# Testing the weak-form efficiency in African stock markets

# Testing the weak-form efficiency in African stock markets

Collins G. Ntim
*School of Management and Business, Aberystwyth University, Aberystwyth, UK*

Kwaku K. Opong and Jo Danbolt
*Accounting & Finance, Business School, University of Glasgow, Glasgow, UK*

Frank Senyo Dewotor
*Falcum Asset Management, London, UK*

## Abstract

**Purpose** – The purpose of this study is to investigate and compare the weak-form efficiency of a set of 24 African continent-wide stock price indices and those of 8 individual African national stock price indices.

**Design/methodology/approach** – The study uses variance-ratio tests based on ranks and signs to examine the weak-form efficiency of the 32 stock price indices investigated.

**Findings** – On average, we find that irrespective of the test employed, the returns of all the 24 African continent-wide stock price indices examined in the study are less non-normally distributed compared to the 8 individual national stock price indices examined. We also report evidence of the African continent-wide stock price indices having significantly better weak-form informational efficiency than their national counterparts.

**Practical implications** – The policy implication of this evidence is that the African equity price discovery process can be significantly improved if African stock markets integrate their operations. Economically, this may contribute to improved liquidity and more efficient allocation of capital, which in turn can be expected to have a positive impact on economic growth.

**Originality/value** – The study makes two major contributions to the extant literature. Firstly, we offer for the first time a comparative analysis of the informational efficiencies of a sample of national stock price indices as against African continent-wide stock price indices. Secondly, there is no prior evidence as to whether African stock markets can improve their informational efficiencies by integrating their operations. Our comparison fills this gap by demonstrating that the African equity price formation process can be improved if African stock markets integrate their operations.



**Keywords:** African stock markets, Integration, Weak-form efficiency, Variance-ratios, Ranks and signs

**Article type:** Research paper

## 1. Introduction

Over the last three decades, there has been a substantial increase in the number of stock markets in Africa. With only 8 active stock markets[1] in 1980, the number of stock markets in Africa increased to 18 by the end of 2002 (UNDP, 2003). Currently, there are 26 stock markets in Africa, and there are proposals to open new stock markets in Congo D.R., Equatorial Guinea, Ethiopia, the Gambia, Lesotho, Madagascar, Mauritania and Sierra Leone (Moin, 2007; Databank Group, 2008). Kenny and Moss (1998) suggest that this phenomenal growth in stock markets in Africa can be attributed to the financial sector reforms[2] undertaken by African countries. Levine (1997) argues that well-developed stock markets promote higher economic growth through their ability to attract international investments and mobilise domestic savings. The development and efficiency of the African stock markets can therefore be expected to have a major impact on the future economic growth of the African economies.

However, despite the rapid increase in the number of stock exchanges, stock markets in Africa (with the exception of South Africa) remain rather underdeveloped compared to their counterparts in developed and other emerging markets. First, they are small in size. The total value of African stocks, excluding those traded in South Africa, was in 2007 only 0.62% of global stock market capitalisation, and 1.55% of all emerging markets stocks (WFE, 2008). Second, the stock markets are also small in relation to their own economies. For example, stock market capitalisation in Mozambique is only 3.20% of GDP, while Nigeria, Uganda and Tunisia's stock market capitalisations are between 25% and 52% of GDP (WFE, 2008). Crucially, they remain extremely thinly traded and illiquid (Mlambo and Npieke, 2005). This severely affects their informational efficiencies.

However, the ability of African stock markets to operate effectively depends on their level of informational efficiency (Smith *et al*., 2002). This raises a crucial policy question as to whether African stock markets can improve their informational efficiency by integrating their operations.

