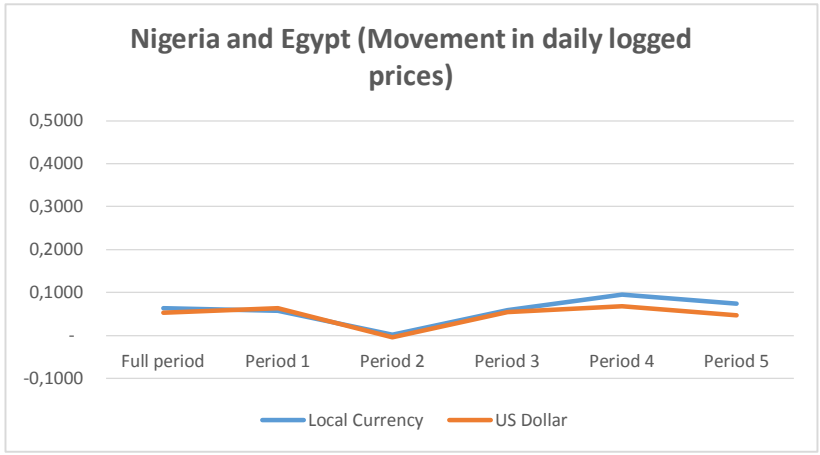


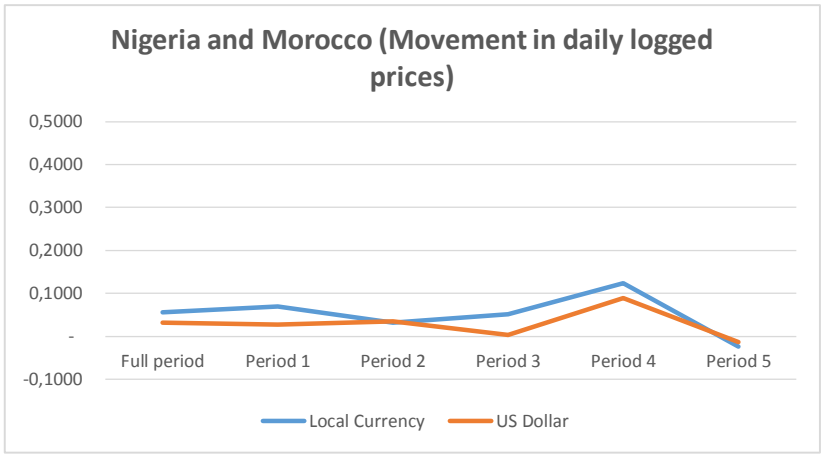


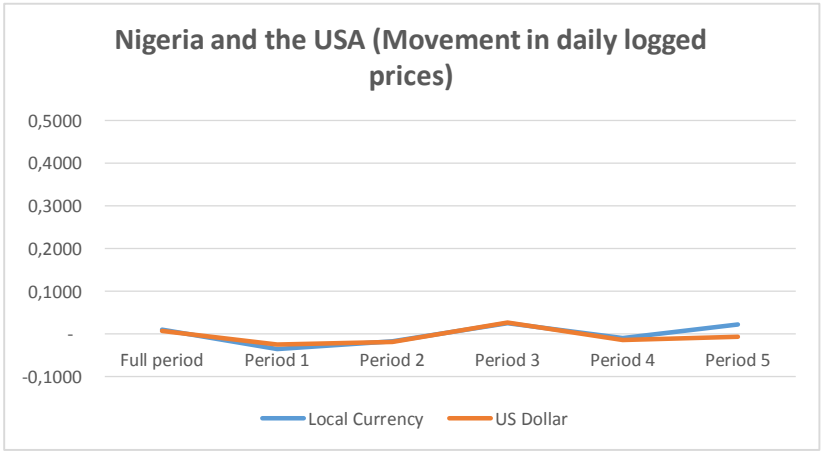


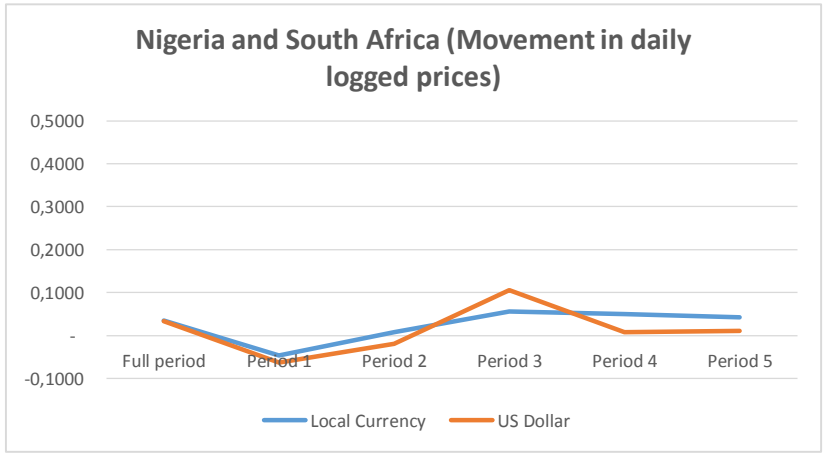
Period Key : Full period 1 Jan 2004 – 30 June 2014; Period 1: 1 Jan 2004 – 31 Dec 2005; Period 2: 1 Jan 2006 – 30 Sep 2007; Period 3: 1 Oct 2007 – 30 Apr 2009; Period 4: 1 May 2009 – 30 Jun 2011; Period 5: 1 Jul 2011 – 30 June 2014

Figure 8: Correlation (y-axis) relationships between Nigeria and the other indices over time (x-axis)









Period Key : Full period 1 Jan 2004 – 30 June 2014; Period 1: 1 Jan 2004 – 31 Dec 2005; Period 2: 1 Jan 2006 – 30 Sep 2007; Period 3: 1 Oct 2007 – 30 Apr 2009; Period 4: 1 May 2009 – 30 Jun 2011; Period 5: 1 Jul 2011 – 30 June 2014

Nigeria's result, from Figure 8 above, appears to offer the best results for obtaining diversification benefits, with very low correlation and sometimes negative correlation with the other exchanges, even during the crisis period. The above trend does not show the correlation increasing over time, and local currency or USD results are fairly similar. This would, however, be expected, as the Nigerian Naira is not free floating and linked to the USD.

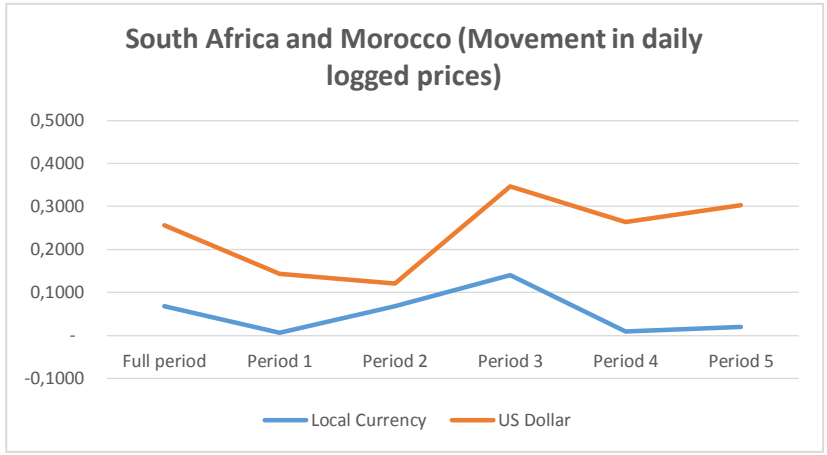
South Africa appears to have the highest correlation with the other markets in this study. The correlation with the USA shows a clear trend that the correlation in stock market movements increases over time from 2004 to 2014.

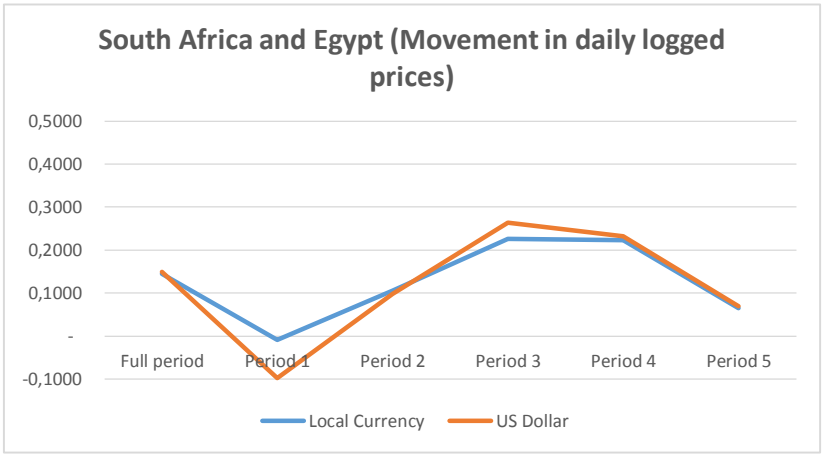
Something to note from Figure 9 below, is that, between South Africa and the USA or South Africa and Morocco, the correlations in local currency and USD appear to diverge in periods 4 and 5. This is a trend that was noted in discussions with global investment analysts as an "emerging market phenomenon" (Wales, personal communication 2015, June 17). This paper does not explore this further, but this could be an area for further research.

