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COINTEGRATION AND DYNAMIC CAUSAL LINKS AMONGST AFRICAN STOCK MARKETS

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Abstract

The paper examines links between African stock markets using cointegration and error-correction modelling. Two long-run stable cointegration relations are found; one hinging on a larger market (South Africa) and the other on a smaller market (Ghana). The short-run error correction framework shows significant feedback and causal effects both ways from smaller to larger markets. There is also evidence of significant effects of misalignments in the South African short-run stock returns model on the short-run model of Ghana.

Key words: Stock markets, cointegration, long-run, short-run, causality, Africa.
JEL Classification: G10, F15, F32.

I. Introduction

Recent developments, in international finance, especially the relaxation of exchange controls on investment have induced greater interaction and interdependence between stock markets across the globe. Interdependence amongst stock markets is useful in determining the causal links amongst markets. Stock market interdependence occurs if there are common underlying structural endowments driving stock markets. The existence of common underlying structural endowments amongst a set of stock markets is indicative of a common stochastic trend or cointegration amongst the markets. It is also possible to ascertain the nature of the short- run and long-run causal dynamics amongst stock markets from cointegration analysis. There has therefore been a growing interest amongst financial analysts and economists in the studying of stock market cointegration. However, most empirical works have focused on either developed markets, or developing markets of South East Asia, with few studies on Africa. This paper, investigates the long-run linkages amongst African stock markets, as well as the short-run dynamic inferences which may be present. The existence of cointegration opportunities can be potentially useful for the development of much envisaged regional stock markets.

The rest of the paper is organized as follows: the next section compares economic and stock market indicators across some African countries, an overview of the research literature is discussed in section three, section four discusses the empirical methods and results and the last section draws conclusions

II. Economic development and stock market indicators in African countries

Economic growth and performance in African economies in the past two decades have been that of a marked improvement from that of the late 1970s and the 1980s. For instance GDP growth which was at an average of 3% in the early to mid 1990s increased to 4% in the late 1990s and 5% from 2000 to 2005 (OECD, 2006). Investment formation (investment to GDP ratio) also had a modest growth from less than 10% in the 1980s to an average of 18% from the mid 1990s to 2004 (IMF, 2004). Inflation and exchange rate management has also generally been commendable. Despite the peculiarities and differences within the various African economies, their economic

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fundamentals and structures are similar, with economic growth being driven largely by the agricultural sector.

Incidentally this period of good performance also witnessed policy moves by a number of African economies towards the establishment of stock markets. Prior to this period, stock markets were only in existence in Egypt, South Africa, Tunisia, Kenya, Zimbabwe and Nigeria. The early to mid 1990s therefore witnessed rapid growth in the number of stock markets in Africa. This development changed the financial structure of African economies.

From 13 stock markets in 1992, Africa is currently home to over 19 fledging stock markets. Total market capitalization for African stock markets (excluding South Africa) more than doubled from US $113,423 million in 1992 to US$ 244,672 million in 2002. In terms of individual market performance, during the first quarter of 2004 Ghana, Uganda, Kenya, Egypt, Mauritius and Nigeria recorded remarkable gains in stock returns. Though most of these stock markets are small and illiquid they have the potential to mobilizing resources for investment in Africa.

Though most of these markets (apart from South Africa) are young, less developed, inactive, small and fraught with institutional and infrastructural bottlenecks; they have survived such problems and performed remarkably well. The benefits from stock market activity are numerous and include capital acquisition, savings, and investment growth amongst others. Indeed most African governments are reforming their domestic financial regulations to attract foreign portfolio for enhanced investment through stock markets.

Table 1 shows the computed mean values for market capitalization ratio, the total value of shares trade to GDP, the Turnover ratio, and the average number of listed for selected[1] African countries. Across the countries, the mean market capitalization ratio shows the top five stock markets in terms of size to be South Africa (142%), Mauritius (28%), Zimbabwe (24%), Morocco (21%) and BRVM[2] in Cote d'Ivoire (16%). Clearly South Africa stands out as a dominant market. The bottom three stock markets by market capitalization ratio are Namibia (8.5%), Egypt (8.4%) and Nigeria (6%). In terms of liquidity (value of shares traded to GDP), the most liquid stock markets are the South Africa (28%), BRVM in Cote d'Ivoire (5%), Zimbabwe (4%), Mauritius (6%) and Tunisia (1.4%).

Though the markets in Mauritius, Zimbabwe, and Morocco are bigger than the BRVM, the BRVM is more liquid. Similarly, Tunisia may be a small market but relatively liquid. With respect to stock market activity and transactions cost (measured here by turnover ratio), the top five markets are Zimbabwe (33%), BRVM (26%), Swaziland (24%), South Africa (20%) and Tunisia (11%). Thus it appears trading costs in Zimbabwe, BRVM and Swaziland are lower than in South Africa. In addition Egypt (910), South Africa (605), Nigeria (189), Zimbabwe (68) and Kenya (57) had the largest average number of listed companies on their stock markets.

Table 1

Selected Stock Market Indicators

	Market capitalization		Turnover ratio		Value of shares traded/GDP		Av. No.[a] of listed firms	
	Value	R	Value	R	Value	R	Value	R
Botswana	0.090	10	0.089	7	0.007	8	14	11
Egypt	0.084	12	0.023	14	0.002	13	910	1
Cote d'Ivoire	0.157	5	0.256	2	0.046	2	36	9
Ghana	0.129	8	0.048	12	0.004	11	22	10
Kenya	0.137	6	0.036	13	0.005	9	57	5
Morocco	0.205	4	0.097	6	0.012	7	55	6

[1] Other countries with stock markets are ignored due to data constraints.

[2] Botswana, Egypt, Cote d'Ivoire (BRVM), Ghana, Kenya, Morocco, Mauritius, Namibia, Nigeria, Swaziland, Tunisia, South Africa, Zambia, Zimbabwe BRVM is the French speaking West African Regional Bourse in Cote d'Ivoire and is made up of Benin, Burkina Faso, Cote d'Ivoire, Guinea Bissau, Mali, Niger, Senegal and Togo.

