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For Peer Review

The Law of One Price: An Examination of Price Integration between Europe and Regional Markets in Africa

This study examines the degree of price-integration of equity indices between the major markets of Africa, namely Morocco, Tunisia, Egypt, Kenya, Nigeria, Namibia and South Africa with the European markets of London and Paris. Vector Autoregressive and Autoregressive Distributed Lag methods reveal that African markets are largely price-segmented. The only markets that are price-integrated have shared economic and financial institutions, such as Namibia and South Africa, and Egypt, Tunisia and France. The evidence suggests that development policy should be focussed on enhancing existing institutions rather than embarking prematurely on regional integration.

1. Introduction

There has been considerable development of financial markets in Africa since the end of the cold war in 1989 and the consequent restructuring of global capital flows. However, while several new stock exchanges have been established and existing ones restructured, the financial markets of Sub Saharan Africa (SSA) have not been successful in attracting significant amounts of global capital flows (Kenny and Moss, 1998). Markets are often dominated by a few large shareholders (see Lavelle (2001) and Hearn and Piesse (2009a) for an extended discussion of these issues) and severe illiquidity inhibits any potential gains from risk diversification by international portfolio managers (Hearn and Piesse, 2009b). In order to counter some of these issues a major policy initiative to integrate these markets has been launched by the major regional development institutions, such as the New Partnership for Africa's Development (NEPAD) and the Southern African Development Community (SADC).

There has also been considerable progress in improving the institutions and many African countries have adopted best practice corporate governance codes, harmonised their accounting systems, and are developing appropriate regulation together with effective enforcement. However, there remain significant differences due to a number of factors. There are widely varying levels of development and differences arising from the underlying legal origins of the market that influence national institutions, business culture and levels of investor protection afforded by the judiciary (La Porta et al, 2008). Markets have different trading hours and trading methods, for example, markets have adopted either open outcry, electronic continuous auction, or simple forms of call auction to execute transactions (Kenny and Moss, 1998). Finally, there are different degrees of macroeconomic stability, such that some markets are attractive to overseas portfolio investors and provide reliable and efficient operations and national and regional payments systems and others do not. Consequently, equity market integration has only been successfully achieved between markets with a shared macroeconomic environment, for example, the

Alexandria and Cairo exchanges in Egypt, the 1998 formation of the Francophone West African regional bourse in Cote d'Ivoire (Lavelle, 2001), and Namibia and South Africa (Piesse and Hearn, 2002).

Given this diverse institutional background, and the current policy to integrate regional financial markets in order to increase liquidity through a common trading environment, an examination of the degree and strength of price-integration between equity markets in Africa is timely. This study builds on previous results that indicate the presence of integration between Namibia and South Africa (Hearn and Piesse, 2002). It extends this analysis to the major markets of Africa, all of which are former colonies of the UK and France. The inclusion of UK and France is motivated by the fact that the majority of portfolio investment in Africa is linked to the London market (Piesse and Hearn, 2005) and most countries have adopted a regulatory system that is influenced by one of these two legal codes (La Porta, 2008).

A test of the law of one price is used to examine potential price-integration relationships between blue chip equity market indices across Africa. This assumes that markets that are integrated have premiums close to zero between mutually substitutable assets and thus prices for similar assets are equal (Levy et al, 2006). Further, long term purchasing power parity is assumed to hold between markets and asset prices are at least weak-form information efficient (Fama, 1991). Given these conditions, and with no restrictions on arbitrage trading, mutually substitutable assets should have the same price (Lamont and Thaler, 2003). However, recent studies by Smith (2008) provide evidence that with the exception of South Africa, stock markets in Africa are not weak-form efficient. This would infer that the law of one price is unlikely to hold.

The findings provide confirmation of the lack of price-integration between equity markets in Africa. In addition, the small degree of price-integration that does exist is between markets with common institutions, such as Egypt and Tunisia plus a weaker link to France. Equally, there is evidence of price-integration between Namibia and South Africa, supporting the earlier evidence (Hearn and Piesse, 2002) although this is a special case as 68% of Namibian firms have primary listings in Johannesburg. However, in this wider country study severe illiquidity, the small size of the exchanges and the skewed ownership of assets affect the returns generating process, which results in some evidence of price-integration between seemingly unrelated markets such as Kenya with Morocco and Tunisia.

The paper proceeds as follows. The next section briefly reviews the theoretical concepts of the Law of One Price. Section 3 discusses the characteristics of the sample and some data issues. The models and results are in Section 4. The final section concludes with a discussion of the implications for African financial markets and policy recommendations.

2. Theoretical Considerations of Equity Market Price Integration

Two prominent strands of literature define approaches to measuring financial market integration. The first is the use of asset pricing models, commonly variations of the Capital Asset Pricing model (CAPM) or the Arbitrage Pricing model (APT), which are used to measure premiums between assets and markets. However, both are hindered by rigid assumptions that concern the joint hypothesis of market efficiency, which states that security prices contain all information available, and for weak form efficiency, that prices reflect information to the point where the marginal benefits of acting on information do not exceed the marginal costs. As a result of this joint-hypothesis, when pricing models produce unexpected results, it is difficult to apportion anomalous results due to hidden information (Fama, 1991).

The second uses an extended form of correlation analysis and statistical cointegration methods. These are either Vector Autoregressive Error Correction models (VECM), or Autoregressive Distributed Lag models (ARDL) to analyse long run relationships between variables. While there are several applications of these methods in developed country markets using index level data, such as Corhay (1993), there are far fewer applications in developing countries. There are disadvantages to the use of index level data due to aggregation bias where only a few stock in the index account for much of the capitalization, activity and movement, a situation that is particularly prevalent in emerging markets. Consequently, empirical applications relate to valuation differences between closed-end country funds and American and Global Depository Receipts (ADR/GDR) and their underlying assets (Lamont and Thaler, 2003). However, this is not appropriate in African markets as there are few liquid ADR or GDR instruments. Furthermore, the only closed-end funds currently are restricted to Egypt or South Africa (Bloomberg LP, 2009).

This study extends Piesse and Hearn (2002) but concentrates specifically on the largest African markets in order to assess the importance of the regional hubs and the potential for integration with world markets, represented here by London and Paris. There is a risk of aggregation bias through the use of market indices as proxies for the underlying national markets, but this is unavoidable due to the lack of country funds and liquid ADR/ GDR noted above. Vector Autoregression (VAR), VECM and ARDL models are useful in interpreting both potential price integration and feedback effects between markets when there is evidence of integration. Harris et al (1995) used these methods to test the Law of One Price in the context of weak-form information efficient markets with prices incorporating all possible information, by focussing on the price history of one stock listed on three domestic exchanges in the US in a study that was free of any potential aggregation bias despite using indices. This study takes the same approach while facing considerably greater challenges.

3. Data

a) Sample Markets and indices

This section briefly contrasts the most important institutional differences between the markets used. An extended description of the market institutions across Africa is in Hearn and Piesse (2005).

The legal origins of the legal and regulatory systems in Africa can largely be traced back to the influence of the former colonial powers, in particular the UK and France. South Africa, by virtue of its history, developed a distinctive Roman-Dutch legal code, although the commercial code is heavily influenced by English common law, a structure that is shared by Namibia. Table 1 shows the differences in legal origins between the sample markets and provides comparisons between corporate governance regimes and the minimum primary listings criteria. As seen in the table, these vary considerably in terms of capital base requirements and audited history. The differences in primary market regulation and information disclosure give an indication of the degree of asymmetric information faced by potential investors, a factor that discourages investment by raising transactions costs. In general, short sales are prohibited in all markets with the exception of South Africa, which has a well-capitalized brokerage industry and follows international standards including G30¹ compliance. The brokerage industry in most other markets is small and even in Egypt and Nigeria, where there are 141 and 219 licensed brokers respectively, it is highly concentrated with only a small group of firms precipitating order flow.

Table 1

Table 2 shows the market concentration profiles in terms of capitalization and traded value on both a market-wide and industry sector level. London and Paris clearly have the highest number of listed firms and also a fairly equal distribution in terms of traded value and capitalization across sectors. However, in the African markets the profile is different. Value is concentrated in only a small number of stocks and this is centred on the local finance industries. For example, concentration of the local finance industry ranges from 59.74% of capitalization in Tunisia to 24.72% in Egypt, compared to London and Paris where the financial sector accounts for 17.80% and 15.14% respectively.

Table 2

The sample includes the major African markets that are central to the NEPAD policy of regional integration that is intended to be implemented through between regional hub markets, namely Egypt (North Africa), Kenya (East Africa), Nigeria (West Africa) and South Africa (Southern Africa). In

¹ The Group of Thirty is the most influential body to encourage the standardization and improvement in global securities administration. Following a symposium in London in March 1989, the following recommendations were agreed: i) Brokers should match trades on day after deal date (T+1); ii) Trade confirmation on trade day plus 2 days (T+2); iii) Central Depository for safe keeping of shares; iv) Net basis settlement of cash and stock; v) Settlement takes place as delivery vs. payment or receipt vs. payment; vi) Settlement in same day funds; vii) Settlement effected on trade date plus 3 days (T+3); viii) Securities lending should be permitted; ix) International securities numbering system must be adopted (ISIN code).

addition, Namibia is included as this market already shares an integrated link with South Africa, Morocco and Tunisia because of their importance in the North African Maghreb region and Mauritius, due to its importance in SADC as a prominent offshore market. Very small and highly illiquid markets are excluded from the study. Nominal end-of-week closing price-index values are from the national stock exchanges for Tunisia, Namibia and Mauritius and for all other markets from Datastream. UK sterling exchange rates are from Datastream and background information on the markets is from Bloomberg, Standard & Poors Global Markets Factbook and national stock exchange websites.

Details of domestic index construction and trading systems and times are in Table 5. Trading times in all markets are largely synchronous, as countries are either one hour less or two hours more than the South African time zone. The index data are converted to their UK sterling equivalence, which assumes long term purchasing power parity between national currencies and sterling to reduce the effects macroeconomic uncertainty in a region of high inflation. While this largely mitigates currency fluctuation effects on returns it facilitates the study of price-integration from the viewpoint of a UK-based investor. All are expressed in natural logarithms and differenced to produce the final adjusted returns series.

Table 3

Table 4 provides details of the stocks that are included in the country indices. As expected, the stocks in the London and Paris indices, which form the FTSE 100 and CAC40, have the lowest percentage daily zero returns, 8.90% and 5.91% respectively, and the lowest bid-ask spreads, of 0.58% and 0.27% respectively. They also have the highest average trading activity and market capitalization indicating that there are large, actively traded and highly liquid. Egypt and South Africa have the next highest percentage daily zero returns, at 35.35% and 16.82%, while Morocco and Kenya have values of 46.67% and 48.56%, indicating a similar degree of liquidity markets. There are similar findings for the Bid-Ask spread in each case. The least liquid markets are Tunisia (73.80% daily zero returns), Nigeria (78.19% daily zero returns), and Mauritius (84.69% daily zero returns). Namibia is the most illiquid of all the markets. The percentage daily zero returns are 59.76% for the overall market, which is composed of largely primary listed South African stocks with a secondary Namibian listing, and 92.35% for the local market. These indicators of price-rigidity are also reflected in the bid-ask spreads, which at 25.59% and 27.13% for the overall and local markets are by far the highest in the sample. The evidence also suggests that firms are smaller than in other markets but more actively traded in terms of turnover than in Mauritius, Kenya, Tunisia and Nigeria, which is an indication of the highly skewed nature of these markets, as seen earlier in Table 2.