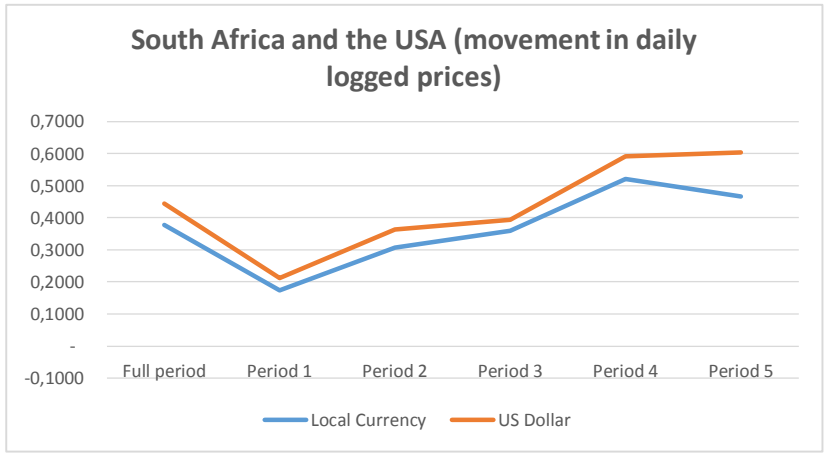
The correlation between South Africa and the USA exceeds 0.6 from late 2009 onwards, which would suggest limited opportunity for diverisification from a US perspective. However, as noted above, the other African exchanges and South Africa do not appear to be highly correlated, and investing across the four exchanges in this study would be assumed to give diversification benefits.

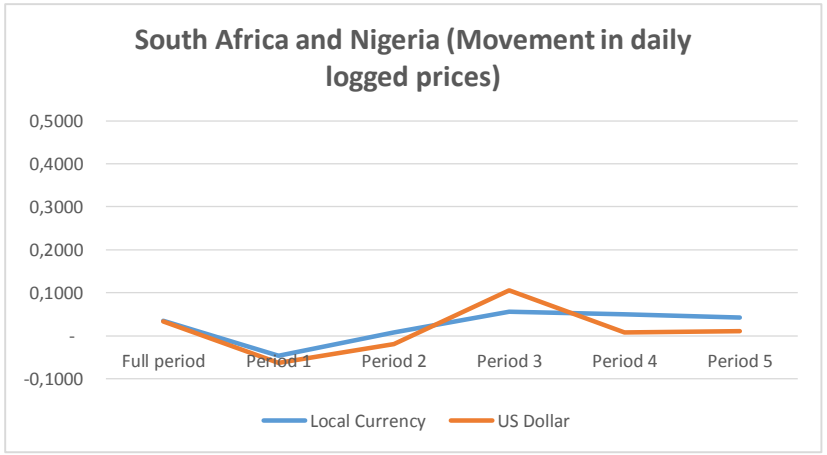
However correlation relationships are short term relationships and consistently low correlation relationships are identified in the above results. This suggests there are short term benefits but not necessarily long term benefits to diversification, and the cointegration results should shed more light on this.

Figure 9: Correlation (y-axis) relationships between South Africa and the other indices over time (x-axis)









[6] Period Key : Full period 1 Jan 2004 – 30 June 2014; Period 1: 1 Jan 2004 – 31 Dec 2005; Period 2: 1 Jan 2006 – 30 Sep 2007; Period 3: 1 Oct 2007 – 30 Apr 2009; Period 4: 1 May 2009 – 30 Jun 2011; Period 5: 1 Jul 2011 – 30 June 2014

The general theory is that, during a financial crisis, correlations among stock markets tend to grow (Sandoval & Franca, 2012:200). Thus diversification is very unhelpful during a crisis and that a concentrated portfolio would do perfectly well. This indicates that passive investment would be seen as relatively successful during a crisis. The correlations in the above tables in respect of all four countries do show slight increases during the crisis period (period 3). However, the correlation relationships are still generally weak.

Correlation coefficients provide some insight into the inter-linkages between the markets but they are only static measures. Consequently, they do not illustrate the dynamic relationships between the markets.

6.3 Tests performed and test results for daily logged closing price data

Unit root testing is a prerequisite for testing cointegration between the stock exchanges. The implication of cointegration is that, individually, the series may be non-stationary, while their linear combination may be stationary (IHS Global Inc., 2013:263).

As the indices are all non-stationary (i.e., I(1)), the cointegration tests illustrate that there are long term associations between the movements in the stock exchanges' price indices (Jefferis & Okeahalam, 1999:35). Thus below the test results begin with the unit root test results followed by the cointegration and Granger causality tests.

6.3.1 Unit root tests on daily logged closing price data

Table 1: Unit root tests results using the Augmented Dickey-Fuller (ADF) unit root test

Augmented Dickey-Fuller test results												
	Full period		Period 1		Period 2		Period 3		Period 4		Period 5	
Daily logged data	T-stat	Prob	T-stat	Prob	T-stat	Prob	T-stat	Prob	T-stat	Prob	T-stat	Prob
Egypt local	-3.1159	0.0255	-0.5157	0.8854	-0.6959	0.8454	-0.5601	0.8762	-2.3756	0.1491	-0.3303	0.9178
Egypt USD	-3.1785	0.0214	-0.4317	0.9011	-0.5691	0.8744	-0.5249	0.8834	-1.8493	0.3566	-0.8789	0.7950
Morocco Local	-2.2054	0.2045	-1.0964	0.7190	-1.7473	0.4069	-0.5652	0.8751	-1.6988	0.4314	-1.6312	0.4661
Morocco USD	-2.0165	0.2799	-1.9060	0.3296	-1.5955	0.4842	-0.4371	0.8999	-2.4567	0.1268	-2.2420	0.1916
Nigeria Local	-1.2830	0.6397	-2.2646	0.1840	-0.1797	0.9383	0.6113	0.9900	-2.7821	0.0614	0.5355	0.9879
Nigeria USD	-1.2491	0.6551	-2.3532	0.1557	-0.1288	0.9442	0.9803	0.9964	-2.7027	0.0740	0.4677	0.9856
South Africa local	-1.1769	0.6866	0.5547	0.9884	-1.0409	0.7399	-0.9802	0.7615	-2.4495	0.1287	-0.2249	0.9327
South Africa USD	-2.1425	0.2281	-0.1296	0.9442	-1.3274	0.6182	-1.0949	0.7193	-2.3322	0.1621	-3.5296	0.0075
USA	-0.8387	0.8075	-1.6368	0.4632	-1.0448	0.7385	-0.8875	0.7920	-1.8949	0.3348	-0.0678	0.9509

Notes: Critical values of ADF are -2.86 at a 5% level and -3.44 at a 1% level (see MacKinnon, 1996). Lag length for ADF based on Schwartz information criterion.

Egypt in both local currency and USD was found to be stationary at a 5% level over the full period, and South Africa in period 5 in USD was found to be stationary at a 1% level of significance.

Where we could not reject the null hypothesis at a 10 percent level of significance, a further Phillips-Perron unit root test was performed as an additional test for robustness. Thus for Nigeria in period 4 in local currency and USD, Phillips-Perron unit root tests were performed and the results are presented below.

Table 2: Phillips-Perron unit root tests results for Nigeria in period 4

Phillips-Perron test results		
Daily logged data	Period 4	
	T-stat	Prob
Nigeria Local	-1.1791	0.6854
Nigeria USD	-1.0562	0.7346

Notes: Critical values of PP are -2.86 at a 5% level and -3.44 at a 1% level (see MacKinnon, 1996).

No further testing was deemed required as both ADF and PP at a 5 percent level cannot reject the null hypothesis that there is a unit root. The null hypothesis was rejected at a 5 percent level for Egypt over the full period, as well as South Africa in USD in period 5. The following tests were therefore performed, with the results shown in Table 3: Phillips-Perron, Elloitt-Rothenberg Stock DF, Kwiatkowski-Phillips-Schmidt-Shin, Elloitt-Rothenberg Stock and Ng-Perron tests.

Table 3: Summary of results of the additional unit root tests run, were stationary was found at a 5% level using the Augmented Dickey-Fuller unit root test

	Augmented Dickey-Fuller test	Phillips-Perron test statistic	Elliott-Rothenberg-Stock DF-GLS test statistic	Kwiatkowski-Phillips-Schmidt-Shin	Elliott-Rothenberg-Stock test statistic	Ng-Perron test statistics
Egypt - Local (Full period)	S	S	U	S	U	U
Egypt - USD (Full period)	S	S	U	S	U	U
USD (Period 5)	S	S	S	S	SU*	SU*

Note: S – Test found the sample exhibited stationarity at a 5% level of significance.
U – Tests found sample had a unit root at a 5% level of significance.
SU - Tests found sample had a unit root at a 10% level of significance, but not at a 5% level.

For the full test results of the additional unit root tests please refer to Appendix 8.3.
As can be seen above it was found that South Africa in USD, in period 5, was found to be stationary at a 5 percent level of significance. There were conflicting results from the unit root tests for Egypt over the full period, in both USD and local currency. Given that this study assesses long term and short term relationships and changes over time, cointegration tests have been performed on the data. However, the results for periods where stationarity was found are not reliable and this has been noted in the discussion below.

As noted above, the Egyptian stock exchange indices did not trade for almost two months in 2011, which is possibly the reason for Egypt having a stationary issue. Other stationarity tests were run to confirm this, and three out of the six tests conducted found the data to be non-stationary.

The results of all 5 tests found South Africa in period 5 in USD to be stationary. In Figure 4 it can be seen that, over the past three years the JSE Top 40 has been fairly flat. The likely reason for this is the steady decline of the Rand value to the dollar from 2011 to 2014. The dollarized JSE Top 40 index tends to stay close to the mean which confirms the finding that the data is stationary. When interpreting the results from the cointegration tests this has been taken into consideration.