Our *a priori* expectation is that a formal integration[3] of operations of African stock markets may help overcome many of the current information challenges facing them (Irving, 2005; Okealaham, 2005). Lugangwa (2006), for example, argues that integration will increase African stock markets' visibility through increasing their size, while Fish and Biekpe (2002) suggest that regional integration will create expansion in trading volumes through economies of scale. Similarly, better communication and technological infrastructure will reduce operational costs and improve the flow of information in the market (Abumustafa, 2007). Such changes are likely to improve overall market efficiency.

Given the potential benefits that an integrated stock market could bring to African economies, we examine the informational efficiency of Africa-wide sector indices and compare them to some of their national counterparts. The study is conducted in the context of weak-form market efficiency. The weak-form market efficiency posits that financial asset prices traded in a market cannot be predicted by using information contained in the sequence of past prices (Fama, 1970). If future prices of financial assets can be modelled using information implicit in historical prices, such inefficiencies may be exploitable. The behaviour of financial asset prices in the context of the weak-form efficiency thus continues to be of considerable interests to researchers, regulators, practitioners and investors alike.

While the weak-form market efficiency of the major developed and emerging stock markets of Latin America, Europe and Asia have been the focus of prior studies (Claessens *et al*., 1995; Urrutia, 1995; Fifield *et al*., 2005), the weak-form hypothesis has received little attention from researchers in Africa. None of the few existing studies provides a continent-wide analysis. The prior studies on the efficiency of African stock markets also offer contradictory results (Parkinson, 1984; Dickinson and Muragu, 1994). A plausible explanation is that most of the extant African studies use conventional techniques such as autocorrelation tests, whose robustness have been questioned elsewhere (Savit, 1988; Hsieh, 1991).

With the increasing importance of emerging African markets, both in terms of size and number, the need for reliable evidence on their informational efficiencies is particularly important. First, unlike their developed counterparts, African countries have fledgling economies in which market efficiency still has significant developmental implications. Second, African stock markets, with the exception of South Africa, have low correlations with global stock markets (Moin, 2007). This offers portfolio diversification opportunities for international investors.

This study adds to the extant African weak-form efficiency literature by providing evidence on the behaviour of continent-wide and national stock price indices. First, we make use of specially constructed size, sectoral and regional African stock price composite indices. To the best of our knowledge, this will be the first comprehensive African continent-wide data series examined in any study. Second, we offer for the first time, a comparative analysis of the informational efficiencies of a sample of national stock price indices as against African continent-wide constructed stock price indices.

The remainder of the paper is organised as follows. Section 2 provides an overview of African stock markets. Section 3 describes the data and research methodology. Section 4 presents empirical results while section 5 concludes.

## 2. Overview of African Stock Markets and the Prior African Weak-form studies

In a relatively short time, several African countries have developed stock markets. With only 8 active stock markets in 1980, the number of African stock markets increased to 18 by the end of 2002 (UNDP, 2003), and is currently 26 (Moin, 2007). As a corollary, African stock markets vary substantially in institutional and market infrastructural characteristics. Smith *et al*. (2002) classify African stock markets into four groups. These are:

1. South Africa – the largest and the oldest stock market in Africa.
2. A group of medium-size markets, consisting of Egypt, Kenya, Nigeria, Morocco, Tunisia and Zimbabwe.
3. A group of small, but rapidly growing markets, consisting of Botswana, Cote d'Ivoire, Ghana, Namibia and Mauritius.
4. A group of very small markets, consisting of Libya, Malawi, Mozambique, Sudan, Swaziland, Tanzania, Uganda and Zambia, which are struggling to take-off.

Table 1 provides development statistics[4] for 18 African stock markets as at the end of 2007. It shows that, excluding South Africa, African stock markets are generally small and immature, with an average of only 70 firms listed in each market. The total continental market capitalisation excluding South Africa is less than $400m with an average market capitalisation of less than $26m. This is important because past evidence

suggests that larger stock markets are better able to attract capital to finance growth (Kenny and Moss, 1998).