Table 4

b) Returns series analysis

The returns series of the sample are all characterised by highly skewed and leptokurtic distributions, as shown in Table 5. Kenya has the highest level of kurtosis (65.52) while all the remaining markets fall between kurtosis values of 4 and 8. Kenya also has the highest level of skewness (1.08) followed by Morocco (-0.85), Namibia Overall (-0.81) and Namibia Local (-0.72). The deviations from normality in Kenya are largely due to the presence of large outliers. A small, illiquid market such as Kenya is unable to absorb shocks that would be relatively insignificant in a larger more liquid market. The outliers in Kenya are largely explained by macroeconomic and exchange rate fluctuations as opposed to corporate events on the market itself.

There are very low levels of correlation across the sample with a few notable exceptions. There are very high correlations, in excess of 80%, between Paris and London and between South Africa and Namibia Overall. Correlations in excess of 60% are between South Africa, London and Paris, while those in excess of 50% are between Namibia Overall and the European markets.

Table 5

4 Econometric Methods

The study uses two unit root tests, Augmented Dickey Fuller (ADF) (Dickey and Fuller (1979)) and the KPSS test (Kwiatkowski et al, 1992), to investigate the presence of unit roots in all index time series. The second stage involves the triangulation of VAR methods (Johansen (1988); Johansen and Juselius (1991)) and ARDL (Pesaran and Shin (1995)) to assess the level of cointegration between markets.

a) Testing for the presence of Unit Roots

The application of both the ADF and KPSS unit root tests should provide more robust evidence of the nonstationarity of the underlying index time series. Given the ADF test has a well known shortcoming of being unable to differentiate between a unit root and a weakly stationary series (Evans, 2006) and performs poorly in the presence of structural breaks, the additional KPSS test is used. This effectively overcomes the ADF tests lack of power to reject the null hypothesis of a unit root when testing a null hypothesis of stationarity.

A considerable literature has developed recently using the ADF test to elaborate on the presence of unit roots usually as a prelude to undertaking further study into the informational efficiency of market time series (Evans (2006) and Smith (2005)) or prior to the application of VAR and ARDL cointegrational methodology (Phylaktis (1999) and Piesse and Hearn (2002)). The potential for higher order correlation within time series is mitigated by including lagged differenced terms of the dependant variable in the regression equation. This is defined

$$y_t = \alpha + (1 - \phi)\delta t + \phi y_{t-1} + \sum_{i=1}^{p+1} \phi_i y_{t-i} + \varepsilon_t, t = 1, \dots, n \quad (1)$$

where y_t is the time series, δ_t is the deterministic trend and α is the non-zero drift constant. Correspondingly, the test for first differences, with a new null hypothesis is $H_0: \rho = 1 - \phi = 0$, is defined:

$$\Delta y_t = \alpha + \rho \delta t - \rho y_{t-1} + \sum_{i=1}^p \gamma \Delta y_{t-i} + \varepsilon_t, t = 1, \dots, n \quad (2)$$

As time trends are a common feature of financial time series both ADF tests are performed both with and without a constant and deterministic trends, or the $(1 - \phi)\delta t$ term. The Schwartz Bayesian Criterion (SBC) is used to assess the appropriate lag length of models. The null of a unit root is accepted (rejected) if the ADF test statistics is less (more) than the critical value at the 1%, 5% and 10% level of significance.

The KPSS test offers an alternative approach to testing for unit roots in time series in the light of the failings of the standard ADF procedure. Questions regarding the false rejection of unit root hypotheses first arose through an application of standard Dickey-Fuller (1979) techniques to US economic time series (Nelson and Plosser, 1982). DeJong et al (1989) provided further support for the inability of the ADF tests to have sufficient power against stable autoregressive alternatives with roots near unity while Diebold and Rudebusch (1990) provided evidence that they also performed poorly when applied to fractionally integrated time series. In contrast to the ADF test, the KPSS method sets the stationarity around a deterministic trend of the series as the null hypothesis and alternate hypothesis of non-stationarity (unit root). Following Evans (2006) the KPSS test statistic is calculated as follows:

$$\eta_u = \frac{T^{-2} \sum_{t=1}^T S_t^2}{S^2(L)} \quad (3)$$

where L is the lag parameter and S_t is the cumulative sum of the residuals (e_t) from the regression of the series on a constant and a linear trend (t),

$$P_t = \alpha + \beta t + e_t \quad (4)$$

$$S_t = \sum_{i=1}^t e_i \quad t = 1, 2, \dots, T \quad (5)$$

and

$$S^2(L) = T^{-1} \sum_{t=1}^T e_t^2 + 2T^{-1} \sum_{s=1}^L \left[\left(1 - \frac{S}{L+1} \right) \sum_{t=s+1}^T e_t t_{t-s} \right] \quad (6)$$

b) Cointegration using a Vector Autoregressive process

The Augmented Vector Autoregressive (AVAR) model from Johansen (1989, 1991) is defined

$$z_t = a_0 + a_1 t + \sum_{i=1}^p \Phi_i z_{t-i} + \Psi w_t + u_t \quad t=1,2,\dots,n \quad (7)$$

where z_t is a $m \times 1$ vector of jointly determined (endogenous) variables, t is a linear time trend, w_t is a $q \times 1$ vector of exogenous variables, and u_t is an $m \times 1$ vector of unobserved disturbances assumed to satisfy the assumptions of *iid*, homoskedasticity, serially uncorrelated, orthogonality, normality with strict adherence to a multivariate normal distribution and stability.

Cointegrating VAR models are underlined by the general vector error correction model (VECM) defined

$$\Delta y_t = a_{0y} + a_{1y} t - \Pi_y z_{t-1} + \sum_{i=1}^{p-1} \Gamma_{iy} \Delta z_{t-i} + \Psi_y w_t + u_{ty} \quad (8)$$

where $z_t = (y_t' x_t')'$

This model distinguishes between four categories of variables, namely:

1. y_t which is an $m_y \times 1$ vector of jointly determined (or endogenous) $I(1)$ variables
2. x_t which is an $m_x \times 1$ vector of $I(1)$ exogenous variables
3. w_t which is a $q \times 1$ vector of $I(0)$ exogenous variables
4. Intercepts and deterministic linear trends

The implicit VAR model for the $I(1)$ exogenous variables, x_t , is given by

$$\Delta x_t = a_{0x} + \sum_{i=1}^{p-1} \Gamma_{ix} \Delta x_{t-i} + \Psi_x w_t + v_t \quad (9)$$

and assumes the x_t 's are not themselves cointegrated. Although (9) does not explicitly contain a deterministic trend, the levels of x_t will be trended due to the coefficients, a_{0x} .

Combining equations (8) and (9) results in following:

$$\Delta z_t = a_0 + a_1 t - \Pi z_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta z_{t-i} + \Psi w_t + u_t \quad (10)$$

where $u_t = (u_{ty} v_t)'$, $a_0 = (a_{0y} a_{0x})'$, $a_1 = (a_{1y} 0)'$
 $\Pi = (\Pi_{0y} 0)$, $\Gamma_i = (\Gamma_{iy} \Gamma_{ix})'$, $\Psi = (\Psi_y \Psi_x)'$

which is a restricted vector error correction form of the original AVAR model (1). The intercept and the trend coefficients, a_{0y} and a_{1y} are $m_y \times 1$ vectors. Π_y is the long-run multiplier matrix of order $m_y \times m$, where $m = m_x + m_y$, Γ_{1y} , Γ_{2y} , $\dots$, $\Gamma_{p-1,y}$ are $m_y \times m$ coefficient matrices capturing the short-run dynamic effects, and Ψ_y is the $m_y \times q$ matrix of coefficients on the $I(0)$ exogenous variables. Under the assumption that $\text{rank}(\Pi_y) = r$, i.e. when there exists r cointegrating relations among the variables in z_t , then

$$\prod_y = \alpha_y \beta'$$

where α_y and β and $m_y \times m$ and $m \times r$ matrices, each with full column rank r . The stochastic trace statistics then determine the number of cointegrating vectors.

c) Granger-causality for cointegrating and non-cointegrating systems

Following Johansen (1991), Granger non-causality for a system of $I(1)$ variables and a common cointegrating vector can be determined through the transformation of the original AVAR (7) into a bivariate VECM in expression (11(i) and 11(ii)) where each y_{it} term is a sub-element of the z_t variable in (7).

$$\Delta y_{1t} = \alpha_0 + (y_{1t-1} - \gamma_{2t-1}) + \sum_{i=1}^k \alpha_{1i} \Delta y_{1t-1} + \sum_{i=1}^k \alpha_{2i} \Delta y_{2t-1} + \varepsilon_{1t} \quad (11i)$$

$$\Delta y_{2t} = \beta_0 + (y_{1t-1} - \gamma_{2t-1}) + \sum_{i=1}^k \alpha_{1i} \Delta y_{1t-1} + \sum_{i=1}^k \alpha_{2i} \Delta y_{2t-1} + \varepsilon_{1t} \quad (11ii)$$

where the $(y_{1t-1} - \gamma_{2t-1})$ represents a drift error correction process for the entire system to re-stabilise following short term deviations from the long term cointegrating trend.

The corresponding measure of causality for an AVAR system of non-cointegrated variables is block Granger non-causality. The null hypothesis that coefficients of a subset of jointly determined variables in the AVAR are equal to zero is tested using the log-likelihood ratio statistic. Statistically it provides a measure of the ability of one set of lagged values of a variable to predict another set of lagged values of a second variable within the model. Assuming $z_t = \begin{pmatrix} z_{1t}' & z_{2t}' \end{pmatrix}'$, where z_{1t} and z_{2t} are $m_1 \times 1$ and $m_2 \times 1$ subsets of z_t , and $m = m_1 + m_2$. The block decomposition is then given by equation (12):

$$z_{1t} = a_{10} + a_{11} + \sum_{i=1}^p \Phi_{i,11} z_{1,t-j} + \sum_{i=1}^p \Phi_{i,12} z_{2,t-j} + \Psi_1 w_t + u_{1t} \quad (12i)$$

$$z_{2t} = a_{20} + a_{21} + \sum_{i=1}^p \Phi_{i,21} z_{1,t-j} + \sum_{i=1}^p \Phi_{i,22} z_{2,t-j} + \Psi_2 w_t + u_{2t} \quad (12ii)$$

The hypothesis that the subset z_{2t} does not Granger-cause z_{1t} is defined

$$H_G : \Phi_{12} = 0$$

where $\Phi_{12} = (\Phi_{1,12}, \Phi_{2,12}, \dots, \Phi_{p,12})$. The standard F-test with a χ^2 distribution can be used to test the null hypothesis that all coefficients are jointly equal to zero.

d) Autoregressive distributed lag approach

There has been a considerable increase in the literature applying ARDL techniques in the study of long term relationships between series since the development of these methods in Pesaran and Shin (1995). The benefits compared to VAR methods are that pre-testing series for unit roots is not necessary as a prerequisite for measuring cointegration. Following Pesaran and Shin (1995) the formal augmented ARDL model is defined

$$\phi(L, p)y_t = \sum_{i=1}^k \beta_i(L, p)x_{it} + \delta' w_t + u_t \quad (13)$$

where $\phi(L, p) = 1 - \phi_1 L - \phi_2 L^2 - \dots - \phi_p L^p$

and $\beta_i(L, q_i) = \beta_{i1} + \beta_{i1}L + \beta_{i2} + \dots + \beta_{iq_i}L^{q_i} \quad i = 1, 2, \dots, k \quad (14)$

and where L is a lag operator such that $LY_t = y_{t-1}$, and w_t is an $s \times 1$ vector of deterministic I(0) variables including the intercept term, dummy variables, time trends or exogenous I(1) variables with fixed lags, none of which are used in this study to avoid any risk of pre-testing bias from a priori knowledge of events.