6.3.2 Cointegration and causality test results on logged daily closing price data

As noted above, both the Engle-Granger (Table 4) and Johansen Cointegration tests (Table 5) were performed on the logged daily closing prices. If a relationship was noted, a further Pairwise Granger Causality test (Tables 4, 5 and 6) was run to assess the direction of the relationship.

The daily returns on the logged closing prices of the indices were used in the pairwise Granger causality tests presented herein. The null hypothesis states that the one index does not Granger cause the other index. This hypothesis is rejected at a 95 percent significance level. This means that rejection of the null will take place for a p-value of less than 5 percent. A lag of 2 was preferred for the causality tests.

Table 6 show the cointegration and causality relationships when the results from the Engle-Granger and Johansen test results are combined. Only when both tests reject their respective null hypotheses was a cointegration result represented.

Table 4 below shows that South Africa in USD was found to have a cointegration with all other countries in period 5 and in Table 3 was found to be stationary in this same period. Thus one should read the results in conjunction with the Johansen tests below as well as the relationships found in local currency terms for this same period. It should also be noted firstly that no cointegration relationships were found over the full period using the Engle-Granger tests (table 4). However, a couple of instances of cointegration over the full period were found when the Johansen cointegration tests (table 5) were run.

Table 4 below shows that, for the majority of these pairings, the test fails to reject the null hypothesis and therefore there is no cointegration relationship. A similar result is seen in the study by Alagidede et al. *(*2011:1338).

Table 4: Results from Engle-Granger cointegration tests and pairwise Granger causality tests for all periods in both local currency and USD

Cointegration findings in local currency

	Egypt	Morocco	Nigeria	South Africa	USA
Egypt					
Morocco					
Nigeria					
South Africa	3	2	2		
USA	1	2		1,2,4,5	

A Pairwise Granger Causality test was run to try further understand the cointegration relationships identified above. The results of the Pairwise Granger causality tests are as follows:

Egypt causes the USA (1)
South Africa causes the USA and vice versa (1,2,4)
Morocco causes South Africa and vice versa (2)
Morocco causes the USA and vice versa (2)
Nigeria causes South Africa (2)
South Africa causes Egypt (3)
The USA causes South Africa (5)

Cointegration findings in USD

	Egypt	Morocco	Nigeria	South Africa	USA
Egypt					
Morocco					
Nigeria					
South Africa	2,3,5	2,5	5		
USA	1	2		1,3,5	

A Pairwise Granger Causality test was run to try further understand the cointegration relationships identified above. The results of the Pairwise Granger causality tests are as follows:

Egypt causes the USA (1)
South Africa causes the USA and vice versa (1,3,5)
South Africa causes Egypt (2,3)
South Africa causes Morocco (2)
Morocco causes the USA and vice versa (2)
Egypt causes South Africa (5)
No pairwise was found for Morocco and South Africa (5)
South Africa causes Nigeria (5)

Note: The different time periods are represented by the numbers 1-5 and the letter "f". "f" represents the full period, and numbers "1,2,3,4,5" represents the different respective periods. The different numbers and "f" are only shown in the table when the null hypothesis for the Engle-Granger cointegration tests is rejected. The null hypothesis states that the pair of stock exchanges is not cointegrated at a five percent significance level. If a Granger causality relationship was found the direction is shown by means of which Country "causes" the other. The number in brackets denotes the period to which the causality relationship relates.

[7] Period Key : Full period: 1 Jan 2004 – 30 June 2014; Period 1: 1 Jan 2004 – 31 Dec 2005; Period 2: 1 Jan 2006 – 30 Sep 2007; Period 3: 1 Oct 2007 – 30 Apr 2009; Period 4: 1 May 2009 – 30 Jun 2011; Period 5: 1 Jul 2011 – 30 June 2014

Table 4 – Engle-Granger cointegration and Granger causality results discussion

From table 4 above there are three observations to note. Firstly, in period 2, which is in the boom before the crisis period, there are a large number of cointegration relationships in local currency and mainly with South Africa, where South African is seen to be led by the other countries. Other than the USA and Egypt, a cointegration relationship was found in either local currency or USD in period 2 between all of the countries involved in this study.

Secondly, in local terms South Africa and the USA are cointegrated throughout the study but not in period 3, which is the crisis period. In USD terms this relationship is different, in that there is cointegration in the crisis period but not in period 2 (pre-crisis). Reading these results together implies there is a fairly continuous cointegration relationship been South Africa and the USA over the entire period.

Thirdly, in USD terms Egypt and South Africa can be seen to exhibit a continual cointegration relationship , apart from in period 4 (the Egyptian revolution), as South Africa and Egypt were found to be cointegrated in all other periods, from 1 January 2006. One major concern would be the stationarity of South Africa in period 5. The fact that a different result was obtained from that of Alagidede et al. (2011), could be because more recent data were used in this study. Several studies have shown that the linkages among stock markets have increased over time, and this could also be relevant to South Africa and Egypt.

The other reason for the cointegration between these countries may be that South Africa and Egypt are, respectively, the largest and second largest stock exchanges in Africa. It would thus be fair to assume that they would be more influenced by global interactions than the other stock exchanges. Moreover, it is likely that these markets would thus behave similarly, and that they would therefore interact. The financial crisis seems to have had a slight impact on the cointegration relationships but not significant enough to be meaningful. Other African stock markets appear to respond more to local information than to global events, indicated by the fact that there were very few cointegration relationships during the crisis period.

When examining the causality results in local currency there is no clear directional relationship between any of the African exchanges. When looking at the causality results in

USD, it can be noted that South Africa seems to be leading the other African markets (excluding in period 5, where South Africa was found to be stationary).

Table 5 – Johansen cointegration and Granger causality results discussion

Once again South Africa in USD shows a cointegration relationship with all the countries, with the exception of the USA in period 5, where it was found to be stationary. With regard to the cointegration between Egypt and Morocco over the full period it is important to note there were conflicting results concerning whether Egypt has a unit root or was stationary. This relationship was not found between Egypt and the other countries over the full period, and this seems to confirm that there was a relationship between Egypt and Morocco over the full period.

During the post-crisis period, South Africa also appears to be integrated with the USA in both USD and local currency terms. Egypt was found to be cointegrated with Nigeria and Morocco in period 4 in local currency terms. Period 4 is the period in which the Egyptian revolution occurred. It also appears from the pairwise test that Egypt caused the movement in the other two exchanges. This also supports past studies which show that stock markets in the MENA region tend to display short term cointegration relationships (Graham et al., 2013:92) (Yu & Hassan, 2008:492).

When examining the causality relationships using the Johansen Cointegration test, the nature of the causality relationships differs significantly from that found in the Engle-Granger results. When the tests are run in USD, it appears that the USA and Egypt exert the most causality on the other exchanges. In local currency the USA again appears to lead the African markets.

Table 5: Results from Johansen cointegration tests and pairwise Granger causality tests for all periods in local currency and USD

Cointegration findings in local currency

	Egypt	Morocco	Nigeria	South Africa	USA
Egypt					
Morocco	f,4				
Nigeria	3,4				
South Africa		2			
USA			f,3	4	

A Pairwise Granger Causality test was run to try further understand the cointegration relationships identified above. The results of the Pairwise Granger causality tests

Egypt causes Morocco (f,4)
The USA causes Nigeria and vice versa (f)
Morocco causes South Africa and vice versa (2)
USA causes South Africa and vice versa (4)
Egypt causes Nigeria (3,4)
USA causes Nigeria (3)

Cointegration findings in USD

	Egypt	Morocco	Nigeria	South Africa	USA
Egypt					
Morocco	f,4				
Nigeria	3				
South Africa	5	5	3,5		
USA			f,3	4	

A Pairwise Granger Causality test was run to try further understand the cointegration relationships identified above. The results of the Pairwise Granger causality tests

Egypt causes Morocco and vice versa (f)
The USA causes Nigeria and vice versa (f)
The USA causes South Africa and vice versa (4)
Egypt causes South Africa (5)
Egypt causes Nigeria (3)
South Africa causes Nigeria (3,5)
USA causes Nigeria (3)
Morocco causes Egypt (4)
No Pairwise relationship was found for Morocco and South Africa (5)

Note: The different time periods are represented by the number 1-5 and the letter "f". "f" represents the full period, and numbers "1,2,3,4,5" represents the different respective periods. The different numbers and "f" are only shown in the table when the null hypothesis for the Johansen cointegration tests is rejected. The null hypothesis states that the pair of stock exchanges is not cointegrated at a five percent significance level. If a Granger causality relationship was found the direction is shown by means of which Country "causes" the other. The number in brackets denotes the period to which the causality relationship relates.

[8] Period Key : Full period 1 Jan 2004 – 30 June 2014; Period 1: 1 Jan 2004 – 31 Dec 2005; Period 2: 1 Jan 2006 – 30 Sep 2007; Period 3: 1 Oct 2007 – 30 Apr 2009; Period 4: 1 May 2009 – 30 Jun 2011; Period 5: 1 Jul 2011 – 30 June 2014

Table 6 – Combined Engle-Granger and Johansen Cointegration and Granger Causality results discussion

In USD terms, when the results are combined (Table 6 below), we can see that the stationarity of South Africa in USD has a significant effect on the cointegration relationships in both tests, and thus the results of the tests cannot be relied on.