Insert Table 1 about here

Table 2 shows the liquidity of 18 African stock markets from 2000 to 2007. Generally, it shows that African stock markets suffer from low liquidity. The average liquidity excluding South Africa was about 7% and 12% for 2000 and 2007, respectively. This suggests gradual rather than substantial improvements in the liquidity of African stock markets over the last eight years. There are also substantial differences in liquidity among the stock markets. For example, while the value of shares traded in Egypt was more than 43% of market capitalisation in 2007, the corresponding value of shares traded in Malawi, Namibia and Tanzania were less than 1%. The low liquidity of African stock markets is important because it indicates that the equity pricing process may be inefficient. This may also impair economic performance (Jun *et al*., 2003; Chordia *et al*., 2008).

Insert Table 2 about here

Table 3 presents development characteristics of 18 African stock markets as at the end of 2007. It shows that most African stock markets have electronic trading systems, trade for five days, and have a 3 day settlement period. However, these are recent developments that may take time to have an impact on pricing efficiency (UNDP, 2003; Moin, 2007). For example, with the exception of Egypt, Nigeria and South Africa, none of the stock markets had electronic trading system, or traded for more than 3 days per week, in 2005. Similarly, with small numbers of listed firms, trading hours are relatively short, averaging about 3 hours per day. This may explain the low liquidity of African

stock markets. It also shows that African stock markets have poor international recognition, which is an indication of poor compliance with global standards. For example, only 3 African stock markets have full membership of the prestigious World Federation of Exchanges (WFE).

Insert Table 3 about here

Despite these weaknesses, however, African stock markets are recognised as major agents of economic development (Okeahalam, 2005). Table 4 shows that the Africa All Share Index, for example, correlates either negatively or lowly with all the major global equity markets, including those of other emerging markets. This presents significant diversification opportunities for international investors (Fifield *et al*., 2002). As discussed above (see Table 1), African stock markets have also experienced fast growth in the number of listed firms and capitalisation. They also offer competitive real returns. Past studies suggest that these returns remain significant even after accounting for transaction costs, although they tend to be volatile (Lesmond, 2005; Collins and Abrahamson, 2006).

Insert Table 4 about here

In spite of their potential future economic relevance, however, little is known about the weak-form efficiency of African stock markets (Appiah-Kusi and Menya, 2003; Simons and Laryea, 2006). This is mainly due to the difficulty of obtaining data of sufficient frequency and duration for empirical research (Smith *et al*., 2002). Samuels and Yacout (1981) and Parkinson (1984) are among the pioneers to examine the weak-form efficiency in Africa using autocorrelation tests, although they offer conflicting results. While the results of Samuels and Yacout suggest that the notion of weak-form market

efficiency cannot be rejected in weekly return series of 21 listed Nigerian firms from 1977 to 1979, those of Parkinson reject it for monthly return series of 30 listed Kenyan firms from 1974 to 1978. Dickinson and Muragu (1994) study the weekly stock return behaviour of 30 Kenyan listed firms from 1979 to 1988. Their results indicate that the notion of weak-form market efficiency cannot be rejected for the 30 firms studied.

By contrast, Magnusson and Wydick (2002) use a partial-autocorrelation test to examine monthly return behaviour of stock markets indices for Botswana, Cote d'Ivoire, Ghana, Kenya, Mauritius, Nigeria, South Africa and Zimbabwe from 1989 to 1998. Their results suggest that all except Ghana and Zimbabwe of the eight African stock markets indices analysed are weak-form efficient. Smith *et al*. (2002) and Jefferis and Smith (2005) have also investigated the return behaviour of a group of African stock markets indices. While Smith *et al*. (2002) use multiple variance-ratios tests to examine the weak-form efficiency in weekly stock indices of eight African countries from 1990 to 1998, Jefferis and Smith (2005) apply a GARCH model to investigate serial-dependence in weekly stock indices of the same group of countries from 1990 to 2001. Both papers reject the notion of weak-form efficiency in the stock indices of all the countries examined except South Africa.