Table 1 (continuous)

	Market capitalization		Turnover ratio		Value of shares traded/GDP		Av. No. [a] of listed firms	
Mauritius	0.280	2	0.060	9	0.016	5	39	7
Namibia	0.085	11	0.065	10	0.005	10	13	12
Nigeria	0.055	14	0.048	11	0.003	12	189	3
Swaziland	0.132	7	0.242	3	0.045	3	6	14
Tunisia	0.113	9	0.112	5	0.014	6	39	8
South Africa	1.422	1	0.197	4	0.275	1	604	2
Zambia	0.083	13	0.068	8	0.004	11	8	13
Zimbabwe	0.244	3	0.327	1	0.037	4	68	4
Average	0.230		0.119		0.034		147	

Values of shares traded and listed shares are in nominal US$. R=rank based on value a. 1995-2002.

For the purpose of this study seven African countries are chosen[1]. Table 2 below shows selected macroeconomic indicators across these seven countries. From the table it is evident that four countries, Egypt, Ghana, Mauritius and Tunisia, share a similar growth trajectory. These countries have over the period recorded an average growth rate of more than 4%, with Mauritius experiencing slightly higher growth rates. South Africa and Nigeria also enjoy a similar growth pattern with South Africa slightly ahead. Kenya is the only country with growth rats less than 3%. These countries have also witnessed substantial investment growth, investment as a proportion of GDP ratio ranged from about 15% to 23%. The level of openness and trade intensity has also been high and similar for the countries selected with the exception of South Africa and Mauritius. Again apart from Nigeria and Ghana which both shared high inflation rates in excess of 20%, the rest of the countries had inflation rates less than 8%. Therefore even though there are some differences in these countries, most of these countries appear to share similar macroeconomic fundamentals. Indeed an examination of the stock market indicators for these countries in Table 1 reveals similar trends. This observation gives an indication of possible interdependences amongst the selected African stock markets.

Table 2

Selected Macroeconomic Indicators

	GDP	GDP growth	Investment	Exports	Imports	TII	Inflation
Egypt							
Av. 1995-1998	64912.25	4.93	17.93	13705.50	17240.50	46.16	7.93
Av. 1999-2002	78856.50	4.47	17.58	15040.25	17957.50	39.14	2.69
Ghana							
Av. 1995-1998	6904.75	4.40	21.91	2089.63	3146.48	73.91	37.13
Av. 1999-2002	8168.20	4.20	22.37	2708.90	3817.85	101.32	21.33
South Africa							
Av. 1995-1998	158382.50	2.71	16.41	38399.00	36688.00	47.78	7.88
Av. 1999-2002	174440.00	2.83	15.02	44595.00	38218.25	56.36	6.35
Mauritius							
Av. 1995-1998	4150.13	5.28	25.78	2485.75	2697.18	126.48	6.56
Av. 1999-2002	5113.48	5.10	24.02	3045.45	3326.40	126.82	5.80

[1] For more on the countries chosen and the criteria for selection, see section on data under methodology.

Table 2 (continuous)

	GDP	GDP growth	Investment	Exports	Imports	TII	Inflation
Nigeria							
Av. 1995-1998	29552.75	2.84	18.01	13822.50	12974.75	79.09	30.16
Av. 1999-2002	32383.25	1.83	20.83	12585.25	18108.75	82.68	11.28
Kenya							
Av. 1995-1998	9464.9	3.06	16.05	2792.5	3557.33	65.68	7.13
Av. 1999-2002	9969.1	0.82	14.25	3020.3	3670.33	59.37	5.86
Tunisia							
Av. 1995-1998	19705.5	4.90	24.24	8488.78	9075.55	89.65	4.19
Av. 1999-2002	24032	4.32	25.82	10719.65	11490.25	92.99	2.58

GDP, Exports and Imports are in constant US$ 1995 prices. Investment is measured by Gross Capital Formation/GDP. TII: Trade intensity index= [exports + imports]/GDP. SOURCE: World Development Indicators, 2004.

III. Overview of Empirical Research Literature

A number of authors, notably Kasa (1992), Chung and Lin (1994), Richards (1995), Gonzalo and Granger (1995), Masih and Masih (2001), Huang, Yang, and Hu (2000), Piesse and Hearn (2002), Pascual (2003), Phylaktis and Ravazolo (2005) have conducted studies into cointegration amongst stock markets. These authors have mostly used cointegration analysis to infer on the level of integration between stock markets. The underlying assumption in this method is that the existence of a single common stochastic trend amongst a group in stock markets implies high long-run correlations and integration amongst the markets. Authors like Phylaktis and Ravazzolo (2005) in their analysis use moving average representations of an error correction model to determine underlying stochastic and deterministic trends that drive cointegration. In their view cointegration implies common arbitrage which links stock markets the short-run and long-run. However as noted by Lence and Falk (2005), even though two stock markets can be cointegrated they may not be necessarily integrated. Cointegration amongst stock markets provides information on the underlying structural endowments common to the two markets and provides inferences on the long and short run dynamic causalities. Again conclusions about cointegration do not lend themselves necessarily to market efficiency or integration as noted by Dwyer and Wallace (1992) and Lence and Falk (2005). In addition cointegration helps in analysing the long-run relationship between stock markets (Masih and Masih, 2001).

In Africa, a couple of studies, Appiah-Kusi and Pescetto (1998), Piesse and Hearn (2002), Wang, Yang and Bessler (2003), Collins and Abraham (2004) and Piesse and Hearn (2005) have variously studied the integration of African stock markets into the global market as well as draw inferences on the volatility spillovers between the markets and the dynamic impulse response. Collins and Biekpe (2003) also examined the degree of exposure of African stock markets to the Asian financial crisis.

There has however been little empirical work on analysing the dynamic long-run and short-run linkages amongst African stock markets. The thrust of this paper therefore is to provide more empirical evidence on the dynamic short-run and long run causal linkages amongst African stock markets. In addition the nature of feedback or correction from disequilibrium to long-run equilibrium is also investigated.