In local currency we find two cointegration relationships. South Africa and USA in period 4, which is post crisis, and Morocco and South Africa in period 2, pre-crisis. It is interesting to note no relationships were found during the crisis period itself. This could be explained by the fact that Africa stock markets other than South Africa tended to "crash" at different times which would support the lack of cointegration found. A reason for the relationship between Morocco and South Africa could be because they have a similar resource based market, this may have given rise to the pre-crisis relationship.

From the below results (table 6) it would appear there is no clear causality relationship that extends beyond single periods.

Table 6: Results where both the Johansen and Engle-Granger cointegration tests found a cointegration relationship, as well as the Granger causality tests, for all periods

Cointegration findings in local currency

	Egypt	Morocco	Nigeria	South Africa	USA
Egypt					
Morocco					
Nigeria					
South Africa		2			
USA				4	

A Pairwise Granger Causality test was run to try further understand the cointegration relationships identified above. The results of the Pairwise Granger causality tests

Morocco causes South Africa and visa versa (2)
The USA causes South Africa and visa versa (4)

Cointegration findings in USD

	Egypt	Morocco	Nigeria	South Africa	USA
Egypt					
Morocco					
Nigeria					
South Africa	5	5	5		
USA					

A Pairwise Granger Causality test was run to try further understand the cointegration relationships identified above. The results of the Pairwise Granger causality tests

Egypt causes South Africa (5)
South Africa causes Nigeria (5)
No Pairwise relationship was found for Morocco and South Africa (5)

Note: The different time periods are represented by the number 1-5 and the letter "f". "f" represents the full period, and numbers "1,2,3,4,5" represents the different respective periods. The different numbers and "f" are only shown in the table when the null hypothesis for both the Engle-Granger and Johansen cointegration tests were rejected. If a Granger causality relationship was found the direction is shown by means of which Country "causes" the other. The number in brackets denotes the period to which the causality relationship relates.

[9] Period Key : Full period 1 Jan 2004 – 30 June 2014; Period 1: 1 Jan 2004 – 31 Dec 2005; Period 2: 1 Jan 2006 – 30 Sep 2007; Period 3: 1 Oct 2007 – 30 Apr 2009; Period 4: 1 May 2009 – 30 Jun 2011; Period 5: 1 Jul 2011 – 30 June 2014

6.4 Tests performed and tests results found on weekly logged closing price data

The same tests performed on the daily logged closing prices were performed on the weekly logged closing prices, with the results depicted below.

6.4.1 Unit root tests on weekly logged closing price data

Table 7: Unit root tests results using the Augmented Dickey-Fuller (ADF) unit root test

Augmented Dickey-Fuller test results										
	Full period		Periods 2&3		Period 1		Period 2		Period 3	
Weekly logged data	T-stat	Prob	T-stat	Prob	T-stat	Prob	T-stat	Prob	T-stat	Prob
Egypt local	-3.4216	0.0107	-1.4859	0.5399	-1.8150	0.3722	-1.1964	0.6762	-1.0777	0.7243
Egypt USD	-3.4652	0.0093	-1.4876	0.5391	-1.7833	0.3877	-1.1961	0.6763	-2.0306	0.2736
Morocco Local	-2.4131	0.1385	-1.1804	0.6841	-0.0674	0.9499	-2.0768	0.2544	-1.8063	0.3766
Nigeria Local	-1.3439	0.6103	-1.7164	0.4222	-1.0737	0.7254	-0.7209	0.8379	0.2036	0.9722
Nigeria USD	-1.3324	0.6159	-0.8351	0.8076	-1.0771	0.7241	-0.5599	0.8753	-0.2954	0.9219
Nigeria Top 30 Local	-0.6985	0.8444	-0.6985	0.8444	N/A	N/A	-1.1313	0.7034	-0.0390	0.9529
Nigeria Top 30 USD	-1.0877	0.7218	-1.0877	0.7218	N/A	N/A	-0.8426	0.8044	-0.4220	0.9016
South Africa local	-1.2793	0.6406	-0.3728	0.9107	0.2360	0.9741	-1.7408	0.4093	0.0992	0.9649
South Africa USD	-2.1185	0.2375	-2.0660	0.2588	-0.4716	0.8923	-1.4497	0.5572	-3.3308	0.0149
USA	-0.8426	0.8057	-0.6602	0.8537	-0.5821	0.8700	-1.4098	0.5770	-0.2402	0.9296

Notes: Critical values of ADF are -2.86 at a 5% level and -3.44 at a 1% level (see MacKinnon, 1996). Lag length for ADF based on Schwartz information criterion.

Notes: Critical values of ADF are -2.86 at a 5% level and -3.44 at a 1% level (see MacKinnon, 1996). Lag length for ADF based on Schwartz information criterion.

Egypt in both local currency and USD over the full period, and South Africa in USD for period 3 were found to be stationary at a 5% level.

Where the null hypothesis was rejected at a 5 percent level, as was found for Egypt over the full period and South Africa in USD in period 3. Phillips-Perron, Elloitt-Rothenberg Stock DF, Kwiatkowski-Phillips-Schmidt-Shin, Elloitt-Rothenberg Stock and Ng-Perron tests were performed with the results represented in Table 8 below.

Table 8: Summary of results of additional unit root tests run, were stationary was found at a 5% level using the Augmented Dickey-Fuller unit root test

	Augmented Dickey-Fuller test	Phillips-Perron test statistic	Elliott-Rothenberg-Stock DF-GLS test statistic	Kwiatkowski-Phillips-Schmidt-Shin	Elliott-Rothenberg-Stock test statistic	Ng-Perron test statistics
Egypt - Local (Full Period)	S	S	U	U	U	U
Egypt - USD (Full Period)	S	S	U	U	U	U
South Africa - USD (Periods 3)	S	S	S	S	S	S

Note: **S – Test found the sample exhibited stationarity at a 5% level of significance.**

U – Tests found sample had a unit root at a 5% level of significance.

SU - Tests found sample had a unit root at a 10% level of significance, but not at a 5% level.

For the full test results please refer to Appendix 8.3. As can be seen in table 8 above, which shows similar results to analysis on the daily data, that there were two instances of stationarity. South Africa in USD, in period 3, was found to be stationary at a 5 percent level of significance across all tests performed. There were conflicting results from the unit root tests for Egypt over the full period in both USD and local currency. Given that this paper is mainly concerned with the change in relationship over the 3 periods, and there is no conclusive evidence of stationarity issues found in any of the individual periods (other than South Africa in USD period 3), cointegration tests have been performed on the data.

6.4.2 Cointegration and causality test results on Logged weekly data

As noted above, both the Engle-Granger (Table 9) and Johansen Cointegration (Table 10) tests were performed and, if a relationship was noted, a further Pairwise Granger Causality (Tables 9 and 10) test was run to assess the direction of the relationship. The relationships over the specified periods are presented below for both Engle-Granger and Johansen.

Period 2&3 was run as a separate period as the NSE 30 was only available from the beginning of period 2[10]. No long term cointegration relationships were noted over the full period in the results. However the following shorter period relationships can be seen: South Africa and the USA, in local currency, are cointegrated pre (period 1) and post (period 3), but not during the crisis (period 2). Nigeria Top 30 and the USA; Egypt and South Africa; Morocco and Nigeria, were all found to be cointegrated during the crisis period. It is interesting to note that no relationship was found between Nigeria and Nigeria Top 30. The Nigeria Top 30 index was the only African stock exchange index with a cointegration relationship with the USA during the crisis. It is important to note that South Africa in USD was found to be stationary in period 3, and thus these cointegration relationships are not statistically reliable.

The Granger causality relationships appear much clearer using the weekly data compared rather than the Daily data. In local currency there are few relationships, with South Africa leading the USA in period 1, and Egypt in period 2. The USA then leads Nigeria Top 30 and South Africa in periods 2 and 3 respectively. In USD, as South Africa was stationary in period 3, the only relationship is between Nigeria Top 30 and Nigeria. It should be noted that there is no sign of a constant cointegration relationship between Nigeria and Nigeria Top 30, which would seem counterintuitive. This however, does show that the choice of index can have a significant influence on the effects of cointegration and causality tests.

[10] Period 2 covers a period before and after the financial crises, as discussed due to the number of observations. However is referred to as the crisis period as it contains the period over which the crisis occurred.

Table 9: Results from Engle-Granger cointegration tests and pairwise Granger causality tests for all periods in both local currency and USD

Cointegration findings in local currency

	Egypt	Morocco	Nigeria	Nigeria Top 30	South Africa	USA
Egypt						
Morocco						
Nigeria			2			
Nigeria Top 30						
South Africa		2				
USA					2 1,3	

A Pairwise Granger Causality test was run to try further understand the cointegration relationships identified above. The results of the Pairwise Granger causality tests are as follows:

South Africa causes the USA (1)
South Africa causes Egypt (2)
Nigeria causes Morocco (2)
The USA causes Nigeria Top 30 (2)
The USA causes South Africa (3)

Cointegration findings in USD

	Egypt	Morocco	Nigeria	Nigeria Top 30	South Africa	USA
Egypt						
Morocco						
Nigeria						
Nigeria Top 30				2		
South Africa		3		3	3	
USA						3

A Pairwise Granger Causality test was run to try further understand the cointegration relationships identified above. The results of the Pairwise Granger causality tests are as follows:

Nigeria Top 30 causes Nigeria (2)
South Africa causes Egypt (3)
South Africa causes Nigeria (3)
South Africa causes Nigeria Top 30 (3)
No pairwise relationship was found for South Africa and the USA (3)

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Note: The different time periods are represented by the number 1-3, 2&3 and the letter "f". "f" represents the full period, and numbers "1,2,3" represents the different respective periods. 2&3 represents period 2 and 3 together. The different numbers and "f" are only shown in the table when the null hypothesis for the Engle-Granger cointegration tests is rejected. The null hypothesis states that the pair of stock exchanges is not cointegrated at a five percent significance level. If a Granger causality relationship was found the direction is shown by means of which Country "causes" the other. The number in brackets denotes the period to which the causality relationship relates.