ARDL models are estimated by first collecting OLS estimates of equation 13 for all possible values of $p = 0, 1, 2, \dots, m$; $q_i = 0, 1, 2, \dots, m$; and $i = 1, 2, \dots, k$, that is, for a total of the $(m+1)^{k+1}$ different ARDL models. The choice of one of the $(m+1)^{k+1}$ estimated models was made using the SBC informational criteria.

The ECM that corresponds to the model selected can be obtained by rewriting equation 13 in terms of the lagged levels and the first differences of $y_t, x_{1t}, x_{2t}, \dots, x_{kt}$, and w_t . Substituting these lagged and differenced terms into equation 13 and rearranging gives

$$\Delta y_t = -\phi(1, \hat{p})EC_{t-1} + \sum_{i=1}^k \beta_{i0} \Delta x_{it} + \delta' \Delta w_t - \sum_{j=1}^{\hat{p}-1} \phi^* y_{t-j} - \sum_{i=1}^k \sum_{j=1}^{\hat{q}_{i-1}} \beta_{ij}^* \Delta x_{i,t-j} + u_t \quad (15)$$

where the error correction term, EC_t , is defined

$$EC_t = y_t - \sum_{i=1}^k \theta_i x_{it} - \hat{\psi}' w_t \quad (16)$$

where the long run coefficients for the response of y_t to a unit change in x_{it} are estimated by

$$\theta_i = \frac{\hat{\beta}_i(1, \hat{q}_i)}{\phi_i(1, \hat{p})} = \frac{\hat{\beta}_{i0} + \hat{\beta}_{i1} + \dots + \hat{\beta}_{iq_i}}{1 - \hat{\phi}_1 - \hat{\phi}_2 - \dots - \hat{\phi}_p} \quad (17)$$

and where $\hat{p}$ and $\hat{q}_i$, $i = 1, 2, \dots, k$ are the selected estimated values of p and q_i , $i = 1, 2, \dots, k$. Similarly, the long run coefficients associated with the deterministic/ exogenous variables with fixed lags are estimated by

$$\hat{\psi} = \frac{\hat{\delta}(\hat{p}, \hat{q}_1, \hat{q}_2, \dots, \hat{q}_k)}{1 - \hat{\phi}_1 - \hat{\phi}_2 - \dots - \hat{\phi}_p} \quad (18)$$

and where $\hat{\delta}(\hat{p}, \hat{q}_1, \hat{q}_2, \dots, \hat{q}_k)$ denotes the OLS estimate of δ for the selected ARDL model.

ARDL estimation is in two stages. The first relates to testing the null hypothesis of whether all the coefficients of the long term forcing variables or error correction term in (16) are jointly equal to zero against an alternate hypothesis of their being jointly significantly different from zero. Following standard OLS estimation methods an F-test is used although with a non-standard distribution this is further categorized into bounds where critical values are in Pesaran et al. (1996). The lack of necessity for testing the initial presence of unit roots in series is justified by the F-statistic being greater than the upper bound critical value, which infers all component series within ARDL model are I(1). Unit root testing is required when values from the F-test fall between the upper and lower bands, while values falling below the lower band can be assumed to be I(0). The error correction version of ARDL (p,q) model for a two-component system, which is a modification of (15) is defined

$$\Delta y_{1t} = \delta' \Delta w_t + \sum_{i=1}^p \beta_i \Delta y_{1t-i} + \sum_{i=1}^p \beta_i \Delta y_{2t-i} + \delta_1 y_{1t} + \delta_2 y_{2t} + u_t \quad (19)$$

where $\delta' \Delta w_t$ is a vector of constant and time trend. The hypothesis to be tested using the non-standard distributed F-test is the null of non-existence of the long-run relationship defined

$$H_0 : \delta_1 = \delta_2 = 0$$

against

$$H_1 : \delta_1 \neq \delta_2 \neq 0$$

The second stage is the estimation of parameters within ARDL model and the long run coefficients in (13), (15) and (16).

5. Models and Results

a) Unit Root tests

The results from the unit root tests are reported in Table 6. The null hypothesis of a unit root using the ADF test cannot be rejected for all series both with and without a deterministic trend at the 99% confidence level. Similar results were obtained from using the KPSS test (without a trend) with the null hypothesis of stationarity rejected at the 99% confidence level for all series except Namibia Local, Egypt and Tunisia where the confidence level was 95%. However, while the null hypothesis of stationarity

could not be rejected for all series in first differences, the results for these three series proved ambiguous in rejecting the null hypothesis at the 95% confidence level. Similar results were obtained using the KPSS test (with trend) although equally ambiguous results were obtained for the series in first differences for Kenya, Egypt and Nigeria. The ambiguities are most likely caused by the presence of outliers in the series and overall the evidence would suggest the presence of a unit root in series levels.

Table 6

b) Bivariate tests of cointegration

Table 7 reports the Johansen trace statistics for the bivariate VAR models, as outlined in expression (10). The VAR models constructed have each of the four regional hub market indices in addition to each of the other market indices in turn. The results indicate Nigeria has no cointegrating vectors, and thus there is no relationship with any other market while Egypt, Kenya and South Africa have only very few long term relationship with other series. The null hypothesis of no cointegrating vectors is rejected at the 95% confidence level in the VAR including Egypt and France and Tunisia. A similar rejection of the null hypothesis at the same confidence level is found for the system including South Africa and Namibia Overall, and between Kenya and Morocco and Kenya and Tunisia. The evidence at this stage suggests that as expected there is very little price-integration amongst equity markets in Africa with only a few exceptions and these are between markets with shared institutions, such as South Africa and Namibia Overall, and between France, Egypt and Tunisia. The results concerning Kenya and its long run relationship with Tunisia and Morocco are initially confusing owing to the heterogeneity in institutions, macroeconomic environments and legal regimes. However, a likely explanation is that the index returns generating process in Kenya is very similar to that in the two illiquid North African markets, which would cause the statistical measure of cointegration between markets to be apparent when these markets have no other obvious ties and thus the relationship is spurious.

Table 7

c) Granger non-Causality for cointegrating and non-cointegrating systems

Granger non-causality between component series of cointegrating VAR models is investigated using the Vector Error Correction Model (VECM) defined in expressions 11(i) and 11(ii). The results of the error correction models are in Appendix 1.

The results for the relationship between Egypt and France indicate that the Paris index is significant in affecting Egyptian returns in the short run while the long-run error correction model does not have a statistically significant role. Conversely, the long run cointegration relationship in the error correction model does have a small but statistically significant role in explaining French returns and the

lagged values of dependent variable that account for the short term system dynamics. The very small time trend included in the long run cointegrating vector is contemporaneous in being representative of various other factors affecting the price levels between the two indices such as exchange rate, institutional and macroeconomic differences. In the Egypt – Tunisia system the long term error correction model is statistically significant in explaining returns in both Tunisia and Egypt only with no lagged dependent variables in the expression for either. However, the size of the ECM coefficient in the expression explaining Egyptian returns is four times greater than that for Tunisia, indicating that Egypt is more affected by Tunisia than the inverse. The three markets have similar institutions, with legal regimes and institutions derived from French civil code law, while illiquidity is greatest in Tunisia, where trading is by call auction, followed by Egypt. A possible explanation for the direction of Granger non-causality from Tunisia to Egypt and from Egypt to France is the affects of illiquidity on the returns generating processes in all three markets.

The evidence for the relationship between South Africa and Namibia Overall returns shows that contrary to the earlier study by Piesse and Hearn (2002) Granger non-causality runs from South Africa to Namibia, supported by the statistical significance of the ECM term and the size and significance of the F-statistic. The size of this long-run relationship has also increased in absolute terms, seen from the long run coefficients taken from the normalised cointegrating vector, as a 1% change in the levels of South Africa leads to a 0.8531% change in Namibia. It is notable that the contemporaneous time trend coefficient is considerably smaller in the long run cointegrating vector between these two markets than between either Egypt and either Tunisia or France indicating fewer external variables influencing price levels between these two markets. This provides further indication of the strength of common institutions and common macroeconomic environment between Namibia and South Africa.

Finally, the evidence for Granger non-causality in the case of the two relationships centred on Kenya is similar to that for those centred on Egypt where the affects of illiquidity on the returns generating process affected the direction of the relationships. The ECM in the Kenya – Morocco system is only significant in explaining Moroccan returns and not Kenyan. Similarly, the ECM in the Tunisia – Kenya relationship is only significant in explaining Kenyan returns as the dependent variable and not those of Tunisia. Given the considerable institutional differences the only commonality between all three markets is their small size, relative insignificance as a source of finance in contrast to their better developed banking sectors and severe illiquidity. Thus, the returns generating processes of all three indices and the degree of co-movement is a function of the degree of inactivity than any tangible homogeneity in institutional development.

Table 8 reports the results for the block Granger non-causality, which investigates the statistical interdependencies between the lagged first differences of dependent variables in a non-cointegrating VAR

model. The size, significance and direction of most of the Granger non-causality relationships are expected given prior knowledge of the markets. South Africa and Nigeria have the fewest relationships when included in bivariate non-cointegrating VAR models with other index series. While the former is the largest and most liquid in Africa the latter is quite segmented with poor regulatory enforcement, a lack of information disclosure and confusion over the application of Nigerian or OECD accounting standards in auditing. Both of these markets have few relationships with the rest of the sample while Nigeria is Granger non-causally affected by London, Paris, Morocco and Mauritius, and South Africa Granger non-causally affects Egypt, Namibia Overall market and Mauritius. There are many more inter-relationships between Egypt and Kenya and the rest of the sample. Egypt Granger non-causally affects Nigeria and Mauritius while being affected by Namibia Overall, London and Paris. Kenya is Granger non-causally affected by South Africa, Egypt, London, Paris and Namibia Overall while having a mutually Granger non-causal relationship with Mauritius and Tunisia.

Table 8

d) Augmented Autoregressive Distributed Lag (ARDL) Analysis

The results from the initial stage of the ARDL methodology to test the null hypothesis that all the coefficients in the long run error correction term of the ARDL model are statistically different from zero are in Table 9. Seven ARDL models had the null hypothesis rejected at the 99% confidence level inferring that series were both I(1) and cointegrated. These included cointegrating relationships between Kenya and Namibia Local, Morocco, and Paris, between Egypt and Morocco and Tunisia, and between Nigeria and both the markets in Namibia. A further nine F-statistics fell between the upper and lower critical value bands. In these cases reference is made to the earlier unit root tests. The relationships with values falling between the bands are between Kenya and Namibia Local, between South Africa and Nigeria, Mauritius, both Namibian markets, and Morocco, and finally between Egypt and Namibia Local and Paris.

Table 9

The results of the ARDL models, with optimal lag criteria given by the SBC informational criterion, are in Appendix 2. Generally the evidence from the ARDL methods supports the earlier VAR methodology.