Empirical Analysis and Results

The study adopts a dynamic vector autoregressive regression (VAR) which explores both cointegration and Granger causality possibilities. The essence is to capture the causal dynamics between stock market returns, and at the same time to observe the long run dynamics. For instance, given a VAR with possible long run cointegration amongst a set of variables:

$$Y_t = \beta_1 Y_{t-1} + \ldots + \beta_k Y_{t-k} + \varepsilon_t , \quad (1)$$

where Y_t is a $(n \times 1)$ vector of stock market prices in log form, $n = 7$),

β_k are the parameters to be estimated,

ε_t are the random errors.

We can examine the nature of relationship between the cointegrated variables via a Granger representation theorem Vector Error Correction Model (VECM) specified as:

$$\Delta Y_t = \alpha\beta' Y_{t-k} + \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + \varepsilon_t , \quad (2)$$

where β' is a vector of parameters of the cointegrating vectors, and $\beta' Y_{t-k}$ are the long-run relationships, α is the vector of the speed of adjustment or equilibrium corrections, Γ_i is the vector of short-run parameters and ε_t is the vector of error-terms. With this formulation we are able to test for the existence of a long run relationship between selected stock market prices, and infer on the nature of the short-run dynamic causal relations as well.

As indicated earlier seven countries[1] are chosen for this study. The seven countries are selected due to three main reasons. In the first place countries which had the longest existing stock markets were considered because of degrees of freedom issues in the econometric exercise, this eliminated most of the countries. Secondly the availability of reliable and consistent data on the stock market prices was used as a criterion to disqualify other countries (e.g. Zimbabwe and Cote d'Ivoire). Finally only markets with available value weighted constructed indexes were considered. This reduced the sample eligible for the analysis to the seven identified markets, each of which used market capitalization as their weight for the indexes. Out of the seven markets, South Africa (1887), Egypt (1888), Kenya (1954), Nigeria (1960) and Tunisia (1969) started operating prior to the 1980s, whilst Mauritius (1989) and Ghana (1990) markets only began in the 1990s. Thus each market had different available start and end points for its market index. Cut-off dates were thus chosen for uniformity and degrees of freedom in the econometric analysis. Thus monthly data for the seven markets was obtained for 1997-11 to 2005-8 from REUTERS database. Indeed this method of choosing the sample period is subject to bias in the analysis if it does not take into effect business cycles (boom and burst periods[2]). A plot of the market trends for the seven countries over the period is shown in Figure 1.

The graphs show some trends of business cycle patterns in the selected African markets. Ghana and Nigeria witnessed little market activity within the early periods (1997 to early 2000), thereafter the markets began a bullish ascent peaking at 2004 and assumed a downward trend. Egypt and Mauritius also shared a similar trend in market activity, with a calm market in the initial stages and a bull trend from 2002. Mauritius however had a relatively more active market activity in the early periods. The Nairobi Stock Exchange in Kenya witnessed two major trends, a steep bearish movement which hit an all period low in 2002 and a steep bullish trend thereafter. Generally four cycles are noticed in the Tunisian market; low activity (1997-1999), bullish trend (1999-2001), bearish trend (2001-2002) and a gradual upward trend from 2003. Finally in South Africa, though there is the presence of short-lived, small-sized bullish and bearish cycles, the general trend appears to be an upward market activity.

[1] Egypt (Cairo & Alexandra Stock Exchange), Ghana (Ghana Stock Exchange), Kenya (Nairobi Stock Exchange), Mauritius (Stock Exchange Mauritius), Nigeria (Nigeria Stock Exchange), South Africa (Johannesburg Stock Exchange) and Tunisia (Tunis Stock Exchange).

[2] We thank an anonymous referee for this advice.

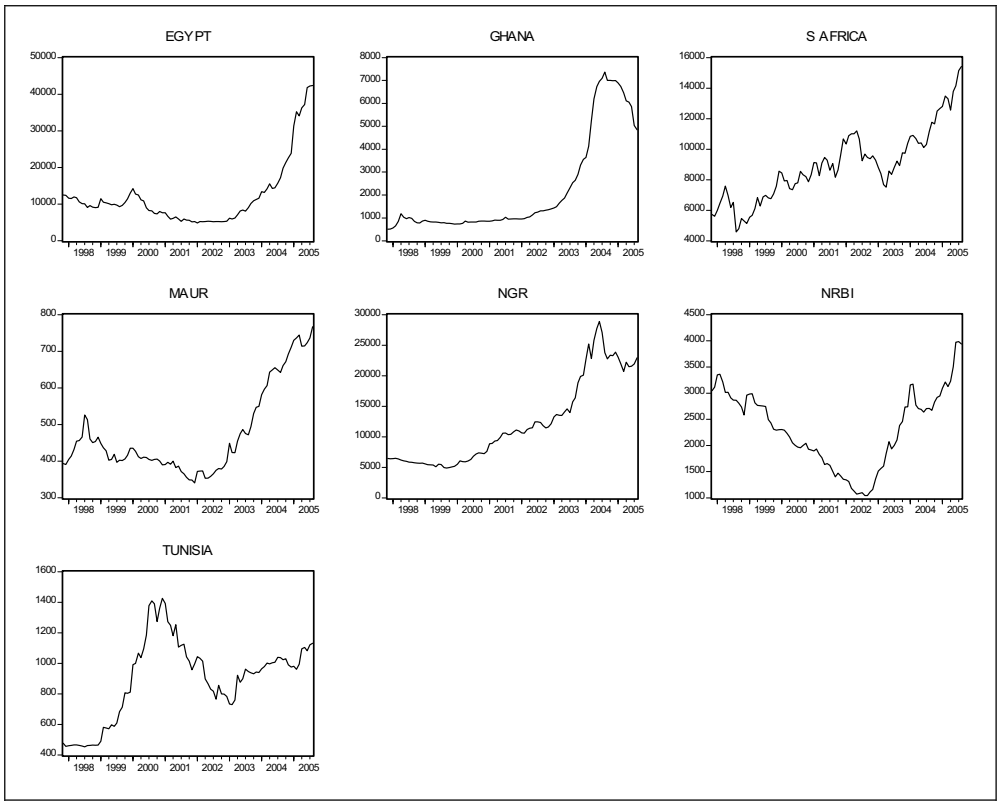


Fig. 1. Trends in stock market activity

Generally, the periods chosen have evidence of typical business cycles in stock market activity for the seven countries. Given that these cycles are experienced at different times by these different markets, it is difficult to isolate their effect in the analysis. However efforts are made to test the stability of the models in an attempt to capture the possible effect of some of these cycles.