Period key: Full period: 1 Jan 2004 – 30 Jun 2014; Period 2&3: 1 Jan 2007 – 30 Jun 2014; Period 1: 1 Jan 2004 – 31 Dec 2006; Period 2: 1 Jan 2007 – 31 Dec 2009; Period 3: 1 Jan 2010 – 30 June 2014

Table 10: Results from Johansen cointegration tests and pairwise Granger causality tests for all periods in local currency and USD

Cointegration findings in local currency

	Egypt	Morocco	Nigeria	Nigeria Top 30	South Africa	USA
Egypt						
Morocco	2					
Nigeria						
Nigeria Top 30			2, 2&3			
South Africa		3				
USA		3				3

A Pairwise Granger Causality test was run to try further understand the cointegration relationships identified above. The results of the Pairwise Granger causality tests are as follows:

Egypt causes Morocco (2)
South Africa causes USA (3)
South Africa causes Egypt (3)
USA causes Egypt (3)
Nigeria Top 30 causes Nigeria (2&3)
No pairwise relationship was found for Nigeria and Nigeria Top 30 (2)

Cointegration findings in USD

	Egypt	Morocco	Nigeria	Nigeria Top 30	South Africa	USA
Egypt						
Morocco	2, 2&3					
Nigeria						
Nigeria Top 30			2, 2&3			
South Africa			2&3	2&3		
USA			2, 2&3			

A Pairwise Granger Causality test was run to try further understand the cointegration relationships identified above. The results of the Pairwise Granger causality tests are as follows:

Egypt causes Morocco and vice versa (2,2&3)
No pairwise relationship was found for Nigeria and Nigeria Top 30 (2)
USA causes Nigeria (2)
Nigeria Top 30 causes Nigeria (2&3)
South Africa causes Nigeria (2&3)
Nigeria causes the USA and vice versa (2&3)
Nigeria Top30 causes South Africa and vice versa (2&3)

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Note: The different time periods are represented by the number 1-3, 2&3 and the letter "f". "f" represents the full period, and numbers "1,2,3" represents the different respective periods. 2&3 represents period 2 and 3 together. The different numbers and "f" are only shown in the table when the null hypothesis for the Johansen cointegration tests is rejected. The null hypothesis states that the pair of stock exchanges is not cointegrated at a five percent significance level. If a Granger causality relationship was found the direction is shown by means of which Country "causes" the other. The number in brackets denotes the period to which the causality relationship relates.

Period key: Full period: 1 Jan 2004 – 30 Jun 2014; Period 2&3: 1 Jan 2007 – 30 Jun 2014; Period 1: 1 Jan 2004 – 31 Dec 2006;
Period 2: 1 Jan 2007 – 31 Dec 2009; Period 3: 1 Jan 2010 – 30 June 2014

When looking at the local currency results the Johansen tests show a long term (Period 2&3) and crisis period (2) relationship between Nigeria and Nigeria Top 30 which was expected, with Nigeria Top 30 leading Nigeria for periods 2&3. Egypt and Morocco show a cointegration relationship during the crisis period with Egypt leading Morocco. Post crisis there are relationships between South Africa and the USA, with South Africa causing the USA. South Africa and the USA are both found to lead Egypt.

Above in USD terms we see some noteworthy results, as this shows several long term relationships between the different indices. Nigeria Top 30 as well as South Africa are found to lead Nigeria for period 2&3 (January 2007 to June 2014). Nigeria Top 30 and South Africa are found to be cointegrated and have a causality effect on each other. Nigeria and the USA also are found to cause each for period 2&3. Egypt and Morocco also share this a long term relationship, both having a causality effect on each other.

This shows that when the currencies are converted to a consistent base, and weekly data is used instead of daily, the markets seem to be more cointegrated. A possible reason for this is that the various time zones, and different trading days, mean daily data may not show the co-movements. This is something that is not examined further in this study but would provide an interesting area for other researchers to explore further.

Running a Johansen test offered very different results to those of the Engle-Granger test for cointegration. However, unlike the daily data, the causality results are not clear. Two relationships appear quite prevalent in the results: Nigeria and Nigeria Top 30 appear to be cointegrated and Nigeria Top 30 leads Nigeria. Egypt is found to lead Morocco in local and USD terms.

Cointegration results when both Johansen and Engle-Granger Cointegration tests are combined show only two instances of cointegration. The first is the USA and South Africa in period 3 in local currency, where the USA was found to lead South Africa. This relationship is intuitive, as during this period the global markets saw large drops in value and this movement did start in the USA. The second case is between Nigeria and Nigeria Top 30 in period 2 in USD, where it was found that Nigeria Top 30 caused the movement in Nigeria. However one would expect to see a relationship between Nigeria Top 30 and Nigeria, and it is interesting to note there was only a relationship found for one period.

6.5 Effect of logging

To assess whether logging the data has a significant effect on the results, the same tests were run on the daily data as were run on the daily logged data to see if any significant differences were found. The results of the tests are presented in Appendix 8.4.

There were significant differences in the results found running the various tests. The first difference to be noted was there were no longer conflicting results regarding the stationarity of Egypt over the full period. Egypt was found to have a unit root. The Engle-Granger cointegration results were similar. However, several additional relationships were found, and one instance of a relationship no longer being statistically significant:

- Morocco and Nigeria in local currency in period 4
- Morocco and South Africa in USD in period 4
- Morocco and USA in USD in period 4
- South Africa and Egypt in period 3 no longer show a cointegration relationship.

With the Johansen Cointegration tests there were significantly fewer relationships found with no relationships being found in the following instances:

- Nigeria and Egypt in local currency (3 and 4)
- Morocco and South Africa in local currency (2)
- Nigeria and the USA in local currency (3)
- South Africa and the USA in local currency (4)
- Nigeria and South Africa in USD (3)
- Nigeria and Egypt in USD (3)
- Nigeria and USA in USD (3)
- South Africa and the USA in USD (4)

There were also changes in the Granger Causality test results. Thus it should be noted that logging data does change the results of the tests performed and this should be examined further. Other studies on this topic have varied in their use of logged and unlogged data or often do not specify if the data was logged. An investigation of this is, however, outside the scope of this study.

6.6 Results discussion

Very little evidence of cointegration was found over the ten year period from the results of both the Engle-Granger and Johansen cointegration tests This is consistent with the results from Alagidede et al. (2011:1339). However a few instances were noted for shorter periods of time. There were instances of cointegration relationships, but nothing consistent over time. The two tests offered varied results, for example the Johansen cointegration test on weekly logged data in USD revealed many relationships for the period of January 2007 to June 2014.

However, when the Johansen and Engle-Granger tests were combined, the only relationships found using logged data were (excluding periods where stationarity was found): Morocco causes South Africa and vice versa during period 2, and the USA causes South Africa and vice versa during period 4. Using the weekly logged data in local currency, the USA causes South Africa during period 3 in local currency, and Nigeria Top 30 causes Nigeria during period 2 in USD.

The fact that no cointegration relationships were found consistently over the period studied supports the findings of Jefferis and Okeahalam (1999:44). They find no relationships between the US and any of the African markets in their study. The only inconsistency is in this study when using weekly logged data, in period 3 with local currency, and daily logged data in local currency in period 4, where the USA is found to cause South Africa. Collins and Biekpe (2003:297) find contagion in Egypt and South Africa and also that other smaller African markets did offer diversification to more developed markets, and also that African market interactions appeared to be regional. The findings of this study support the finding that African markets do offer diversification benefits, but there is little evidence to support regional market integration.

Although of results did show periods of cointegration between African countries, there was no consistent trend. Wang et al. (2003:532), studying the same countries but also including Zimbabwe, found limited cointegration between African countries and also between African countries and the USA. There was some cointegration between South Africa and the USA, but this was very limited.

Alagidede et al. (2011:1340) find few long term relationships between African markets, and between African and developed markets. They also find low correlations between African and other countries, implying there are benefits to diversification.

Graham et al. (2013:98), looking at the MENA region, did find long term linkages with the USA and Egypt was included in their sample. This differs from the results in this study, where cointegration between the Egypt and the USA was only evident in period 1 and only using the Engle-Granger cointegration test.

Chen et al. (2014:99), find there was integration, and the US market caused frontier market movements, and supported the leading market hypothesis. They also noted that they expected the leading markets to become more integrated with frontier markets in the future. This is supported by the results of the Johansen cointegration test run on the weekly logged data in USD. However, in local currency terms, using both Johansen and Engle-Granger tests, this study's results do not support the conclusion of Chen et al. (2014:99).

7. CONCLUSION AND AREAS OF FURTHER RESEARCH

7.1 Conclusion

This study examines whether there are benefits to diversification across Africa from an international perspective. The conclusions of this study support those of previous research which find very weak correlation relationships, except between South Africa and the USA.

When using the logged daily closing prices, numerous cointegration results were found over short periods. However, no long term cointegration relationships were found over the full test period using Engle-Granger. However using Johansen cointegration tests a relationship was found between Nigeria and the USA over the full period of this study. The USA and Nigeria were found to have a causality effect on each other.