In the case of Kenya, the long run cointegrating relationship between variable levels is significant in explaining the returns in the small and highly illiquid Namibian local market. Equally, the long run relationship between variable levels is significant in explaining the index returns in Morocco and also in Paris, which is interestingly. The directions of these relationships are likely explained by the severity of illiquidity affecting the returns generating processes of the markets in the ARDL system as opposed to

explanations relating to common institutions. The directions of the relationships in the ARDL models centred on South Africa are more intuitive with the long term relationship with Nigeria, Morocco, Mauritius, both Namibian markets being highly significant in explaining the returns of these other markets. In line with similar findings involving VAR methods the relationship is particularly strong between South Africa and both Namibian markets, where the direction of influence from South Africa. However, owing to the high level of dual listings this relationship with South Africa is most significant and has the adjusted R-squared of all the ARDL models. In the case of Egypt the long adjustment term is significant in explaining the returns of Namibia Local, Morocco and Paris but not the returns of Egypt itself. This is probably the result of a combination of genuine shared institutions, as with the case of Morocco and France following French civil code along with Egypt, but also of illiquidity, as in the Namibian local market. Finally, the relationships between Nigeria and the both Namibian markets show that Nigerian returns are influenced by the long run error correction term in the case of the Namibian Overall while the results for the Namibian local market are inconclusive as they are not statistically different from zero.

6. Conclusions and Policy Implications

This study has examined the extent of price-integration between the major markets in Africa and Paris and London using two cointegration methods, Vector Autoregression and Autoregressive Distributed Lag. The study has been motivated by the recent NEPAD and SADC policy drives to integrate the equity markets and introduce common institutions in Africa within a phased approach of first integrating regional markets centred on the geographical hubs of Egypt (North), Kenya (East), Nigeria (West) and South Africa (Southern).

The evidence from both the VAR and ARDL methods reveals that African markets are generally price-segmented and only those with shared financial and economic institutions such as Namibia and South Africa and Egypt, Tunisia and France is there any evidence of price-integration. However, the effects of severe illiquidity and the low trading activity that does occur is highly concentrated and this causes ambiguous strong long term relationships to appear between markets, which is probably spurious. This is the most likely explanation of the strong statistical long term relationship between Tunisia, Kenya and Morocco with Granger non-causality running from the most illiquid market (Tunisia) to the least illiquid market (Morocco). The evidence from the block Granger non-causality that results from the non-cointegrating VAR systems concerning the short term statistical dependencies between different markets lagged returns is largely in line with expectations. South African returns Granger non-cause the lagged returns of Egypt, Mauritius and Namibia Overall, while Egypt exerts short term influence on returns of Nigeria, Mauritius and Namibia Overall. In Nigeria, returns are Granger non-causally affected by both

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Mauritius and Morocco while Kenya is affected by South Africa, Egypt, Namibia Overall. Both Nigerian and Kenya are both affected by and affecting Tunisia and Mauritian returns. Finally, as expected London and Paris exert short term block Granger non-causality on the returns in Kenya, Egypt and Nigeria.

Overall these results indicate a general lack of long term price-integration across markets in Africa and suggest that any relationships that are found are due to shared institutions or with a common level of illiquidity that gives potentially misleading results. Thus, considerable improvement in both economic and financial institutions is necessary before markets can be formerly integrated.

For Peer Review

References

- Bloomberg L P (2009). Institutional fund stock holdings for Africa 1/1/90 to 1/01/07. Retrieved December 2, 2006 from Bloomberg terminal.
- Corhay A, Rad A and Urbain J (1993). Common Stochastic Trends in European Stock Markets, *Economics Letters*, 42, 385–90.
- DeJong D, Nankervis J, Savin N and Whiteman C (1989). Integration versus trend stationary in macroeconomic time series, Working paper no. 89-99, Department of Economics, University of Iowa, Iowa City, IA, USA
- Dickey D and Fuller W (1979). Distribution of the Estimators for Autoregressive Time Series with a unit root. *Journal of the American Statistical Association*, 74:366, 427-431
- Diebold F and Rudebusch G (1990). On the power of Dickey-Fuller tests against fractional alternatives, Finance and Economics discussion series 119, United States Board of Governors of the Federal Reserve system
- Evans T (2006). Efficiency tests of the UK financial futures markets and the impact of electronic trading systems. *Applied Economics*, 16:1, 1273-1283
- Fama E (1991). Efficient Capital Markets: II. *The Journal of Finance*, 46:5, 1575-1617.
- Harris de B, McNish T, Shoesmith G and Wood R (1995). Cointegration, Error Correction, and Price Discovery on Informationally Linked Security Markets. *The Journal of Financial and Quantitative Analysis*, 30:4, 563-579.
- Hearn B, and Piesse J (2005). Integration and the Asymmetric Transmission of Volatility: A Study of Equity Markets in Sub Saharan Africa. *South African Journal of Economics*, 73:1. 36-53
- Hearn B and Piesse J (2009a). The limited role of small stock exchanges in economic development: A case study of Mozambique and Swaziland. *Development Southern Africa*, Forthcoming
- Hearn B and Piesse J (2009b). Modelling size and illiquidity in West African equity markets. Working paper no. WP-EMG-12-2009, *Emerging Markets Group Cass Business School*
- Johansen S (1988). Statistical Analysis of Cointegrating Vectors. *Journal of Economic Dynamics and Control*, 21:2, 231-254
- Johansen S (1991). Estimation and Hypothesis testing of cointegrating vectors in Gaussian Vector Autoregressive Models. *Econometrics*, 59:6, 1551-1580
- Kwiatkowski D, Phillips C, Schmidt P and Shin Y (1992). Testing the null hypothesis of stationarity against the alternate of a unit root: how sure are we that economic times series have a unit root?, *Journal of Econometrics*, 54, 159-178
- Kenny C and Moss T (1998). Stock Markets in Africa: Emerging Lions or White Elephants? *World Development*, 26:5, 829-843

Lamont O and Thaler R (2003). Anomalies: The Law of One Price in Financial Markets. *The Journal of Economic Perspectives*, 17:4) 191-202

La Porta R, Lopez-de-Silanes F and Shleifer A (2008). The Economic Consequences of Legal Origins. *Journal of Economic Literature*, 46, 285-332

Lavelle K (2001). Architecture of Equity Markets: The Abidjan Regional Bourse, *International Organization*, 55, 717-742.

Levy E, Sergio Y and van Horen S (2006). International Financial Integration through the Law of One Price, World Bank Policy Research Paper 3897, April 2006. Washington, DC: World Bank

Nelson C and Plosser C (1982). Trends and random walks in macroeconomic time series, *Journal of Monetary Economics*, 10, 139-62

Pesaran M and Shin Y (1995). An autoregressive distributed lag modelling approach to cointegration analysis. DAE Working Paper No. 9514, Dept. of Applied Economics, University of Cambridge.

Pesaran M, Shin Y and Smith R (1996). Testing for the existence of a long-run relationship. DAE Working Paper No. 9622, Dept. of Applied Economics, University of Cambridge.

Phylaktis K (1999), Capital Market integration in the Pacific Basin region: an impulse response analysis, *Journal of International Money and Finance*, 18, 267-87

Piesse J and Hearn, B (2002). Equity Market Integration versus Segmentation in Three Dominant Markets of the Southern African Customs Union: Cointegration and Causality Tests. *Applied Economics*, 34:14, 1711-1722

Smith G and Jefferis K (2005). The Changing Efficiency of African Stock Markets, *South African Journal of Economics*, 73:1, 54-67

Table 1. Summary of African primary and secondary market regulations

	South Africa	Namibia	Egypt	Morocco	Mauritius	Kenya	Nigeria
Panel 1: Primary Market Regulations							
Commercial Law	Roman-Dutch. Commercial code based on English Common Law	Commercial	French civil code	French civil code	French civil code	English Common Law	English Common Law
Corporate Governance	King II report recommendations		OECD principles followed	OECD principles followed	OECD principles followed	Loosely based on UK Cadbury report	OECD principles followed
Minimum Requirement	Min. capital base of Rand 25m. Min pre-tax audited profit in last 3 years of Rand 8m. Disclosure and corporate governance in accordance with King II report. 13 core principals of JSE listings rules. Net asset worth of Rand 25m verified by JSE approved auditor.		Min Capital base: LE 500m. Annual reports compiled to International Accounting Standards.	Min capital base: Dirham 75m. Filed audited financial statements for previous 3 years prior to listing. Conform to International Accounting Standards.	Min capital base: Rupees 20m. Filed audited financial statements for previous 3 years prior to listing. Min 25% free float	Min capital base: Kshs 50m. Auditing compliant with International Accounting Standards. Corporate governance and disclosure approved by CMA. Net asset worth: Kshs 100m	Audited annual reports in accordance to IAS. Quarterly interim profit and sales reports.
Panel 2: Secondary Market Regulation							
No. licensed Brokers	101	6	141*	15	21	18	219
Short Sales Permissible?	Yes	Not in local market	No	No	No	No	No
Capital Gains Tax	Exempt		Exempt	Exempt	Exempt	Exempt	10%
Other Taxes and Fees	VAT at commission rate 0.5% marketable security. 1.0% stamp duty. Investor Protection fee: 0.0002%		None	VAT applied to the amount of commissions is 10%. No other tax/ fees.	None	Withholding Tax on Dividends is 10% for non-residents and 5% for residents. Otherwise no Capital Gains, Stamp Duty, nor VAT	Stamp Duty of 0.07%. SEC fee of 1%. VAT levied as % of commission fee. Withholding tax on dividend and interest is 10%; corporate income tax, 35%

Source: Compiled by authors from national stock exchange websites

Notes: *30 brokers account for 78% of total order flow in Egypt

Table 2 Market profiles, 2008

	Europe		North Africa			West Africa	East Africa	Southern Africa	
	London†	Paris†	Egypt	Tunisia	Morocco	Nigeria	Kenya	South Africa	Namibia
Listed Firms	2,210	1,164	302	53	78	234	46	373	8
Proportion market capitalisation to total (%)									
Top 1	7.72	9.29	7.43	12.51	27.55	8.40	21.02	8.31	55.55
Top 5	30.35	27.51	29.64	43.56	57.81	27.08	63.67	30.36	99.12
Top 10	46.12	43.86	43.58	65.23	74.29	44.38	78.79	45.44	100.00
Top 20	60.95	61.13	59.69	88.20	88.88	64.33	94.31	62.31	-- --
Proportion Turnover value to total (%)									
Top 1	-- --	-- --	11.50	9.69	19.42	9.00	20.44	12.74	46.77
Top 5	-- --	-- --	36.81	38.19	58.92	36.45	56.73	42.19	100.00
Top 10	-- --	-- --	55.31	61.98	78.00	52.66	74.76	59.67	100.00
Top 20	-- --	-- --	78.67	86.51	92.01	69.59	95.78	76.28	-- --
Sector Concentration by Market Capitalization									
Financials	17.80	15.14	24.72	57.38	42.04	59.74	46.90	28.11	70.45
Comm.	9.74	10.79	18.22	0.31	27.55	1.37	0.96	14.09	-- --
Basic Materials (Mining etc)	11.98	2.08	14.63	3.89	3.37	0.53	1.63	23.86	-- --
Consumer cyclical	4.90	5.91	5.00	12.16	2.55	2.81	4.73	6.52	-- --
Consumer non-cyclical	26.84	17.74	6.59	8.92	4.35	17.79	26.95	6.63	21.12
Diversified	0.37	2.89	1.57	12.51	7.39	1.57	0.08	4.27	8.42
Energy	19.08	11.68	1.03	0.38	1.46	10.41	4.41	9.50	-- --
Industrial	4.21	13.67	18.86	4.45	9.93	5.35	14.33	5.58	-- --
Technology	1.13	2.15	0.12	-- --	0.14	0.02	-- --	0.31	-- --
Utilities	3.96	17.95	0.18	-- --	1.23	-- --	-- --	0.00	-- --