Table 3 also shows summary descriptive statistics on the stock market returns in the seven countries. Ghana recorded the highest mean market returns (2.4%), whilst Mauritius recorded the lowest mean market returns (0.7%). The highest market return was also recorded on the Ghanaian market (33%). In terms of market return lowest, the Johannesburg Stock Exchange in South Africa was the worst performer with a loss of 35%.

Table 3

Summary statistics on market returns (1997-11)-(2005-8)

	EGYP	GHAN	SAFRICA	MAUR	NGR	KEN	TUN
Mean	0.013	0.024	0.011	0.007	0.014	0.0031	0.009
Median	0.004	0.007	0.013	0.007	0.005	-0.003	0.003
Maximum	0.271	0.333	0.132	0.122	0.150	0.160	0.201
Minimum	-0.193	-0.153	-0.351	-0.108	-0.130	-0.136	-0.123
Std. Dev.	0.080	0.075	0.071	0.035	0.050	0.057	0.058
Skewness	0.332	1.151	-1.459	0.287	0.291	0.679	0.917
Kurtosis	3.501	6.557	8.739	4.968	3.625	3.684	5.085
Jarque-Bera	2.683	69.568	160.618	16.287	2.826	8.957	29.889
Probability	0.261	0	0	0	0.243	0.011	0
Observations	93	93	93	93	93	93	93

Prior to the cointegration analysis unit roots tests are conducted to determine the stationarity or otherwise of the stock market indices. The unit roots tests are conducted on log levels of the stock market indexes using the Augmented Dickey Fuller (ADF) and Philips Perron (PP) Results from the test (Table 3) indicate that all the stock prices in the 7 countries are. $I(1)$

Table 4

Unit Root Test

	Stock Market Prices				
			First Diff ADF	First Diff PP	Order of integration
	ADF	PP			
Legypt	-1.6547	-1.6887	-5.2751***	-8.4706***	I(1)
lg *hana*	-2.5214	-1.4971	-6.3228***	-7.9993***	I(1)
lken	-1.3627	-0.4411	-5.0172***	-6.7333***	I(1)
lmaur	-1.79953	-1.7969	-6.3821***	-7.5049***	I(1)
ln *gr*	-1.4432	-0.7444	-4.887***	-5.3748***	I(1)
lsafrica	-1.295	-1.211	-7.8623***	-10.8221***	I(1)
ltunisia	-1.290	-1.282	-5.83***	-8.05***	I(1)

Legypt, lg *hana*, *lken*, *lmaur*, ln *gr lsafrica*, *ltunisia* are log levels of stock market indexes in Egypt, Ghana Kenya, Mauritius, Nigeria, South Africa and Tunisia respectively. ** (***) Indicate significance at 5% and 1% respectively.

The cointegration analysis is carried out in the Johansen (1992), Johansen and Juselius (1992) framework. Given the sensitivity of the cointegration test to lag lengths, various tests are performed to choose the optimal lag length for each country (Table 5). From the test results in Table 6, the trace test indicates the presence of 2 cointegrating equations. The presence of cointegration implies that technological and structural endowments amongst the countries involved are cointegrated. This also implies that there are dynamic long run causal relationships between stock markets in the countries.

Table 5

VAR Lag Order Selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	208.028	NA	2.20e-11	-4.675	-4.475	-4.595
1	971.082	1384.144	1.36e-18*	-21.281	-19.683*	-20.638*
2	1009.210	62.956	1.78e-18	-21.028	-18.032	-19.822
3	1049.469	59.921	2.31e-18	-20.825	-16.431	-19.056
4	1102.472	70.261	2.35e-18	-20.918	-15.125	-18.586
5	1159.069	65.811	2.39e-18	-21.095	-13.903	-18.200
6	1197.832	38.763	4.12e-18	-20.857	-12.266	-17.399
7	1288.202	75.658*	2.53e-18	-21.819	-11.830	-17.799
8	1350.323	41.896	3.85e-18	-22.124*	-10.737	-17.541

* indicates lag order selected by the criterion LR: sequential modified LR test statistic (each test at 5% level) FPE: Final prediction error AIC: Akaike information criterion SC: Schwarz information criterion HQ: Hannan-Quinn information criterion.

Intuitively it is expected that the 2 long-run relations will be hinged, first on a smaller market influencing a larger market, and second, on a smaller market being influenced by a relatively larger market. Two long run equations are therefore derived from the cointegration analysis;

the first is normalized on the Johannesburg Stock Exchange in South Africa and the second on the Ghana Stock Exchange. The first equation is normalised on the South African stock market since it is the most active and largest exchange, and the second equation normalized on Ghana the smaller and relatively less developed market within the group.

Table 6

Cointegration Tests

H_0	$\lambda_{\max}$	*95% critical value*	*trace*	*95% critical value*
$r = 0$	56.884*	46.231	153.925*	125.615
$r \leq 1$	30.662	40.078	97.041*	95.754
$r \leq 2$	25.824	33.877	66.379	69.819
$r \leq 3$	22.368	27.584	40.555	47.856
$r \leq 4$	11.576	21.132	18.187	29.797
$r \leq 5$	6.579	14.265	6.611	15.495
$r \leq 6$	0.032	3.841	0.032	3.841

* denotes rejection of the hypothesis of no cointegration at the 0.05 level using MacKinnon-Haug-Michelis (1999) p-values, trace test indicates 2 cointegration equation at 0.05% significance level.