The cointegration tests on the weekly logged closing prices offer several long term relationships for the period 1 January 2007 – 30 June 2014 in USD. These relationships did not show in local currency except for Nigeria and Nigerian Top 30. These long term relationships were only shown when using the Johansen tests with prices based in USD. None of these long term cointegration relationships were found in the Engle-Granger cointegration test results.

A robustness check was run using unlogged closing prices and the results differed substantially from that of the logged data. Further consideration needs to be given to the effect of logging on the statistic tests performed.

There might be a variety of reasons explaining the movement in the various exchanges and this study is limited to looking at cointegration and correlation with some brief explanations as to the reasons. The correlation relationships were constantly low over the test period, implying there has not been a significant change in the relationships over time. The use of local currency verses USD offered differing results from both the cointegration and correlations tests. The number of cointegration relationships over time did not tend to increase. These results imply that there are potential benefits from diversification, which could be obtained by investors, over the long term, across the four African exchanges, with this finding being practical due to the size and liquidity of the indices used.

7.2 Areas for further research

As briefly noted above, logging data has a significant effect on the outcomes of the cointegration results and thus the effect should be further researched. As with logging, capping the weightings of stocks in an index would also have an effect on the results, which has not been noted in this study but should be explored further. It has also been noted through discussions with emerging market analysts that the stationarity found between South Africa and the USA in period 5 is an emerging market phenomenon that is not limited to South Africa (Wales, personal communication 2015, June 17). This would be an interesting topic to research further. The extent of the link between the Nigerian All Share index and the Nigerian Top 30 index would also be interesting to explore further.

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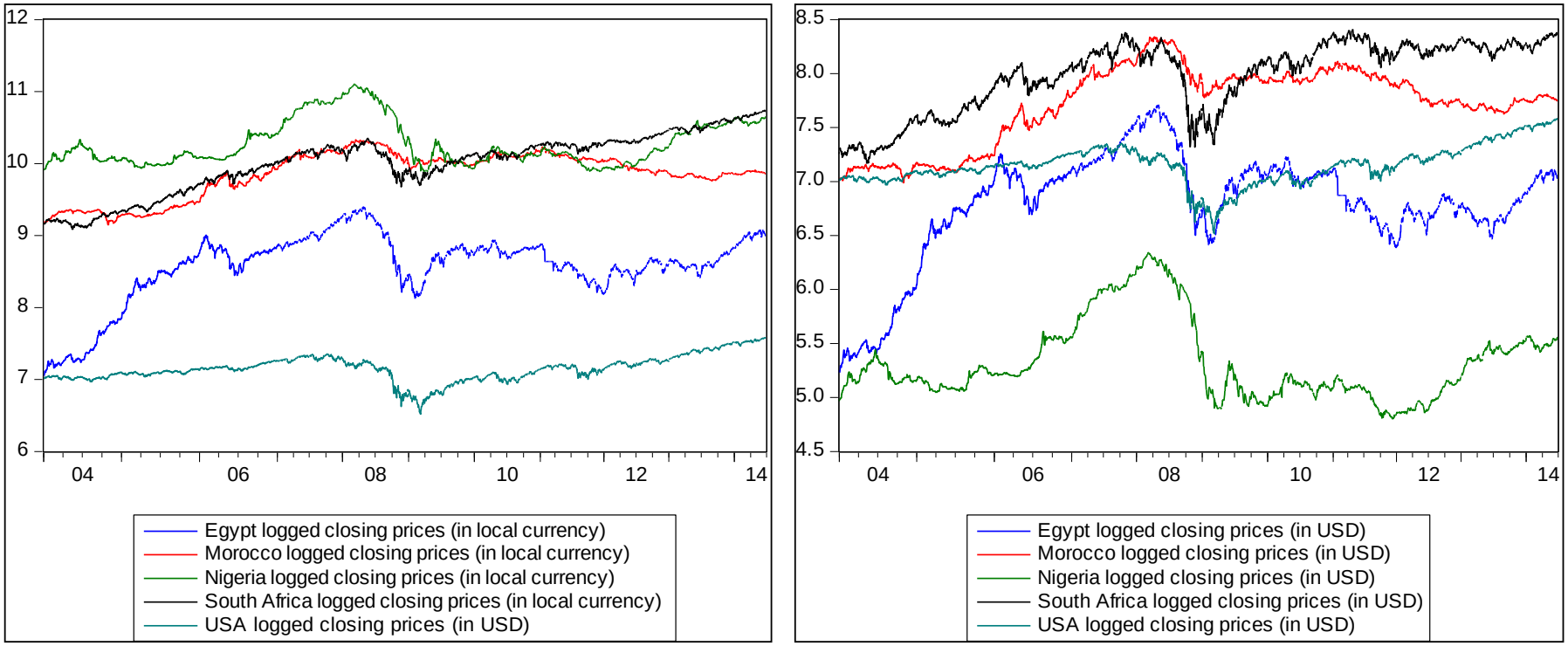
8. APPENDICIES

8.1 Graphical Interpretation

Figure 10: Logged index closing prices in local currency (left) and USD (right)



As can been seen above, when converting to USD it appears the effects on the closing prices are more pronounced. It also can be seen that most of the exchanges have not reached their respective pre-crisis level expect the USA and South Africa.

8.2 Correlation results

8.2.1 Stock Market Linkages – Correlation of logged daily closing price returns

Figure 11: Correlation results for logged daily closing price returns

Correlations Full Period

	Egypt	Morocco	Nigeria	South Africa	USA
Egypt		0.1092	0.0533	0.1495	0.0733
Morocco	0.1083		0.0320	0.2566	0.1229
Nigeria	0.0642	0.0562		0.0329	0.0066
South Africa	0.1442	0.0683	0.0344		0.4437
USA	0.0729	0.0271	0.0098	0.3769	

Correlations Period 1

	Egypt	Morocco	Nigeria	South Africa	USA
Egypt		0.0219	0.0639	-0.0969	-0.0365
Morocco	0.0656		0.0273	0.1440	-0.0131
Nigeria	0.0568	0.0699		-0.0634	-0.0256
South Africa	-0.0092	0.0068	-0.0468		0.2129
USA	-0.0387	-0.0500	-0.0358	0.1737	

Correlations Period 2

	Egypt	Morocco	Nigeria	South Africa	USA
Egypt		0.1507	-0.0037	0.0980	0.0103
Morocco	0.1548		0.0354	0.1211	-0.0217
Nigeria	0.0012	0.0315		-0.0186	-0.0184
South Africa	0.1062	0.0684	0.0074		0.3636
USA	0.0144	-0.0253	-0.0176	0.3065	

Correlations Period 3

	Egypt	Morocco	Nigeria	South Africa	USA
Egypt		0.1434	0.0552	0.2639	0.1547
Morocco	0.1416		0.0030	0.3463	0.1210
Nigeria	0.0593	0.0517		0.1055	0.0268
South Africa	0.2254	0.1410	0.0553		0.3938
USA	0.1524	0.0833	0.0251	0.3602	

Correlations Period 4

	Egypt	Morocco	Nigeria	South Africa	USA
Egypt		0.1538	0.0678	0.2316	0.0922
Morocco	0.1178		0.0891	0.2632	0.2474
Nigeria	0.0955	0.1238		0.0078	-0.0138
South Africa	0.2238	0.0093	0.0501		0.5914
USA	0.0910	0.0358	-0.0099	0.5199	

Correlations Period 5

	Egypt	Morocco	Nigeria	South Africa	USA
Egypt		0.0364	0.0474	0.0691	-0.0014
Morocco	0.0344		-0.0133	0.3034	0.2227
Nigeria	0.0734	-0.0245		0.0110	-0.0061
South Africa	0.0645	0.0194	0.0426		0.6043
USA	0.0017	-0.0101	0.0224	0.4664	

Note: The top half of the table (highlighted), shows the correlation between the various exchange proxies in USD terms. The bottom half of the table (un-highlighted), represents the correlation between the various exchange proxies in local currency terms.

Figure 12: Correlation results for logged weekly closing price returns

Correlations Full period

	Egypt	Morocco	Nigeria	South Africa	USA
Egypt		0.2473	0.0757	0.2319	0.2276
Morocco	0.1945		0.0557	0.3120	0.2251
Nigeria	0.0815	0.0199		0.0684	0.0260
South Africa	0.2103	0.1156	0.0380		0.7170
USA	0.2274	0.0862	0.0311	0.6424	

Correlations Period 1

	Egypt	Morocco	Nigeria	South Africa	USA
Egypt		0.2198	0.0142	0.1264	0.0746
Morocco	0.2135		0.0151	0.3186	0.1677
Nigeria	0.0066	0.0464		-0.0476	0.0043
South Africa	0.1218	0.2043	-0.0932		0.5365
USA	0.0766	0.0944	0.1677	0.5380	

Correlations Period 3

	Egypt	Morocco	Nigeria	Nigeria Top 30	South Africa	USA
Egypt		0.1093	0.1099	0.0963	0.1453	0.1112
Morocco	0.0902		0.0280	0.0583	0.3293	0.2536
Nigeria	0.0860	-0.0167		0.9688	0.0772	0.1343
Nigeria Top 30	0.0756	0.0407	0.9625		0.0688	0.1286
South Africa	0.0662	0.0886	0.0438	0.0711		0.7187
USA	0.1194	0.0484	0.1570	0.1490	0.6386	

Correlations Period 2 and 3

	Egypt	Morocco	Nigeria	Nigeria Top 30	South Africa	USA
Egypt		0.2474	0.0875	0.0536	0.2597	0.2676
Morocco	0.1713		0.0648	0.0696	0.3157	0.2511
Nigeria	0.0989	0.0096		0.7214	0.0838	0.0278
Nigeria Top 30	0.0160	0.0147	0.6041		0.0423	0.0117
South Africa	0.2333	0.0764	0.0613	0.0190		0.7453
USA	0.2670	0.0910	0.0333	0.0031	0.6682	

Correlations Period 2

	Egypt	Morocco	Nigeria	Nigeria Top 30	South Africa	USA
Egypt		0.3225	0.0190	0.0585	0.3181	0.3496
Morocco	0.2203		0.0303	0.0749	0.3127	0.2560
Nigeria	0.1146	0.0189		0.9759	0.0318	0.0026
Nigeria Top 30	0.0934	0.0243	0.9910		0.0421	0.0046
South Africa	0.3139	0.0761	0.0637	0.0616		0.7566
USA	0.3461	0.1128	0.0128	0.0104	0.6777	

Note: The top half of the table (highlighted), shows the correlation between the various exchange proxies in USD terms. The bottom half of the table (un-highlighted), represents the correlation between the various exchange proxies in local currency terms.