Source: Compiled by authors from Bloomberg
Notes: (1) * Refers to Central Market and Block Trading Market
(2) † Refers to entire market including Main and AIMS for London

Table 3. Summary of trading arrangements and stock price index construction

<i>Market</i>	<i>Trading Hours</i>	<i>Trading Arrangement</i>	<i>Index</i>	<i>Details of Index Construction</i>
London		Shares Electronically Traded System (SETS) system	FTSE100	Top 100 London stocks by market capitalization.
Paris		Euronext electronic platform	Paris CAC40	Top 40 Euronext-Paris stocks by market capitalization.
South Africa	8-25 am – 9-00 am: Pre-Opening electronic call auction// 9-00 am – 4-00 pm: Cont. Trading// 4-00 pm – 6-00 pm: Run-Off.	JSE SETS Electronic Trading system (SETS trading system has been in place at the London Stock Exchange and replaced the former JET system in 2002)	FTSE/JSE Top 40	Top 40 stocks by market capitalization. Index is under effectively constant review in terms of potential corporate actions and capital structure changes.
Namibia	As South Africa	As South Africa	NSX All Share	Capital weighted average of all listed stocks with base period in 1992 at start of index – 100.
			NSX Local Market	As above but with universe made up from only local primary listed stocks
Egypt (Cairo and Alexandria Stock Exchange(CASE))	Listed Securities Market: 11-30am – 15-30pm	Exchange based Automated trading system CASE – The CASE Trading System, or CTS	EFG-Hermes Financial	Top 40 stocks in terms of liquidity and is market capitalisation weighted.
Morocco	9-00am – 9-30am: Pre-Open// 9-30am - 15-30pm: Cont. Trading// 15-30pm-16-00pm: Pre-Close	Delocalized Electronic quote driven trading system – NCS.	CFG 25	Recalculated at the end of each trading session with a stock by stock weighting in accordance to market capitalization
Tunisia	9-00am to 10-00am: Pre-opening// 10-00am – 11-30am Trading Session	Delocalized Electronic order matching system. Terminals installed remotely at local brokers.	BVMT Tunindex	Market Capitalization weighted index of all companies traded on exchange.
Nigeria (Lagos Floor)	11-00am to 13-00pm	Exchange based Automated Trading System (ATS). Each exchange in Nigeria has its own automated system.	NSE All Shares Index	Index formulated in January 1984. Only common stocks (ordinary shares) are included in the computation of the index. The index is value-relative and is computed daily.
Mauritius	9-00am – 10-00am: Pre-Opening electronic call auction// 10-00am – 13-30 pm: Cont. Trading// Closing: 13-30pm	Delocalized Automated Trading system. Authorised terminals installed at individual brokerage houses	SEMDEX (All Share)	The SEMDEX reflects capitalisation based on each listed stock that is weighted in accordance to its shares in the total market. The index has a base date of 5 July 1989 with a value of 100.
Kenya	10-00am – 12-00noon	Exchange based Automated Trading system.	NSE All Share	Market Capitalization weighted and takes account of all lines of stock on market.

Source: Compiled by authors from Datastream and respective national stock exchanges

Notes: All trading hours quoted are in local time. Nigeria is –1 hours less than South Africa, Kenya and Mauritius are +1 and +2 hours ahead of South Africa.

Table 4. Descriptive statistics of market price index constituent stocks

Market Index	Start	No. constituent stocks	Local currency values				UK£ equivalent			
			Zero return (%)	Price	Traded Volume (thousands)	Market Capitalization (millions)	Price	Market Capitalization (millions)	Bid-Ask spread (%)	
London (FTSE100)	1995	100	8.90	6.14	233,872.45	10,863.00	6.14	10,863.00	0.58	
Paris (CAC40)	1995	40	5.91	41.99	47,565.09	15,341.07	28.84	10,573.83	0.27	
South Africa (FTSE/JSE Top 40)	1995	40	16.82	63.07	40,691.90	35,028.47	5.44	2,837.82	1.05	
Namibia (NSX All Share)	1998	30	59.76	30.00	619.79	19,752.42	2.44	1,548.84	25.59	
Namibia (Local Market)	1998	7	92.35	9.65	623.70	296.76	0.76	25.29	27.13	
Egypt (EFG-Hermes Financial)	1996	40	35.35	34.64	14,292.69	2,308.37	4.38	250.54	2.57	
Morocco (CFG 25)	1995	25	46.67	842.54	380.78	5,725.49	54.57	375.71	0.59	
Tunisia (Tunindex)	1991	67	73.80	29.10	54.77	101.06	15.93	53.34	-- --	
Nigeria (All Share)	2002	229	78.19	10.39	39,564.31	22,067.17	0.05	95.41	-- --	
Mauritius (SEMDEX)	1995	75	84.69	87.77	315.50	9,401.05	1.73	173.93	-- --	
Kenya (NSE All Share)	1995	18	48.56	50.93	6,659.36	8,726.81	0.43	69.46	8.84	

Source: Compiled by authors from Bloomberg, Datastream and National stock exchanges
Notes: (1) * Indicates Namibian domestic market of 7 locally listed firms. Remaining 23 Namibian firms have primary listings overseas mostly in South Africa

Table 5. Characteristics of weekly index closing returns (Log UK\$ adjusted): January 1998 to June 2009

	London	Paris	South Africa	Namibia (Overall)	Namibia (Local)	Nigeria	Mauritius	Egypt	Morocco	Tunisia	Kenya
Observations	595	595	595	595	595	595	595	595	595	595	595
Mean	-0.00011	0.00027	0.00067	0.00031	-0.00038	0.00061	0.00059	0.00074	0.00073	0.00079	-0.00019
Median	0.00071	0.00122	0.00168	0.00204	-0.00015	0.00018	0.00033	0.00147	0.00044	0.00076	-0.00057
Std. Deviation	0.01157	0.01425	0.01745	0.02004	0.01442	0.01623	0.01057	0.01780	0.01137	0.00751	0.01950
Skewness	-0.23306	-0.19314	-0.49986	-0.81738	-0.72001	-0.32220	-0.14851	-0.54379	-0.85596	0.50735	1.08766
Kurtosis	7.74695	6.78367	6.45622	8.05036	8.20916	7.92383	6.74438	4.64954	9.94631	5.37297	65.52867
Jarque-Bera Statistic	564.03	358.62	320.93	698.59	724.14	611.35	349.78	96.78	1,268.88	165.13	97,048.62
Correlations											
London	100.00%										
Paris	85.20%	100.00%									
South Africa	65.06%	61.46%	100.00%								
Namibia (Overall)	53.99%	51.52%	87.15%	100.00%							
Namibia (Local)	14.52%	16.10%	37.13%	35.73%	100.00%						
Nigeria	1.96%	6.34%	1.38%	-0.47%	2.72%	100.00%					
Mauritius	12.65%	18.23%	6.94%	3.58%	5.97%	23.51%	100.00%				
Egypt	19.19%	20.66%	22.36%	19.53%	12.29%	8.42%	25.97%	100.00%			
Morocco	6.58%	16.55%	10.07%	6.09%	6.21%	10.15%	16.86%	19.22%	100.00%		
Tunisia	3.15%	13.07%	5.59%	4.59%	9.94%	10.83%	27.49%	22.48%	26.31%	100.00%	
Kenya	13.44%	11.70%	9.43%	10.55%	10.57%	10.53%	17.72%	16.90%	9.80%	19.61%	100.00%

Source: Compiled by authors from Datastream and Bloomberg for Tunisia, Kenya and Nigeria.

Notes: The null hypotheses for the mean, median, skewness, excess kurtosis are that they are all respectively zero

Table 6. Unit Root tests

Variable	Level	First Difference	Level with trend	First Differences with trend
Panel 1: Augmented Dickey-Fuller test				
yKenya	-1.207419	-29.09890***	-1.672027	-29.09265***
yNigeria	-0.804020	-24.91325***	-1.924238	-24.89205***
ySouth Africa	-0.986699	-25.12033***	-2.436170	-25.10129***
yNamibia Overall	-1.368295	-25.00205***	-2.365877	-24.98157***
yNamibia Local	-1.888937	-23.62267***	-1.045911	-23.99650***
yMauritius	-0.145805	-23.31767***	-1.592750	-23.33935***
yEgypt	-0.020077	-22.48868***	-1.559794	-22.56845***
yMorocco	0.198336	-23.97215***	-1.030731	-24.03165***
yTunisia	1.498168	-24.72299***	-0.370133	-24.89954***
yUK	-1.537415	-27.52569***	-1.684841	-27.51759***
yFrance	-2.191621	-27.17065***	-1.999675	-27.18757***
Panel 2: KPSS test				
yKenya	1.236805***	0.278226	0.579296***	0.213267***
yNigeria	2.844602***	0.174440	0.104950***	0.174685**
ySouth Africa	2.682842***	0.061519	0.355391***	0.053798
yNamibia Overall	2.311163***	0.071164	0.300367***	0.068472
yNamibia Local	0.885437**	0.874173**	0.700976***	0.071031
yMauritius	2.335987***	0.259857	0.625454***	0.118314
yEgypt	1.932951***	0.516802**	0.624614***	0.226263***
yMorocco	1.920662***	0.414741*	0.755967***	0.125661*
yTunisia	2.189443***	0.623850**	0.671684***	0.101473
yUK	0.470552**	0.113354	0.383805***	0.100980
yFrance	0.532316**	0.163082	0.322241***	0.117908*

Notes: (1) Test statistics reported in each case
(2) KPSS refers to Kwiatkowski, Phillips, Schmidt, and Shin (1992) unit root test with null hypothesis of stationarity or no unit root
(3) Augmented Dickey-Fuller unit root test has null hypothesis of unit root
(4) *, **, *** indicates 90%, 95%, and 99% confidence level of rejection of null hypothesis

Table 7. Bivariate VAR cointegration tests

Johansen trace test statistics		
	$H_0: r = 0$	$H_0: r \leq 1$
Panel A: comparisons with Egypt		
UK (2)	20.5838	5.9540
France (2)	29.3070**	9.2250
Morocco (1)	17.7160	4.6286
Tunisia (1)	32.5347**	11.2953*
Nigeria (1)	11.4748	1.9383
Kenya (2)	12.6182	4.2205
Namibia Overall (2)	12.3491	4.9268
Namibia Local (1)	16.3690	2.0692
Mauritius (1)	12.6402	3.5048
South Africa (2)	16.6191	5.1705
Panel B: comparisons with South Africa		
UK (1)	24.1459*	3.6511
France (1)	25.5253*	4.3651
Morocco (1)	14.3528	3.1370
Tunisia (1)	12.5136	4.1291
Nigeria (1)	16.4550	6.4009
Kenya (2)	14.3278	4.0581
Namibia Overall (1)	32.9901**	7.2638
Namibia Local (1)	18.1158	6.1219
Mauritius (1)	21.3919	4.4970
Panel C: comparisons with Kenya		
UK (2)	20.1273	5.5129
France (2)	24.4163*	6.5992
Morocco (1)	26.0438**	4.8921
Tunisia (2)	26.3612**	10.9242*
Nigeria (1)	7.5138	3.5929
Namibia Overall (2)	12.4795	3.7366
Namibia Local (1)	17.7988	3.6981
Mauritius (2)	14.4791	4.4804
Panel D: comparisons with Nigeria		
UK (1)	14.6436	3.8946
France (1)	16.0148	4.4205
Morocco (1)	8.6511	3.6607
Tunisia (1)	10.9141	4.0275
Namibia Overall (1)	18.8022	5.5664
Namibia Local (1)	18.2417	4.2990
Mauritius (1)	8.2827	4.0321
Panel E: comparisons with UK		
France (1)	21.8768	4.2809
Morocco (1)	9.7127	1.8304
Tunisia (1)	12.1842	1.9614
Namibia Overall (1)	20.8856	3.3729
Namibia Local (1)	18.1094	5.7484
Mauritius (1)	12.8458	1.9797
Panel F: comparisons with France		
Morocco (1)	12.2454	2.9602
Tunisia (1)	14.5635	1.4943
Namibia Overall (1)	21.3044	3.9627
Namibia Local (1)	24.6090*	10.4380
Mauritius (1)	13.1483	1.9597

Notes: (1) If r denotes the number of significant vectors, then the Johansen trace statistics test the hypotheses of at most one and zero cointegrating vectors, respectively

(2) ** indicates significance at 5% level. * indicates significance at 10% level

(3) Figures in parentheses indicate number of lags in VAR models

(4) Lag length of models chosen on basis of SBC informational criterion.