However the cointegration relations may not necessarily be uniquely identified so restrictions are placed on the β vector to identify the cointegration relations. The assumptions for the restrictions on the β vector are motivated by the assumptions underlying the normalization of the β vector for the cointegration equations. In addition it is assumed that South African stock market will react more rapidly to the largest market in the subgroup (in this case Egypt) on a one-to-one relationship. In the case of the second cointegration relation based on Ghana, it is assumed that the Ghanaian market will also react more rapidly to the two largest markets in the group (South Africa and Egypt), in a one-to-one basis. Finally based on exclusions tests[1] on the significance of the cointegration coefficients to each of the 2 markets it is evident that the Tunisian stock market may be redundant in the second cointegration space. Δ

Table 7

α vector coefficients from normalized β vector

Δ *lsafrica*	-0.205 [2.444]*	0.146 [-3.054]*
Δ *legypt*	0.174 [-1.834]*	-0.111 [2.058]*
Δ lg *hana*	-0.166 [2.051]*	0.125 [-2.701]*
Δ ln *gr*	0.066 [-0.992]	-0.033 [0.870]
Δ *lken*	-0.148 [2.162]*	0.069 [-1.752]*
Δ *lmaur*	0.048 [-1.112]	-0.010 [0.421]
Δ *ltunisia*	-0.115 [1.498]	0.054 [-1.221]

* indicates significance of at least 10% Figures in square brackets are t-values of α vector.

Following Harris and Sollis (2003, p. 142) individual weak exogeneity tests are not performed for the α coefficients since they are reported with t-values upon which inferences can be drawn on weak exogeneity. Thus restrictions on the α vector are based on an inspection of the t-

[1] The test results not shown for brevity indicate Tunisian market may not be participating in the cointegration space. Not shown for brevity.

value. The t-values (Table 7) suggest that weak exogeneity for Nigeria, Mauritius and Kenyan stock markets are likely to hold. Based on the assumptions and information from the α and β vectors the following initial restrictions on the vector $\Pi_r = \alpha_r \beta_r'$ are likely to hold with $r =$ cointegration rank or number of cointegrating equations $r = 2$

$$\alpha_r \beta_r' = \begin{pmatrix} \alpha_{11} & \alpha_{21} \\ \alpha_{12} & \alpha_{22} \\ \alpha_{13} & \alpha_{23} \\ 0 & 0 \\ \alpha_{15} & \alpha_{25} \\ 0 & 0 \\ 0 & 0 \end{pmatrix} \begin{pmatrix} 1 & -1 & \beta_{13} & \beta_{14} & \beta_{15} & \beta_{16} & \beta_{17} \\ -1 & -1 & 1 & \beta_{24} & \beta_{25} & \beta_{26} & 0 \end{pmatrix}$$

LR test of restrictions: $\chi^2(8) = 9.120$ Probability: [0.332]

The overall Likelihood Ratio (LR) test statistics does not reject the null hypothesis thus the restrictions are binding and accepted. Additional test for weak exogeneity of the Ghana stock market in the South African cointegrating relationship is also conducted and the LR test $\chi^2(9) = 13.038\,[0.161]$ indicates that this additional restriction is binding.

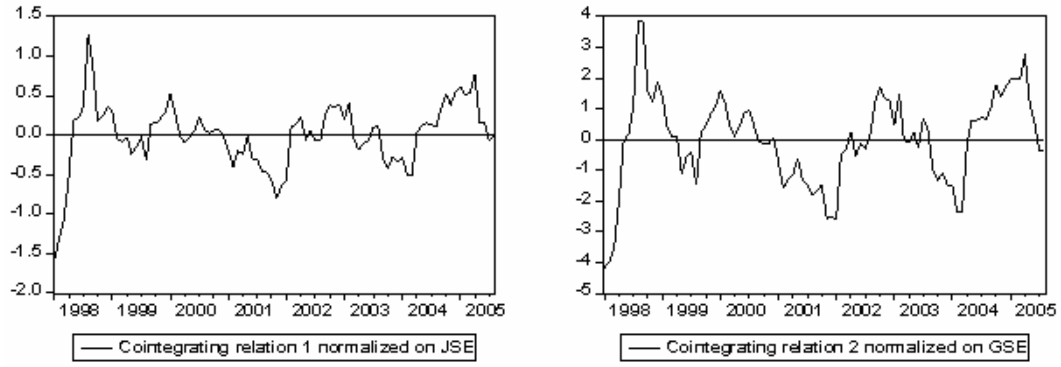
Table 8

Restricted eigenvectors and adjustment coefficients

β	β_1	β_2	α	α_1	α_2
lsafrica	1	-1	Δ *lsafrica*	-0.231 (0.072)	0.044 (0.02)
Legypt	-1	-1	Δ *legypt*	0.123 (0.079)	-0.013 (0.021)
lg *hana*	0.428 [3.445]	1	Δ lg *hana*	0	-0.019 (0.006)
ln *gr*	-1.552 [-6.649]	-3.200 [-3.931]	Δ ln *gr*	0	0
lken	-0.954 [-2.843]	-5.388 [-4.278]	Δ *lken*	-0.189 (0.050)	0.066 (0.014)
lmaur	4.472 [5.663]	12.925 [4.665]	Δ *lmaur*	0	0
ltunisia	-0.086 [-1.541]	0	Δ *ltunisia*	0	0

Figures in square brackets are t-statistics of unrestricted long-run coefficient estimates and figures in parenthesis are standard errors of unrestricted coefficient estimates. LR test of restrictions: $\chi^2(9) = 13.038\,[0.161]$.

The resulting restricted long-run cointegration relations are reported in Table 8. The first equation (column 2) shows that the Nigerian, Kenyan and Tunisian stock markets positively influence the Stock African stock market whilst the Ghana and Mauritian stock markets have a negative long-run influence on the South African stock market. The second equation (column 3) shows that with the exception of the Mauritian market all other markets have a positive long-run influence on the Ghana stock market. A plot of the two cointegrating relations (Figure 2) shows a fairly stable relationship in each equation.



JSE: The South African stock market (Johannesburg Stock Exchange), GSE: The Ghana Stock market (Ghana Stock Exchange).

Fig. 2. Plot of cointegrating relations

Having obtained the long-run relations the short-run models are now formulated in a VECM framework and are of the form:

$$\Delta Y_t = \sum_{i=0}^{k-1} \gamma_i \Delta Y_{t-i} + \alpha\left[\delta_1 ect1 + \delta_2 ect2\right]_{t-k} + \mu_t , \quad (3)$$

where $ect1_{t-1}$, $ect2_{t-1}$ are the error terms representing the speed of adjustment from short-run disequilibrium in the South African and Ghanaian stock market cointegration relationships respectively. Given that all restrictions on the relevant vectors are binding, ordinary least squares (OLS) is an efficient way to estimate the VECM. The optimal lag length 4 for the short run models is based on tests for lag length criteria. The model diagnostics from the VECM in Table 9 show that generally the model is congruent and is devoid of serious misspecification.