8.3 Unit root test results

Table 11: Unit root tests results for additional tests performed on daily logged data

Egypt Local (Full period)	**Phillips-Perron test statistic**		**Elliott-Rothenberg-Stock DF-GLS test statistic**		**Kwiatkowski-Phillips-Schmidt-Shin**		**Elliott-Rothenberg-Stock test statistic**		**Ng-Perron test statistics**				
	Adj. t-Stat	Prob.*	Test critical	t-Statistic	Asymptotic	LM-Stat.		P-Statistic	Asymptotic	MZa	MZt	MSB	MPT
	-3.178862	0.0214	values:	0.741373	critical values*:	2.04111	Test critical values:	126.076	critical values*:	0.51682	0.73997	1.4318	122.273
			1% level	-2.5656	1% level	0.739	1% level	1.99	1%	-13.8	-2.58	0.174	1.78
			5% level	-1.9409	5% level	0.463	5% level	3.26	5%	-8.1	-1.98	0.233	3.17
			10% level	-1.6166	10% level	0.347	10% level	4.48	10%	-5.7	-1.62	0.275	4.45
Egypt USD (Full period)	**Phillips-Perron test statistic**		**Elliott-Rothenberg-Stock DF-GLS test statistic**		**Kwiatkowski-Phillips-Schmidt-Shin**		**Elliott-Rothenberg-Stock test statistic**		**Ng-Perron test statistics**				
	Adj. t-Stat	Prob.*	Test critical	t-Statistic	Asymptotic	LM-Stat.		P-Statistic	Asymptotic	MZa	MZt	MSB	MPT
	-3.231362	0.0184	values:	0.541775	critical values*:	1.78434	Test critical values:	124.4176	critical values*:	0.37319	0.54014	1.4474	120.585
			1% level	-2.5656	1% level	0.739	1% level	1.99	1%	-13.8	-2.58	0.174	1.78
			5% level	-1.9409	5% level	0.463	5% level	3.26	5%	-8.1	-1.98	0.233	3.17
			10% level	-1.6166	10% level	0.347	10% level	4.48	10%	-5.7	-1.62	0.275	4.45
South Africa USD (Period 5)	**Phillips-Perron test**		**Elliott-Rothenberg-Stock DF-GLS**		**Kwiatkowski-Phillips-Schmidt-Shin**		**Elliott-Rothenberg-Stock test**		**Ng-Perron test statistics**				
	Adj. t-Stat	Prob.*	Test critical	t-Statistic	Asymptotic	LM-Stat.		P-Statistic	Asymptotic	MZa	MZt	MSB	MPT
	-3.390277	0.0116	values:	-1.937152	critical values*:	0.94423	Test critical values:	3.75117	critical values*:	-6.83982	-1.84673	0.27	3.59144
			1% level	-2.5656	1% level	0.739	1% level	1.99	1%	-13.8	-2.58	0.174	1.78
			5% level	-1.9409	5% level	0.463	5% level	3.26	5%	-8.1	-1.98	0.233	3.17
			10% level	-1.6166	10% level	0.347	10% level	4.48	10%	-5.7	-1.62	0.275	4.45

Where stationarity was found using the Augmented Dickey-Fuller unit root tests, further testing was performed to confirm that the data is stationary. The above table shows the results of the various unit root tests.

Table 12: Unit root tests results for additional tests performed on weekly logged data

Egypt Local (Full period)	**Phillips-Perron test statistic**		**Elliott-Rothenberg-Stock DF-GLS test statistic**		**Kwiatkowski-Phillips-Schmidt-Shin**		**Elliott-Rothenberg-Stock test statistic**		**Ng-Perron test statistics**					
	Adj. t-Stat	Prob.*	Test critical values:	t-Statistic	Asymptotic critical	LM-Stat.		P-Statistic	Asymptotic critical values*:	MZa	MZt	MSB	MPT	
	-3.173757	0.0221		0.701832		0.69066	Test critical values:	131.996		0.50489	0.71003	1.40632	117.85	
			1% level	-2.565646	1% level	0.739	1% level	1.99	1%	-13.8	-2.58	0.174	1.78	
			5% level	-1.940918	5% level	0.463	5% level	3.26	5%	-8.1	-1.98	0.233	3.17	
			10% level	-1.616637	10% level	0.347	10% level	4.48	10%	-5.7	-1.62	0.275	4.45	
Egypt USD (Full Period)	**Phillips-Perron test statistic**		**Elliott-Rothenberg-Stock DF-GLS test statistic**		**Kwiatkowski-Phillips-Schmidt-Shin**		**Elliott-Rothenberg-Stock test statistic**		**Ng-Perron test statistics**					
	Adj. t-Stat	Prob.*	Test critical values:	t-Statistic	Asymptotic critical	LM-Stat.		P-Statistic	Asymptotic critical values*:	MZa	MZt	MSB	MPT	
	-3.191776	0.021		0.465162		0.583591	Test critical values:	123.6986		0.34031	0.4726	1.38872	110.658	
			1% level	-2.565646	1% level	0.739	1% level	1.99	1%	-13.8	-2.58	0.174	1.78	
			5% level	-1.940918	5% level	0.463	5% level	3.26	5%	-8.1	-1.98	0.233	3.17	
			10% level	-1.616637	10% level	0.347	10% level	4.48	10%	-5.7	-1.62	0.275	4.45	
South Africa USD (Period 3)	**Phillips-Perron test statistic**		**Elliott-Rothenberg-Stock DF-GLS test statistic**		**Kwiatkowski-Phillips-Schmidt-Shin**		**Elliott-Rothenberg-Stock test statistic**		**Ng-Perron test statistics**					
	Adj. t-Stat	Prob.*	Test critical values:	t-Statistic	Asymptotic critical	LM-Stat.		P-Statistic	Asymptotic critical values*:	MZa	MZt	MSB	MPT	
	-3.218879	0.0205				0.186489	Test critical values:	2.627894		-10.8178	-2.31099	0.21363	2.32404	
			1% level	-2.565646	1% level	0.739	1% level	1.99	1%	-13.8	-2.58	0.174	1.78	
			5% level	-1.940918	5% level	0.463	5% level	3.26	5%	-8.1	-1.98	0.233	3.17	
			10% level	-1.616637	10% level	0.347	10% level	4.48	10%	-5.7	-1.62	0.275	4.45	

Where stationarity was found using the Augmented Dickey-Fuller unit root tests, further testing was performed to confirm that the data is stationary. The above table shows the results of the various unit root tests.

8.4 Test results on daily closing prices (Unlogged)

8.4.1 Stock Market Linkages – Correlation

Figure 13: Correlation results for unlogged daily closing price returns

Correlations Full Period

	Egypt	Morocco	Nigeria	South Africa	USA
Egypt		0.1175	0.0481	0.1468	0.0583
Morocco	0.1070		0.0282	0.2559	0.0367
Nigeria	0.0602	0.0563		0.0090	-0.0168
South Africa	0.1451	0.0597	0.0277		0.4565
USA	0.0579	0.0367	-0.0118	0.3807	

Correlations Period 1

	Egypt	Morocco	Nigeria	South Africa	USA
Egypt		-0.0378	0.0502	-0.0510	-0.0454
Morocco	0.0097		0.0182	0.1397	-0.0137
Nigeria	0.0491	0.0651		-0.0541	-0.0276
South Africa	0.0109	0.0057	-0.0359		0.2098
USA	-0.0449	-0.0520	-0.0387	0.1719	

Correlations Period 2

	Egypt	Morocco	Nigeria	South Africa	USA
Egypt		0.1146	0.0191	0.1188	-0.0044
Morocco	0.1097		0.0528	0.0839	-0.0343
Nigeria	0.0235	0.0542		-0.0399	-0.0334
South Africa	0.1215	0.0273	-0.0069		0.3776
USA	-0.0000	-0.0401	-0.0300	0.3195	

Correlations Period 3

	Egypt	Morocco	Nigeria	South Africa	USA
Egypt		0.1371	0.0443	0.1844	0.1008
Morocco	0.1461		-0.0035	0.3148	0.1040
Nigeria	0.0482	0.0400		0.0360	-0.0283
South Africa	0.1722	0.1365	0.0265		0.3709
USA	0.1007	0.1037	-0.0259	0.3383	

Correlations Period 4

	Egypt	Morocco	Nigeria	South Africa	USA
Egypt		0.1569	0.0748	0.2242	0.0995
Morocco	0.1202		0.0902	0.2748	0.2540
Nigeria	0.1006	0.1256		0.0060	-0.0132
South Africa	0.2197	0.0127	0.0437		0.5858
USA	0.0967	0.0448	-0.0097	0.5173	

Correlations Period 5

	Egypt	Morocco	Nigeria	South Africa	USA
Egypt		0.0434	0.0349	0.0726	0.0042
Morocco	0.0300		-0.0115	0.3273	0.2248
Nigeria	0.0624	-0.0212		0.0029	-0.0057
South Africa	0.0857	0.0169	0.0407		0.5845
USA	0.0127	-0.0120	0.0111	0.4231	

Note: The top half of the table (highlighted), shows the correlation between the various exchange proxies in USD terms. The bottom half of the table (un-highlighted), represents the correlation between the various exchange proxies in local currency terms.