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Table 8. Block Granger non-Causality

	Causation	Kenya	South Africa	Egypt	Nigeria
Kenya	----/----> <----/----				
South Africa	----/----> <----/----	15.1286 [0.00] † 0.1642 [0.68]			
Egypt	----/----> <----/----	5.6997 [0.02] * 0.5215 [0.47]	0.5551E-3 [0.98] 37.6950 [0.00] †		
Nigeria	----/----> <----/----	0.2998 [0.58] 1.0056 [0.32]	0.4978 [0.48] 1.1388 [0.28]	0.4599 [0.49] 10.8677 [0.01] †	
Mauritius	----/----> <----/----	11.2616 [0.01] † 5.1645 [0.02] *	0.0315 [0.85] 16.5455 [0.00] †	0.0049 [0.94] 12.7633 [0.00] †	7.8981 [0.05] ** 3.7383 [0.05]
Namibia	----/----> <----/----	15.7725 [0.00] † 0.0046 [0.95]	1.7716 [0.18] 11.0205 [0.01] †	30.9967 [0.00] † 0.0196 [0.89]	0.6371 [0.43] 1.1579 [0.28]
Overall	----/----> <----/----	0.2868 [0.59]	3.0372 [0.08]	2.7693 [0.09]	3.0974 [0.08]
Namibia	----/----> <----/----	0.2209 [0.64]	2.1197 [0.14]	1.9527 [0.16]	0.1127 [0.74]
Local	----/----> <----/----	0.5310 [0.47]	0.0128 [0.91]	1.4126 [0.24]	7.0017 [0.01] **
Morocco	----/----> <----/----	1.3148 [0.25]	0.9851 [0.32]	0.2107 [0.65]	2.8898 [0.09]
Tunisia	----/----> <----/----	6.4925 [0.01] * 5.3725 [0.02] *	0.1513 [0.69] 3.6064 [0.05]	0.9489 [0.33] 1.3663 [0.24]	1.9042 [0.17] 1.0568 [0.30]
UK	----/----> <----/----	11.6415 [0.01] † 0.0524 [0.82]	0.0377 [0.84] 2.4811 [0.11]	20.9125 [0.00] † 0.0736 [0.79]	11.6728 [0.01] † 1.5178 [0.22]
France	----/----> <----/----	15.7648 [0.00] † 0.4009 [0.53]	0.1210 [0.72] 0.8351 [0.36]	21.9848 [0.00] † 0.0764 [0.78]	6.4928 [0.01] * 1.5177 [0.22]

Notes: (1) Figures in square parentheses are standard errors
(2) One lag used in all unrestricted VAR models.
(3) Chi-Square value (1 degree of freedom) for 99.90% confidence is 10.83, for 99% confidence is 6.64, and for 95% confidence is 3.84
(4) * indicates 95% confidence, ** indicates 99% confidence, † indicates 99.90% confidence

Table 9. ARDL F-statistics for bivariate pair-wise combinations

	Dependent Variable	Kenya	South Africa	Egypt	Nigeria
Kenya	----/---- >				
	< ----/----				
South Africa	----/---- >	1.9455 [0.14]			
	< ----/----	0.8588 [0.42]			
Egypt	----/---- >	1.8172 [0.16]	1.5213 [0.22]		
	< ----/----	0.2997 [0.74]	1.0542 [0.35]		
Nigeria	----/---- >	1.6706 [0.19]	0.8549 [0.43]	0.6208 [0.54]	
	< ----/----	0.4094 [0.66]	4.8603 [0.08]	0.5816 [0.56]	
			UB-LB		
Mauritius	----/---- >	1.2127 [0.29]	0.4558 [0.64]	0.2092 [0.81]	0.5954 [0.55]
	< ----/----	0.5607 [0.57]	4.4477 [0.01]	0.9868 [0.37]	1.3537 [0.26]
			UB-LB		
Namibia	----/---- >	2.2338 [0.11]	2.7954 [0.06]	0.6254 [0.54]	5.6695 [0.04] †
Overall	< ----/----	1.4794 [0.23]	3.6579 [0.03]	2.3930 [0.09]	UB
			UB-LB		
Namibia	----/---- >	3.1993 [0.04]	1.3814 [0.25]	1.1530 [0.32]	5.2839 [0.05] †
Local		UB-LB			UB
	< ----/----	6.4806 [0.02] †	3.4277 [0.03]	4.2622 [0.02]	2.7888 [0.06]
		UB	UB-LB	UB-LB	
Morocco	----/---- >	1.2134 [0.29]	0.5353 [0.59]	0.1958 [0.82]	0.5476 [0.58]
	< ----/----	7.5632 [0.01] †	3.4840 [0.03]	5.2908 [0.05] †	2.0406 [0.13]
		UB	UB-LB	UB	
Tunisia	----/---- >	1.9493 [0.14]	0.6932 [0.50]	1.0022 [0.37]	0.5414 [0.58]
	< ----/----	2.7997 [0.06]	2.5222 [0.08]	4.9997 [0.01] †	1.1853 [0.31]
			UB		
UK	----/---- >	2.7269 [0.07]	1.1910 [0.31]	2.9941 [0.05]	1.3826 [0.25]
	< ----/----	2.3456 [0.09]	1.1751 [0.31]	0.9468 [0.39]	1.7702 [0.17]
France	----/---- >	1.9351 [0.15]	1.2063 [0.30]	3.1053 [0.05]	2.4321 [0.09]
				UB-LB	
	< ----/----	5.8574 [0.03] †	2.6207 [0.07]	4.4247 [0.01]	2.6953 [0.07]
		UB		UB-LB	

Notes: (1) † 99% Critical Value bound.

(2) LB represents Lower Bound of F-statistic critical values, UB represents Upper Bound of F-statistic critical values. LB-UB represents a value falling between bands. Four lags were chosen in all cases for the differenced variables in equation 19.

Appendix 1: Granger non-Causality for cointegrating systems and Vector Error Correction Models

Appendix 1a) Vector Error Correction models for Egypt

Egypt – France

Dependent Variable is Δy_{Egypt}		
Regressor	Coefficient	Standard Errors (T-Ratio)
Intercept	-0.00244	0.028931 (-0.08)
Δy_{Egypt}	0.03752	0.041280 (0.91)
Δy_{France}	0.24305	0.051473 (4.72)
ECM(-1)	-0.00187	0.017488 (-0.11)
ECM(-1) = 1.0000* y_{Egypt} -2.7499* y_{France} -0.0014*Trend		
F(3, 589) = 8.6725 [0.00]		

Dependent Variable is Δy_{France}		
Regressor	Coefficient	Standard Errors (T-Ratio)
Intercept	0.1008	0.0231 (4.36)
Δy_{Egypt}	-0.0155	0.0329 (-0.47)
Δy_{France}	-0.1042	0.0411 (-2.53)
ECM(-1)	0.0117	0.0027 (4.35)
ECM(-1) = 1.0000* y_{Egypt} -2.7499* y_{France} -0.0014*Trend		
F(3, 589) = 8.7467 [0.00]		

Egypt – Tunisia

Dependent Variable is Δy_{Egypt}		
Regressor	Coefficient	Standard Errors (T-Ratio)
Intercept	0.0995	0.0223 (4.47)
ECM(-1)	0.0049	0.0011 (4.44)
ECM(-1) = 1.0000* y_{Egypt} -8.1986* y_{Tunisia} + 0.0056*Trend		
F(1, 592) = 19.6994 [0.00]		

Dependent Variable is $\Delta y_{\text{Tunisia}}$		
Regressor	Coefficient	Standard Errors (T-Ratio)
Intercept	0.0224	0.0095 (2.35)
ECM(-1)	0.0011	0.4675E-3 (2.27)
ECM(-1) = 1.0000* y_{Egypt} -8.1986* y_{Tunisia} + 0.0056*Trend		
F(3,419) = 5.1666 [0.02]		

Appendix 1b) Vector Error Correction models for South Africa

South Africa – Namibia (Overall)

Dependent Variable is $\Delta y_{\text{South Africa}}$		
Regressor	Coefficient	Standard Errors (T-Ratio)
Intercept	-0.0531	0.0479 (-1.11)
ECM(-1)	0.0341	0.0304 (1.12)
ECM(-1) = 1.0000* $y_{\text{South Africa}}$ -0.8531* y_{Namibia} - 0.2832E-3*Trend		
F(1, 592) = 1.2562 [0.26]		

Dependent Variable is $\Delta y_{\text{Namibia}}$		
Regressor	Coefficient	Standard Errors (T-Ratio)
Intercept	-0.1855	0.0546 (-3.39)
ECM(-1)	0.1178	0.0346 (3.40)
ECM(-1) = 1.0000* $y_{\text{South Africa}}$ -0.8531* y_{Namibia} - 0.2832E-3*Trend		
F(1, 592) = 11.5809[0.00]		

Appendix 1c) Vector Error Correction models for Kenya**Kenya – Morocco**

Dependent Variable is Δy_{Kenya}		
Regressor	Coefficient	Standard Errors (T-Ratio)
Intercept	0.0053	0.0124 (0.42)
ECM(-1)	0.0032	0.0072 (0.44)
ECM(-1) = 1.0000*y _{Kenya} - 1.1087*y _{Morocco} + 0.5599E-3*Trend		
F(1,592) = 0.19857 [0.66]		

Dependent Variable is $\Delta y_{\text{Morocco}}$		
Regressor	Coefficient	Standard Errors (T-Ratio)
Intercept	0.0336	0.0071 (4.7253)
ECM(-1)	0.0191	0.0041 (4.6325)
ECM(-1) = 1.0000*y _{Kenya} - 1.1087*y _{Morocco} + 0.5599E-3*Trend		
F(1,592) = 21.4603 [0.00]		

Kenya – Tunisia

Dependent Variable is Δy_{Kenya}		
Regressor	Coefficient	Standard Errors (T-Ratio)
Intercept	0.0841	0.0222 (3.78)
$\Delta y_{\text{Kenya}1}$	-0.2132	0.0406 (-5.25)
$\Delta y_{\text{Tunisia}1}$	0.3271	0.1058 (3.09)
ECM(-1)	-0.0069	0.0018 (-3.81)
ECM(-1) = 1.0000*y _{Kenya} + 4.1599*y _{Tunisia} - 0.0031*Trend		
F(3,589) = 14.0068 [0.00]		