Table 9

VECM Residual Diagnostics

	White Heteroskedasticity	Normality	Serial Correlation LM
Test-statistic	1687.76	60.941	33.579
Probability	0.442	0.000***	0.954

***, **, * denote significance at 1%, 5% and 10% respectively.

Insignificant regressors are also removed in the error-correction-models based on the Hendry (1995, pp. 344-367) general-to-specific approach to modelling, to achieve parsimony. The model reduction process is guided by inspection of F test results, Schwartz and Akaike Information Criteria. Final[1] results of OLS estimates for each short-run equation are shown in Tables 10 and 11.

[1] The general models are shown in Tables A1 and A2 in the appendix.

Table 10

Short-run parsimonious error correction model on South African stock market

Dependent Variable: Δ *lsafrica*				
White Heteroskedasticity-Consistent Standard Errors & Covariance				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Δ $lsafrica_{t-1}$	0.269	0.090	2.973	0.004***
Δ $lsafrica_{t-2}$	0.251	0.096	2.613	0.011**
Δ $lsafrica_{t-3}$	0.330	0.077	4.315	0.000***
Δ *legypt*	0.331	0.079	4.172	0.000***
Δ $legypt_{t-2}$	-0.132	0.075	-1.772	0.081*
Δ lg *hana*	-0.145	0.126	-1.145	0.256
Δ lg $hana_{t-2}$	-0.233	0.083	-2.801	0.007***
Δ lg $hana_{t-3}$	0.275	0.111	2.479	0.016**
Δ lg $hana_{t-4}$	-0.224	0.110	-2.027	0.046**
Δ ln *gr*	0.186	0.106	1.756	0.083*
Δ *lken*	-0.439	0.098	-4.471	0.000***
Δ $lken_{t-4}$	0.169	0.112	1.513	0.135
Δ *ltunisia*	-0.171	0.088	-1.935	0.057*
Δ $ltunisia_{t-4}$	-0.207	0.096	-2.143	0.036**
$ect1_{t-1}$	-0.597	0.089	-6.730	0.000***
$ect2_{t-1}$	0.027	0.051	0.526	0.601
Constant	0.008	0.006	1.312	0.194
R-squared	0.568	Akaike info criterion		-2.904
Adjusted R-squared	0.472	Schwarz criterion		-2.429
S.E. of regression	0.052	F-statistic		5.908 [0.000]***
Diagnostic Tests				
Breusch-Godfrey Serial Correlation LM	1.098 [0.373]	Normality		0.051 [0.975]
ARCH	0.922 [0.484]	Chow Breakpoint 2002 Chow Breakpoint 2003		1.092 [0.385] 0.753 [0.735]
White Heteroskedasticity	1.342 [0.165]	RESET		4.983[0.029]**

***, **, * denote significance at 1%, 5% and 10% respectively. $ect1_{t-1}$, $ect2_{t-1}$ are the error terms representing the speed of adjustment from short-run disequilibrium in the South African and Ghanaian stock market cointegration relationships respectively.

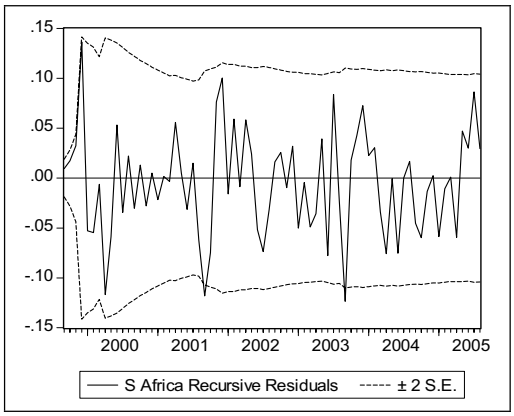


Fig. 3. South African model stability recursive residuals

The structure of the error-correction-model for the South African market (Table 10) is validated by the significance of the error correction term ($ect1_{t-1}$). The error correction shows significant correction of approximately 60% from short-run disequilibrium to the long-run equilibrium. The term $ect2_{t-1}$ which represents disturbances from the second short-run error-correction-model (the error-correction model for Ghana) has a puzzling positive sign[1] this is however insignificant. This implies that disturbances from the short-run in the Ghanaian equation do not significantly influence the South African short-run dynamics. The model diagnostics also show a fairly robust model. Furthermore Chow Breakpoint tests for model stability were conducted for 2002 and 2003 to capture the likely effect of some of the cycles noticed in the South African market in Figure 1. The test results in the diagnostic section in Table 10 show that the model is resilient under such cycles. Generally, in the short-run, instantaneous increases in stock returns in Egypt, Ghana and Nigeria result in increases in stock returns in the South African stock market. However, thereafter, changes in lagged stock returns in Egypt, Ghana and Nigeria result in a depression in stock returns on the South African stock market. In addition changes in stock returns in Tunisia appear to depress stock returns in the South African market.

Table 11

Short-run error correction model on Ghana stock market

Dependent Variable: Δ lg *hana*				
White Heteroskedasticity-Consistent Standard Errors & Covariance				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Δ lg $hana_{t-1}$	0.454	0.167	2.718	0.008***
Δ lg $hana_{t-3}$	0.130	0.083	1.572	0.120
Δ $lsafrica_{t-1}$	0.264	0.074	3.585	0.001***
Δ $lsafrica_{t-2}$	0.198	0.077	2.580	0.012**
Δ $lsafrica_{t-3}$	0.216	0.071	3.054	0.003***
Δ *lmaur*	0.773	0.255	3.029	0.003***

[1] The positive error term shows that short-run disequilibrium from the Ghana market veers off again from long-run equilibrium after settling initially, however the magnitude of the South African short-run error correction term outweighs that of the Ghanaian market error term. We thank Simon Harvey for the comments.