8.4.2 Unit root tests on weekly logged data

Table 13: Unit root tests results using the Augmented Dickey-Fuller unit root test

Augmented Dickey-Fuller Unit Root Test Results												
Daily unlogged data	Full period		Period 1		Period 2		Period 3		Period 4		Period 5	
	T-stat	Prob	T-stat	Prob	T-stat	Prob	T-stat	Prob	T-stat	Prob	T-stat	Prob
Egypt Local	-2,00	0,287	1,00	0,997	-0,52	0,885	-0,33	0,918	-2,34	0,158	0,00	0,958
Egypt USD	-2,03	0,273	1,11	0,998	-0,34	0,917	-0,31	0,921	-1,88	0,344	-0,64	0,859
Morocco Local	-1,82	0,370	-0,86	0,801	-1,19	0,682	-0,53	0,882	-1,74	0,412	-1,66	0,453
Morocco USD	-1,70	0,433	-1,77	0,397	-0,78	0,822	-0,39	0,908	-2,45	0,129	-2,29	0,175
Nigeria Local	-1,19	0,682	-2,24	0,194	0,01	0,959	0,28	0,977	-2,80	0,059	0,65	0,991
Nigeria USD	-1,19	0,680	-2,28	0,179	0,13	0,968	0,52	0,987	-2,72	0,071	0,51	0,987
South Africa Local	0,02	0,959	1,05	0,997	-0,76	0,828	-0,90	0,789	-2,14	0,230	0,12	0,967
South Africa USD	-1,96	0,304	0,33	0,980	-1,11	0,715	-1,01	0,750	-1,89	0,338	-3,35	0,013
USA	-0,13	0,944	-1,60	0,481	-1,01	0,751	-0,90	0,788	-1,64	0,464	-0,01	0,957

Notes: Critical values of ADF are -2.86 at a 5% level and -3.44 at a 1% level (see MacKinnon, 1996). Lag length for ADF based on Schwartz information criterion. South Africa in USD for period 5 is found to be stationary at a 5% level.

Where we could not reject the null hypothesis in the Augmented Dickey-Fuller test at a 10 percent level of significance, a further Phillips-Perron unit root test was performed as an additional test for robustness. Thus for Nigeria in period 4 in local currency and USD, Phillips-Perron unit root tests were performed and the results are presented below.

Table 14: Phillips-Perron unit root tests results for Nigeria in period 4

Phillips-Perron test results		
Daily logged data	Period 4	
	T-stat	Prob
Nigeria Local	-2.7188	0.0713
Nigeria USD	-2.66847	0.0801

Notes: Critical values of PP are -2.86 at a 5% level and -3.44 at a 1% level (see MacKinnon, 1996).

Table 15: Summary of results of additional unit root tests run, were stationary was found at a 5% level using the Augmented Dickey-Fuller unit root test

	Augmented Dickey-Fuller test	Phillips-Perron test statistic	Elliott-Rothenberg-Stock DF-GLS test statistic	Kwiatkowski-Phillips-Schmidt-Shin	Elliott-Rothenberg-Stock test statistic	Ng-Perron test statistic
South Africa - USD (Period 5)	S	S	S	S	SU*	SU*

S - Stationary at a 5% level U - Has a unit root at a 5% level

Note: **S – Test found the sample exhibited stationarity at a 5% level of significance.**

U – Tests found sample had a unit root at a 5% level of significance.

SU - Tests found sample had a unit root at a 10% level of significance, but not at a 5% level.

Table 16: Unit root tests results for additional tests performed on daily unlogged data

	Phillips-Perron test statistic		Elliott-Rothenberg-Stock DF-GLS test statistic		Kwiatkowski-Phillips-Schmidt-Shin		Elliott-Rothenberg-Stock test statistic		Ng-Perron test statistics				
South Africa USD (Period 5)	Adj. t-Stat	Prob.*	Test critical values:	t-Statistic	Asymptotic critical values*:	LM-Stat.	Test critical values:	P-Statistic	Asymptotic critical values*:	MZa	MZt	MSB	MPT
	-3.265958	0.0168		-2.039644		0.92195		3.825558		-6.70031	-1.82508	0.27239	3.67569
			1% level	-2.565646	1% level	0.739	1% level	1.99	1%	-13.8	-2.58	0.174	1.78
			5% level	-1.940918	5% level	0.463	5% level	3.26	5%	-8.1	-1.98	0.233	3.17
			10% level	-1.616637	10% level	0.347	10% level	4.48	10%	-5.7	-1.62	0.275	4.45

Where stationarity was found using the Augmented Dickey-Fuller unit root tests, further testing was performed to confirm that the data is stationary. The above table shows the results of the various unit root tests.

8.4.3 Cointegration and causality test results on unlogged daily data

Table 17: Results from Engle-Granger cointegration tests and pairwise Granger causality tests for all periods in both local currency and USD

Cointegration findings in local currency

	Egypt	Morocco	Nigeria	South Africa	USA
Egypt					
Morocco					
Nigeria		4			
South Africa	3	2	2		
USA	1	2		1,2,4,5	

Cointegration findings in USD

	Egypt	Morocco	Nigeria	South Africa	USA
Egypt					
Morocco					
Nigeria					
South Africa	2,5	2,4,5	5		
USA	1	2,4		1,3,5	

A Pairwise Granger Causality test was run to try further understand the cointegration relationships identified above. The results of the Pairwise Granger causality tests are as follows:

The USA causes South Africa (1,4,5)
No Pairwise relationship was found for Egypt and the USA (2)
South Africa causes the USA and vice versa (2)
No Pairwise relationship was found for Nigeria and South Africa (2)
No Pairwise relationship was found for Morocco and the USA (2)
No Pairwise relationship was found for Morocco and South Africa (2)
South Africa causes Egypt (3)
No Pairwise relationship was found for Morocco and Nigeria (4)

A Pairwise Granger Causality test was run to try further understand the cointegration relationships identified above. The results of the Pairwise Granger causality tests are as follows:

No Pairwise relationship was found for Egypt and the USA (1)
The USA causes South Africa (1,3,5)
South Africa causes Egypt (2)
No Pairwise relationship was found for Morocco and South Africa (2,4,5)
The USA causes Morocco (2)
No Pairwise relationship was found for Morocco and the USA (4)
No Pairwise relationship was found for Egypt and South Africa (5)
South Africa causes Nigeria (5)

Note: The different time periods are represented by the number 1-5 and the letter "f". "f" represents the full period, and numbers "1,2,3,4,5" represents the different respective periods. The different numbers and "f" are only shown in the table when the null hypothesis for the Engle-Granger cointegration tests is rejected. The null hypothesis states that the pair of stock exchanges is not cointegrated at a five percent significance level. If a Granger causality relationship was found the direction is shown by means of which Country "causes" the other. The number in brackets denotes the period to which the causality relationship relates.

Table 18: Results from Johansen cointegration tests and pairwise Granger causality tests for all periods in local currency and USD

Cointegration findings in local currency

	Egypt	Morocco	Nigeria	South Africa	USA
Egypt					
Morocco	f,4				
Nigeria					
South Africa					
USA			f		

A Pairwise Granger Causality test was run to try further understand the cointegration relationships identified above. The results of the Pairwise Granger causality tests are as follows:

USA causes Nigeria and visa versa (f)
Egypt causes Morocco (f)
No Pairwise relationship was found for Morocco and Egypt (4)

Cointegration findings in USD

	Egypt	Morocco	Nigeria	South Africa	USA
Egypt					
Morocco	f,4				
Nigeria					
South Africa	5	5	5		
USA			f		

A Pairwise Granger Causality test was run to try further understand the cointegration relationships identified above. The results of the Pairwise Granger causality tests are as follows:

Egypt causes Morocco and vice versa (f)
The USA causes Nigeria (f)
No Pairwise relationship was found for Morocco and Egypt (4)
No Pairwise relationship was found for South Africa and Egypt (5)
No Pairwise relationship was found for South Africa and Morocco (5)
South Africa casues Nigeria (5)

Note: The different time periods are represented by the number 1-5 and the letter "f". "f" represents the full period, and numbers "1,2,3,4,5" represents the different respective periods. The different numbers and "f" are only shown in the table when the null hypothesis for the Johansen cointegration tests is rejected. The null hypothesis states that the pair of stock exchanges is not cointegrated at a five percent significance level. If a Granger causality relationship was found the direction is shown by means of which Country "causes" the other. The number in brackets denotes the period to which the causality relationship relates.

Once combined there is only cointegration between South Africa and the other African exchanges, Egypt, Morocco and Nigeria in USD in period 5.