Dependent Variable is $\Delta y_{\text{Tunisia}}$		
Regressor	Coefficient	Standard Errors (T-Ratio)
Intercept	-0.0017	0.0089 (-0.19)
$\Delta y_{\text{Kenya}1}$	-0.0357	0.0161 (-2.21)
$\Delta y_{\text{Tunisia}1}$	0.3638E-3	0.0421 (0.01)
ECM(-1)	0.2021E-3	0.7220E-3 (0.27)
ECM(-1) = 1.0000*y _{Kenya} + 4.1599*y _{Tunisia} - 0.0031*Trend		
F(3,589) = 1.7554 [0.15]		

Appendix 2. Bivariate ARDL models

Appendix 2a) Bivariate ARDL models for relationships centred on Kenya

Kenya – Namibia (Local)

Dependent Variable is Δy_{Kenya}		
Regressor	Coefficient	Standard Errors (T-Ratio)
ΔKenya_1	-0.1907	0.0411 (-4.64)
$\Delta \text{Namibia (Local)}$	0.1525	0.0568 (2.68)
$\Delta \text{Intercept}$	0.0090	0.0059 (1.52)
ECM(-1)	-0.0016	0.0051 (-0.31)
ECM = $y_{\text{Kenya}} + 5.2606*y_{\text{Namibia Local}} - 5.7541*\text{Intercept}$		
F(3, 571) = 10.9215 [0.00]		
Adjusted R-Squared = 0.0543		
Estimated Long-run coefficients using ARDL(2,1) error correction model (N=571) Dependent variable is Kenya		
$y_{\text{Namibia Local}}$	-5.2606	18.9695 (-0.28)
Intercept	5.7541	15.9474 (0.36)

Namibia (Local) - Kenya

Dependent Variable is $\Delta y_{\text{Namibia Local}}$		
Regressor	Coefficient	Standard Errors (T-Ratio)
ΔKenya	0.0129	0.0036 (3.51)
$\Delta \text{Intercept}$	-0.0075	0.0043 (-1.71)
ECM(-1)	-0.0119	0.0035 (-3.36)
ECM = $y_{\text{Namibia Local}} - 1.0831*y_{\text{Kenya}} + 0.6258*\text{Intercept}$		
F(2, 572) = 7.8668 [0.00]		
Adjusted R-Squared = 0.0267		
Estimated Long-run coefficients using ARDL(1,0) error correction model (N=571) Dependent variable is Namibia		
y_{Kenya}	1.0831	0.3157 (3.43)
Intercept	-0.6258	0.4316 (-1.45)

Kenya – Morocco

Dependent Variable is Δy_{Kenya}		
Regressor	Coefficient	Standard Errors (T-Ratio)
ΔKenya_1	-0.1834	0.0417 (-4.39)
$\Delta \text{Morocco}$	-0.0041	0.0079 (-0.52)
$\Delta \text{Intercept}$	0.0138	0.0149 (0.92)
ECM(-1)	-0.0015	0.0083 (-0.18)
ECM = $y_{\text{Kenya}} + 2.7762*y_{\text{Morocco}} - 9.3080*\text{Intercept}$		
F(3, 571) = 7.0973 [0.00]		
Adjusted R-Squared = 0.0308		
Estimated Long-run coefficients using ARDL(2,0) error correction model (N=571) Dependent variable is Kenya		
y_{Morocco}	-2.7762	20.2444 (-0.14)
Intercept	9.3080	58.3259 (0.16)

Morocco - Kenya

Dependent Variable is $\Delta y_{\text{Morocco}}$		
Regressor	Coefficient	Standard Errors (T-Ratio)
ΔKenya	0.0171	0.0046 (3.68)
$\Delta \text{Intercept}$	0.0155	0.0085 (1.81)
ECM(-1)	-0.0129	0.0045 (-2.91)
ECM = $y_{\text{Morocco}} - 1.3192*y_{\text{Kenya}} - 1.1896*\text{Intercept}$		
F(2, 572) = 6.8382 [0.00]		
Adjusted R-Squared = 0.0199		
Estimated Long-run coefficients using ARDL(1,0) error correction model (N=572) Dependent variable is Morocco		
y_{Kenya}	1.3192	0.25034 (5.27)
Intercept	1.1896	0.32947 (3.61)

Kenya – France

Dependent Variable is Δy_{Kenya}		
Regressor	Coefficient	Standard Errors (T-Ratio)
ΔKenya_1	-0.2094	0.0406 (-5.16)
ΔFrance	0.2058	0.0558 (3.68)
ΔFrance_1	0.2627	0.0561 (4.68)
$\Delta \text{Intercept}$	0.0431	0.0344 (1.25)
ECM(-1)	-0.0029	0.0053 (-0.55)
ECM = $y_{\text{Kenya}} + 3.8106*y_{\text{France}} - 14.4990*\text{Intercept}$		
F(4, 570) = 13.8718 [0.00]		
Adjusted R-Squared = 0.0808		
Estimated Long-run coefficients using ARDL(2,2) error correction model (N=570) Dependent variable is Kenya		
y_{France}	-3.8106	9.5496 (-0.39)
Intercept	14.4990	33.0311 (0.43)

France - Kenya

Dependent Variable is Δy_{France}		
Regressor	Coefficient	Standard Errors (T-Ratio)
ΔFrance_1	-0.1323	0.0414 (-3.19)
ΔKenya	0.1058	0.0301 (3.51)
$\Delta \text{Intercept}$	0.0611	0.0253 (2.41)
ECM(-1)	-0.0212	0.0081 (-2.62)
ECM = $y_{\text{France}} - 0.44246*y_{\text{Kenya}} - 2.8816*\text{Intercept}$		
F(3, 571) = 9.6223 [0.00]		
Adjusted R-Squared = 0.041523		
Estimated Long-run coefficients using ARDL(2,1) error correction model (N=571) Dependent variable is France		
y_{Kenya}	0.4425	0.1612 (2.74)
Intercept	2.8816	0.2181 (13.21)

Appendix 2b) Bivariate ARDL models for relationships centred on South Africa

South Africa – Nigeria

Dependent Variable is $\Delta y_{\text{South Africa}}$		
Regressor	Coefficient	Standard Errors (T-Ratio)
$\Delta \text{Nigeria}$	0.2058	0.0558 (3.68)
$\Delta \text{Intercept}$	0.0431	0.0344 (1.25)
ECM(-1)	-0.0029	0.0053 (-0.55)
ECM = $y_{\text{South Africa}} - 0.58114*y_{\text{Nigeria}} - 1.9041*\text{Intercept}$		
F(4, 570) = 0.84149[0.43]		
Adjusted R-Squared = -0.5526E-3		
Estimated Long-run coefficients using ARDL(1,0) error correction model (N=572) Dependent variable is South Africa		
y_{Nigeria}	0.5811	0.2880 (2.02)
Intercept	1.9041	0.5635 (3.38)

Nigeria - South Africa

Dependent Variable is $\Delta y_{\text{Nigeria}}$		
Regressor	Coefficient	Standard Errors (T-Ratio)
$\Delta \text{South Africa}$	0.0209	0.0072 (2.92)
$\Delta \text{Intercept}$	-0.0305	0.0135 (-2.26)
ECM(-1)	-0.0161	0.0053 (-3.04)
ECM = $y_{\text{Nigeria}} - 1.3003*y_{\text{South Africa}} + 1.8954*\text{Intercept}$		
F(2, 572) = 4.7852 [0.01]		
Adjusted R-Squared = 0.013017		
Estimated Long-run coefficients using ARDL(1,0) error correction model (N=572) Dependent variable is Nigeria		
$y_{\text{South Africa}}$	1.3003	0.22600 (5.75)
Intercept	-1.8954	0.66844 (-2.83)

South Africa – Mauritius

Dependent Variable is $\Delta y_{\text{South Africa}}$		
Regressor	Coefficient	Standard Errors (T-Ratio)
Δ Mauritius	0.0026	0.0079 (0.33)
Δ Intercept	0.0131	0.0153 (0.86)
ECM(-1)	-0.0052	0.0075 (-0.69)
ECM = $y_{\text{South Africa}} - 0.49277*y_{\text{Mauritius}} - 2.5053*\text{Intercept}$		
F(2, 572) = 0.38728 [0.68]		
Adjusted R-Squared = -0.0021395		
Estimated Long-run coefficients using ARDL(1,0) error correction model (N=572) Dependent variable is South Africa		
$y_{\text{Mauritius}}$	0.4927	0.9712 (0.51)
Intercept	2.5053	1.1954 (2.09)

Mauritius - South Africa

Dependent Variable is $\Delta y_{\text{Mauritius}}$		
Regressor	Coefficient	Standard Errors (T-Ratio)
Δ South Africa	0.0459	0.0250 (1.84)
Δ South Africa1	0.0911	0.0253 (3.60)
Δ Intercept	-0.0288	0.0092 (-3.15)
ECM(-1)	-0.0134	0.0047 (-2.84)
ECM = $y_{\text{Mauritius}} - 1.1157*y_{\text{South Africa}} + 2.1441*\text{Intercept}$		
F(3, 571) = 10.3481 [0.00]		
Adjusted R-Squared = 0.0449		
Estimated Long-run coefficients using ARDL(1,2) error correction model (N=572) Dependent variable is Mauritius		
$y_{\text{South Africa}}$	1.1157	0.2007 (5.56)
Intercept	-2.1441	0.5894 (-3.64)

South Africa – Namibia Overall

Dependent Variable is $\Delta y_{\text{South Africa}}$		
Regressor	Coefficient	Standard Errors (T-Ratio)
Δ South Africa1	-0.1867	0.0421 (-4.43)
Δ Namibia Overall	0.7651	0.0178 (42.86)
Δ Namibia Overall1	0.1160	0.0363 (3.19)
Δ Intercept	0.0060	0.0139 (0.43)
ECM(-1)	-0.0026	0.0101 (-0.26)
ECM = $y_{\text{South Africa}} - 0.54156*y_{\text{Namibia Overall}} - 2.3190*\text{Intercept}$		
F(4, 570) = 474.24 [0.00]		
Adjusted R-Squared = 0.7672		
Estimated Long-run coefficients using ARDL(2,2) error correction model (N=570) Dependent variable is South Africa		
$y_{\text{Namibia Overall}}$	0.5416	2.1480 (0.25)
Intercept	2.3190	3.9290 (0.59)

Namibia Overall - South Africa

Dependent Variable is $y_{\text{Namibia Overall}}$		
Regressor	Coefficient	Standard Errors (T-Ratio)
Δ Namibia Overall1	-0.1876	0.0414 (-4.53)
Δ South Africa	0.9934	0.0231 (42.95)
Δ South Africa1	0.2704	0.0481 (5.63)
Δ South Africa2	0.0753	0.0232 (3.24)
Δ Intercept	-0.0277	0.0158 (0.02)
ECM(-1)	-0.0219	0.0123 (-1.78)
ECM = $y_{\text{Namibia Overall}} - 0.93160*y_{\text{South Africa}} + 1.2615*\text{Intercept}$		
F(5, 569) = 399.46 [0.00]		
Adjusted R-Squared = 0.7763		
Estimated Long-run coefficients using ARDL(2,3) error correction model (N=569) Dependent variable is Namibia Overall		
$y_{\text{South Africa}}$	0.9316	0.0964 (9.66)
Intercept	-1.2615	0.2880 (-4.38)