Table 11 (continuous)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Δ *lken*	-0.268	0.140	-1.909	0.060*
$ect1_{t-1}$	-0.312	0.126	-2.476	0.015**
$ect2_{t-1}$	-0.296	0.074	-4.021	0.000***
Constant	0.001	0.006	0.090	0.929
R-squared	0.503	Akaike info criterion		-2.832
Adjusted R-squared	0.447	Schwarz criterion		-2.554
S.E. of regression	0.056	F-statistic		8.995 [0.000]***
Diagnostic Tests				
Breusch-Godfrey Serial Correlation LM	0.562 [0.759]	Normality		0.051 [0.975]
ARCH	0.877 [0.516]	Chow Breakpoint 2002 Chow Breakpoint 2004		1.770 [0.082]* 1.010 [0.443]
White Heteroskedasticity	6.551 [0.000]***	RESET		20.430 [0.000]***

***, **, * denote significance at 1%, 5% and 10% respectively. $ect1_{t-1}$, $ect2_{t-1}$ are the error terms representing the speed of adjustment from short-run disequilibrium in the South African and Ghanaian stock market cointegration relationships respectively.

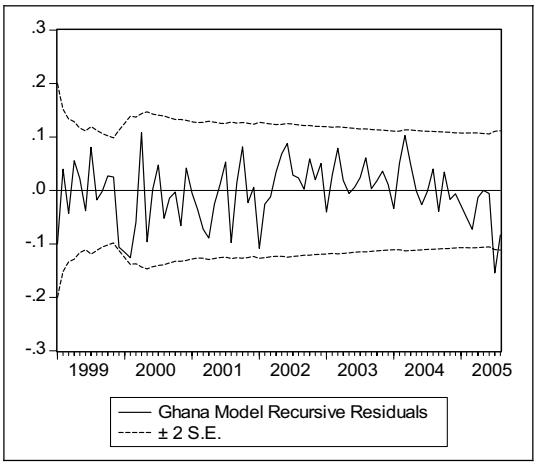


Fig. 4. Ghana model stability recursive residuals

The equilibrium structure of the error-correction-model for the Ghana stock market (Table 11) is also validated by the significance of the error correction term ($ect2_{t-1}$). The error correction shows a slow but significant feedback of approximately 30% from short-run disequilibrium to the long-run equilibrium. Interestingly disturbances from the short-run South African stock market model ($ect2_{t-1}$) significantly influence the short-run model for the Ghana stock market returns. Thus there are dynamic short-run impacts of short-run misalignments in the South African stock market. The model diagnostics though not as good as that of the South African situation also show a fairly robust model. Indeed the stability of the model is weakened slightly when the breakpoint test is conducted in one of the business cycle years (2002) noticed in Figure 1 earlier. Generally, in the short-run, the most significant stock markets that influence stock returns on the Ghana stock market are stock returns in South Africa, Mauritius and Kenya. Stock returns in these markets are positively related to stock returns in the Ghana stock market, with Mauritius stock returns

having a rather huge effect on returns on the Ghana stock market. Stock returns in Kenya however have a negative relationship with stock returns in Ghana.

IV. Conclusion

The empirical findings from this paper are three-fold. First, there are unique long-run relationships underlying African stock markets. Second, the long-run relations hinge on two markets: a larger more relatively active market (South African stock market) and a smaller and inactive market (Ghana stock market). Third, there are dynamic short run responses and feedbacks from other African stock markets affecting the South African and Ghanaian stock market in the short-run. Equilibrium correction is faster in the South African model as compared to the Ghanaian model. Disturbances from the short-run disequilibrium in the Ghana stock returns error-correction do not influence the short-run dynamics in South African stock market. However short-run disequilibrium in the South African market significantly influences stock market returns in the Ghana stock market in the short-run. Thus the South African stock market appears to have a dominating influence on the younger and relatively inactive Ghanaian market. Overall the evidence points to the fact that there is long-run interdependence between African stock markets as well as dynamic causality running both ways from larger to smaller markets.

The presence of long-run market causality along two types of markets (large and small) has interest implications. Long-run variations in the South African market are influenced significantly to an extent by reactions from other markets such as Egypt, Mauritius, Nigeria, Kenya and Ghana. Similarly market activity changes in South Africa, Egypt, Mauritius, Kenya and Nigeria have significant long-run impacts on the Ghanaian market. This implies that the South African (larger market) market and the Ghanaian market (smaller markets) must regularly monitor developments in these other markets, due to their long-run impacts. From the short-run dynamics it is also evident, that in the case of Ghana (small market) in particular, short-run disequilibrium in the South African market has significant influences on the Ghanaian market. This also means short-run adjustments in the South African market help to correct disequilibrium in the Ghanaian market. It also implies that the South African market (larger) has a domineering influence on the Ghanaian (smaller) market. Thus the Ghanaian market must be particularly mindful of developments in the South African market especially since disequilibrium correction in Ghana depends also on the South African market.

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Table A1

General short-run model (South Africa)

Dependent Variable: $\Delta lsafrica_t$				
White Heteroskedasticity-Consistent Standard Errors & Covariance				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
$\Delta lsafrica_{t-1}$	0.363413	0.144921	2.507667	0.0153
$\Delta lsafrica_{t-2}$	0.302279	0.143048	2.113136	0.0394
$\Delta lsafrica_{t-3}$	0.416833	0.122805	3.394280	0.0013
$\Delta lsafrica_{t-4}$	-0.083925	0.107847	-0.778186	0.4400
$\Delta legypt_t$	0.342284	0.101824	3.361511	0.0015
$\Delta legypt_{t-1}$	-0.051763	0.122601	-0.422210	0.6746
$\Delta legypt_{t-2}$	-0.227702	0.103825	-2.193136	0.0328
$\Delta legypt_{t-3}$	-0.095755	0.108038	-0.886311	0.3795
$\Delta legypt_{t-4}$	-0.127907	0.096145	-1.330348	0.1892
$\Delta \lg hana_t$	-0.157271	0.128147	-1.227270	0.2252
$\Delta \lg hana_{t-1}$	-0.027529	0.102814	-0.267755	0.7899
$\Delta \lg hana_{t-2}$	-0.293309	0.122364	-2.397020	0.0202
$\Delta \lg hana_{t-3}$	0.234725	0.128268	1.829957	0.0730
$\Delta \lg hana_{t-4}$	-0.317599	0.151697	-2.093641	0.0412
$\Delta \ln gr_t$	0.169662	0.108801	1.559370	0.1250
$\Delta \ln gr_{t-1}$	0.210390	0.154041	1.365807	0.1779
$\Delta \ln gr_{t-2}$	-0.044886	0.185601	-0.241843	0.8099
$\Delta \ln gr_{t-3}$	-0.091707	0.149172	-0.614771	0.5414
$\Delta \ln gr_{t-4}$	-0.145976	0.165953	-0.879622	0.3831
$\Delta lmaur_t$	0.029185	0.244726	0.119258	0.9055
$\Delta lmaur_{t-1}$	0.386270	0.332036	1.163338	0.2500
$\Delta lmaur_{t-2}$	0.133028	0.254470	0.522764	0.6034
$\Delta lmaur_{t-3}$	0.336484	0.243019	1.384602	0.1721
$\Delta lmaur_{t-4}$	0.368814	0.253025	1.457615	0.1510
$\Delta lken_t$	-0.632680	0.141623	-4.467363	0.0000
$\Delta lken_{t-1}$	0.084599	0.155668	0.543460	0.5891
$\Delta lken_{t-2}$	0.066657	0.166819	0.399576	0.6911

Table A1 (continuous)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$\Delta lken_{t-3}$	0.092856	0.145957	0.636183	0.5274
$\Delta lken_{t-4}$	0.190513	0.137804	1.382491	0.1727
$\Delta ltunisia_{t}$	-0.171383	0.103222	-1.660335	0.1029
$\Delta ltunisia_{t-1}$	0.069038	0.117137	0.589381	0.5582
$\Delta ltunisia_{t-2}$	-0.178872	0.131679	-1.358400	0.1802
$\Delta ltunisia_{t-3}$	0.007156	0.135938	0.052640	0.9582
$\Delta ltunisia_{t-4}$	-0.246467	0.115190	-2.139649	0.0371
$ect1_{t-1}$	-0.704109	0.156006	-4.513341	0.0000
$ect2_{t-1}$	0.134769	0.102143	1.319413	0.1928
Constant	0.010806	0.008070	1.339108	0.1864

R-squared	0.645105	Mean dependent var	0.008974
Adjusted R-squared	0.399409	S.D. dependent var	0.071573
S.E. of regression	0.055467	Akaike info criterion	-2.651982
Sum squared resid	0.159984	Schwarz criterion	-1.617380
Log likelihood	155.0132	F-statistic	2.625621
Durbin-Watson stat	1.841211	Prob(F-statistic)	0.000734

Diagnostic test results are not shown for brevity and are available from authors upon request.

Table A2

General short-run model (Ghana)

Dependent Variable: $\Delta \lg hana_{t}$				
White Heteroskedasticity-Consistent Standard Errors & Covariance				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
$\Delta \lg hana_{t-1}$	0.328052	0.280301	1.170355	0.2467
$\Delta \lg hana_{t-2}$	-0.123769	0.144717	-0.855250	0.3960
$\Delta \lg hana_{t-3}$	0.112554	0.120437	0.934551	0.3540
$\Delta \lg hana_{t-4}$	0.007676	0.082968	0.092522	0.9266
$\Delta lsafrica_{t}$	-0.106327	0.116361	-0.913766	0.3647
$\Delta lsafrica_{t-1}$	0.186878	0.097185	1.922916	0.0595
$\Delta lsafrica_{t-2}$	0.133018	0.100586	1.322428	0.1913
$\Delta lsafrica_{t-3}$	0.250197	0.097935	2.554732	0.0133
$\Delta lsafrica_{t-4}$	0.000191	0.101825	0.001874	0.9985

Table A2 (continuous)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$\Delta lmaur_t$	0.652429	0.261535	2.494618	0.0155
$\Delta lmaur_{t-1}$	0.175694	0.235512	0.746008	0.4587
$\Delta lmaur_{t-2}$	-0.063704	0.220987	-0.288269	0.7742
$\Delta lmaur_{t-3}$	-0.066202	0.214236	-0.309014	0.7584
$\Delta lmaur_{t-4}$	0.027853	0.178124	0.156367	0.8763
$\Delta \ln gr_t$	0.012162	0.145350	0.083673	0.9336
$\Delta \ln gr_{t-1}$	0.168075	0.146136	1.150127	0.2549
$\Delta \ln gr_{t-2}$	0.271513	0.168643	1.609983	0.1129
$\Delta \ln gr_{t-3}$	-0.141313	0.185239	-0.762871	0.4487
$\Delta \ln gr_{t-4}$	0.060455	0.143116	0.422421	0.6743
$\Delta lken_t$	-0.261664	0.180037	-1.453390	0.1516
$\Delta lken_{t-1}$	-0.166642	0.130691	-1.275082	0.2075
$\Delta lken_{t-2}$	-0.067462	0.132851	-0.507801	0.6136
$\Delta lken_{t-3}$	0.291407	0.127408	2.287193	0.0259
$\Delta lken_{t-4}$	0.121531	0.116615	1.042155	0.3017
$\Delta ltunisia_t$	-0.068394	0.076098	-0.898754	0.3726
$\Delta ltunisia_{t-1}$	-0.076520	0.108907	-0.702610	0.4852
$\Delta ltunisia_{t-2}$	0.008605	0.099066	0.086860	0.9311
$\Delta ltunisia_{t-3}$	0.019575	0.106543	0.183728	0.8549
$\Delta ltunisia_t$	-0.142699	0.127612	-1.118230	0.2682
$ect1_{t-1}$	-0.324807	0.199875	-1.625052	0.1097
$ect2_{t-1}$	-0.146019	0.104573	-1.396335	0.1680
Constant	0.003397	0.006762	0.502342	0.6174

R-squared	0.563924	Mean dependent var	0.019560
Adjusted R-squared	0.326759	S.D. dependent var	0.070560
S.E. of regression	0.057896	Akaike info criterion	-2.586836
Sum squared resid	0.191058	Schwarz criterion	-1.692046
Log likelihood	147.1142	F-statistic	2.377776
Durbin-Watson stat	2.096108	Prob(F-statistic)	0.002277

See notes to Table A1.