South Africa – Namibia Local

Dependent Variable is $\Delta y_{\text{South Africa}}$		
Regressor	Coefficient	Standard Errors (T-Ratio)
Δ Namibia Local	0.4777	0.0473 (10.10)
Δ Intercept	0.0209	0.0108 (1.95)
ECM(-1)	-0.0062	0.0036 (-1.74)
ECM = $y_{\text{South Africa}} + 0.37024*y_{\text{Namibia Local}} - 3.3901*\text{Intercept}$		
F(2, 572) = 52.5422 [0.00]		
Adjusted R-Squared = 0.1509		
Estimated Long-run coefficients using ARDL(1,1) error correction model (N=572) Dependent variable is South Africa		
$y_{\text{Namibia Local}}$	-0.3702	0.6239 (-0.59)
Intercept	3.3901	0.5739 (5.91)

South Africa - Morocco

Dependent Variable is $\Delta y_{\text{South Africa}}$		
Regressor	Coefficient	Standard Errors (T-Ratio)
Δ Morocco	0.0027	0.0061 (0.45)
Δ Intercept	0.0083	0.0119 (0.69)
ECM(-1)	-0.0053	0.0062 (-0.85)
ECM = $y_{\text{South Africa}} - 0.5159*y_{\text{Morocco}} - 1.5533*\text{Intercept}$		
F(2, 572) = 0.43429 [0.65]		
Adjusted R-Squared = -0.0019		
Estimated Long-run coefficients using ARDL(1,0) error correction model (N=572) Dependent variable is South Africa		
y_{Morocco}	0.5159	0.7719 (0.67)
Intercept	1.5533	2.3051 (0.67)

Morocco - South Africa

Dependent Variable is $\Delta y_{\text{Morocco}}$		
Regressor	Coefficient	Standard Errors (T-Ratio)
Δ South Africa	0.0127	0.0039 (3.17)
Δ Intercept	-0.0105	0.0077 (-1.36)
ECM(-1)	-0.0091	0.0039 (-2.29)
ECM = $y_{\text{Morocco}} - 1.3974*y_{\text{South Africa}} + 1.1605*\text{Intercept}$		
F(2, 572) = 5.0704 [0.01]		
Adjusted R-Squared = 0.0139		
Estimated Long-run coefficients using ARDL(1,0) error correction model (N=572) Dependent variable is Morocco		
y_{Morocco}	1.3974	0.3812 (3.66)
Intercept	-1.1605	1.1124 (-1.04)

Appendix 2c) Bivariate ARDL models for relationships centred on Egypt**Egypt – Namibia Local**

Dependent Variable is Δy_{Egypt}		
Regressor	Coefficient	Standard Errors (T-Ratio)
Δ Namibia Local	0.1561	0.0529 (2.95)
Δ Intercept	0.0049	0.0038 (1.29)
ECM(-1)	0.8842E-3	0.0024 (0.37)
ECM = $y_{\text{Egypt}} - 6.9284*y_{\text{Namibia Local}} + 5.5770*\text{Intercept}$		
F(2, 572) = 5.9373 [0.00]		
Adjusted R-Squared = 0.0152		
Estimated Long-run coefficients using ARDL(1,0) error correction model (N=572) Dependent variable is Egypt		
$y_{\text{Namibia Local}}$	6.9284	17.2841 (0.40)
Intercept	-5.5770	17.4629 (-0.32)

Namibia Local - Egypt

Dependent Variable is $\Delta y_{\text{Namibia Local}}$		
Regressor	Coefficient	Standard Errors (T-Ratio)
Δ Egypt	0.0961	0.0326 (2.95)
Δ Intercept	0.1529E-3	0.0029 (0.05)
ECM(-1)	-0.0094	0.0034 (-2.77)
ECM = $y_{\text{Namibia Local}} - 0.5893*y_{\text{Egypt}} - 0.01621*\text{Intercept}$		
F(2, 572) = 10.7406 [0.00]		
Adjusted R-Squared = 0.0312		
Estimated Long-run coefficients using ARDL(1,0) error correction model (N=572) Dependent variable is Namibia Local		
y_{Egypt}	0.5893	0.2198 (2.68)
Intercept	0.0162	0.3133 (0.05)

Egypt – Morocco

Dependent Variable is Δy_{Egypt}		
Regressor	Coefficient	Standard Errors (T-Ratio)
Δ Morocco	0.2990	0.0647 (4.62)
Δ Morocco1	0.1012	0.0643 (1.57)
Δ Morocco2	-0.2259	0.0642 (-3.52)
Δ Intercept	0.0115	0.0198 (0.58)
ECM(-1)	0.0019	0.0048 (0.39)
ECM = $y_{\text{Egypt}} - 2.3957*y_{\text{Morocco}} + 6.0287*\text{Intercept}$		
F(5, 569) = 9.5911 [0.00]		
Adjusted R-Squared = 0.0549		
Estimated Long-run coefficients using ARDL(1,3) error correction model (N=569) Dependent variable is Egypt		
y_{Morocco}	2.3957	2.8303 (0.85)
Intercept	-6.0287	8.9878 (-0.67)

Morocco - Egypt

Dependent Variable is $\Delta y_{\text{Morocco}}$		
Regressor	Coefficient	Standard Errors (T-Ratio)
Δ Egypt	0.1209	0.0257 (4.68)
Δ Intercept	0.0284	0.0125 (2.28)
ECM(-1)	-0.0138	0.0055 (-2.52)
ECM = $y_{\text{Morocco}} - 0.6609*y_{\text{Egypt}} - 2.0579*\text{Intercept}$		
F(2, 572) = 16.0798 [.000]		
Adjusted R-Squared = 0.0483		
Estimated Long-run coefficients using ARDL(1,0) error correction model (N=572) Dependent variable is Morocco		
y_{Egypt}	0.6609	0.1166 (5.66)
Intercept	2.0579	0.1547 (13.31)

Egypt – France

Dependent Variable is Δy_{Egypt}		
Regressor	Coefficient	Standard Errors (T-Ratio)
ΔFrance	0.2875	0.0505 (5.68)
$\Delta \text{France1}$	0.3025	0.0504 (6.00)
$\Delta \text{Intercept}$	0.0777	0.0347 (2.24)
ECM(-1)	0.0036	0.0028 (1.32)
ECM = $y_{\text{Egypt}} - 6.4808*y_{\text{France}} + 21.3730*\text{Intercept}$		
$F(3, 571) = 22.4204 [0.00]$		
Adjusted R-Squared = 0.0993		
Estimated Long-run coefficients using ARDL(1,2) error correction model (N=571) Dependent variable is Egypt		
y_{France}	6.4808	3.6918 (1.76)
Intercept	-21.3730	12.9572 (-1.65)

France - Egypt

Dependent Variable is Δy_{France}		
Regressor	Coefficient	Standard Errors (T-Ratio)
$\Delta \text{France1}$	-0.1588	0.0414 (-3.84)
ΔEgypt	0.1868	0.0328 (5.69)
$\Delta \text{Intercept}$	0.0541	0.0281 (1.93)
ECM(-1)	-0.0169	0.0086 (-1.96)
ECM = $y_{\text{France}} - 0.2035*y_{\text{Egypt}} + 3.1915*\text{Intercept}$		
$F(3, 571) = 15.9416 [0.00]$		
Adjusted R-Squared = 0.0709		
Estimated Long-run coefficients using ARDL(2,1) error correction model (N=571) Dependent variable is France		
y_{Egypt}	0.2035	0.0994 (2.05)
Intercept	3.1915	0.1394 (22.90)

Appendix 2d) Bivariate ARDL models for relationships centred on Nigeria

Nigeria – Namibia Overall

Dependent Variable is $\Delta y_{\text{Nigeria}}$		
Regressor	Coefficient	Standard Errors (T-Ratio)
$\Delta \text{Namibia Overall}$	0.0240	0.0071 (3.38)
$\Delta \text{Intercept}$	-0.0043	0.0059 (-0.72)
ECM(-1)	-0.0165	0.0049 (-3.39)
ECM = $y_{\text{Nigeria}} - 1.4545*y_{\text{Namibia Overall}} + 0.2564*\text{Intercept}$		
$F(2, 572) = 6.2519 [0.00]$		
Adjusted R-Squared = 0.0179		
Estimated Long-run coefficients using ARDL(1,0) error correction model (N=571) Dependent variable is Nigeria		
$y_{\text{Namibia Overall}}$	1.4545	0.2426 (5.99)
Intercept	-0.2564	0.3679 (-0.69)

Namibia Overall - Nigeria

Dependent Variable is $\Delta y_{\text{Namibia Overall}}$		
Regressor	Coefficient	Standard Errors (T-Ratio)
$\Delta \text{Nigeria}$	0.0085	0.0061 (1.39)
$\Delta \text{Intercept}$	0.0093	0.0073 (1.27)
ECM(-1)	-0.0166	0.0089 (-1.87)
ECM = $y_{\text{Namibia Overall}} - 0.5090*y_{\text{Nigeria}} - 0.5584*\text{Intercept}$		
$F(2, 572) = 1.8103 [0.17]$		
Adjusted R-Squared = 0.0028		
Estimated Long-run coefficients using ARDL(1,0) error correction model (N=571) Dependent variable is Namibia Overall		
y_{Nigeria}	0.5090	0.1993 (2.55)
Intercept	0.5584	0.3854 (1.45)

Nigeria – Namibia Local

Dependent Variable is $\Delta y_{\text{Nigeria}}$		
Regressor	Coefficient	Standard Errors (T-Ratio)
Δ Namibia Local	-0.0041	-0.0041 (-1.13)
Δ Intercept	0.0106	0.0066 (1.61)
ECM(-1)	-0.0033	0.0027 (-1.21)
ECM = y_{Nigeria} + 1.2533* $y_{\text{Namibia Local}}$ - 3.2183*Intercept		
F(2, 572) = 1.1517 [0.32]		
Adjusted R-Squared = 0.5283E-3		
Estimated Long-run coefficients using ARDL(1,0) error correction model (N=571) Dependent variable is Nigeria		
$y_{\text{Namibia Local}}$	-1.2533	1.3631 (-0.92)
Intercept	3.2183	1.3095 (2.46)

Namibia Local - Nigeria

Dependent Variable is $\Delta y_{\text{Namibia Local}}$		
Regressor	Coefficient	Standard Errors (T-Ratio)
Δ Nigeria	0.0052	0.0024 (2.23)
Δ Intercept	-0.0067	0.0057 (-1.17)
ECM(-1)	-0.0043	0.0032 (-1.35)
ECM = $y_{\text{Namibia Local}}$ + 1.2272* y_{Nigeria} + 1.5664*Intercept		
F(2, 572) = 4.1756 [0.02]		
Adjusted R-Squared = 0.0109		
Estimated Long-run coefficients using ARDL(1,0) error correction model (N=571) Dependent variable is Namibia Local		
y_{Nigeria}	1.2272	1.1545 (1.06)
Intercept	-1.5664	2.2625 (-0.69)

Notes to Appendices 1 and 2.

- (1) Variable in first differences: $\Delta y_{\text{Market Name}} = y_{\text{Market Name}} - y_{\text{Market Name} (-1)}$
- (2) Variable in second differences: $\Delta y_{\text{Market Name}1} = y_{\text{Market Name} (-1)} - y_{\text{Market Name} (-2)}$
- (3) Variable in third differences: $\Delta y_{\text{Market Name}1} = y_{\text{Market Name} (-1)} - y_{\text{Market Name} (-2)}$
- (4) Intercept first difference: $\Delta \text{Intercept} = \Delta \text{Intercept} - \Delta \text{Intercept} (-1)$