As has been pointed out, with the exception of South Africa, there have been relatively few studies of the weak-form efficiency of African stock markets. Most of the studies were carried out using data prior to the surge in interest in African stock markets in the early 1990s (Smith *et al*., 2002). Crucially, prior African weak-form market efficiency studies have produced conflicting results (Parkinson, 1984; Dickinson and Muragu, 1994). As Tables 1 to 3 show, the conflicting findings in the prior studies may

partly be explained by the operational differences among the African stock markets. However, it may also be attributable to the fact that most past studies conduct their analyses based on conventional techniques such as autocorrelation and unit root tests which may not be appropriate. The main problem with these methods is that they assume that stock returns are normally or linearly distributed (Hsieh, 1991; Urrutia, 1995). Recent evidence, however, suggests that African stock returns are non-normal (Jefferis and Smith, 2005; Ntim, *et al*., 2007). This raises questions regarding the reliability of prior results.

The current paper differs from existing studies in several important respects. First, we apply the Wright (2000) non-parametric variance-ratio tests, which have power against a wide range of non-normal return behaviour to analyse the data. Secondly, we offer evidence on the price behaviour of continent-wide stock price indices. Our results may have implications for the pricing of equities and economic attempts to integrate African economies. If the returns of African continent-wide stock price indices are less non-normally distributed than their national counterparts[5], it will suggest that the equity price discovery process may be improved by integration. Finally, we offer for the first time a comparative analysis of the informational efficiencies of a sample of national stock price indices as against African continent-wide stock price indices.

## 3. Data and Research Methodology

Two types of datasets[6] are used for the weak-form efficiency tests. The first consists of Africa continent-wide (excluding South Africa) sectoral, size and regional daily closing stock price indices. These indices were constructed and supplied by Africa

Business Research Ltd (ABR)[7]. ABR sets two main inclusion criteria for countries: (1) non-nationals must be allowed to fully invest in the stock market, and (2) there must be no exchange controls preventing the repatriation of dividends or capital/gains. The rationale is to ensure that international investors can freely enter and exit the market without any restrictions.

Botswana, Cote d'Ivoire, Egypt, Ghana, Kenya, Malawi, Mauritius, Morocco, Mozambique, Namibia, Nigeria, Swaziland, Tanzania, Tunisia, Uganda and Zambia are currently included. Zimbabwe is excluded because of exchange rate restrictions. The main index computed is the Africa All Share Index. It is a composite measure of the average performance of all companies listed on African stock markets excluding South Africa. ABR sets two main inclusion criteria for listed firms: (1) they must have a minimum market value of $10m at the quarterly index review date, and (2) they must achieve a traded turnover of at least 0.01% of its market capitalisation in the quarter preceding the index review date. The rationale is to ensure that the firms maintain some level of size and trading liquidity. In total, 550 firms listed on African stock markets, which meet the above criteria, are included in the Africa All Share Index.

The Africa All Share Index is segmented into three main groups of sub-indices:

a. Three capitalisation/size indices: *Africa large company index* covers the largest 50 companies; *Africa medium company index* covers the next 100 largest companies below the top 50, and *Africa small company index* covers all companies below the top 150. The Africa small company index is made up 400 listed firms.
b. Six major sectoral/industrial indices: consisting of 4 consumer goods sub-sector indices, 2 financials sub-sector indices, 3 industrials sub-sector indices, 2 natural

resources sub-sector indices, 3 services sub-sector indices, and 2 utilities sub-sector indices.

c. Five geographical/regional indices: *Eastern-Africa sub-region* consists of Kenya, Mauritius, Tanzania and Uganda; *Northern-Africa sub-region* consists of Algeria, Egypt, Morocco and Tunisia; *Southern-Africa sub-region* consists of Botswana, Malawi, Namibia, Swaziland and Zambia; *Sub-Saharan-Africa sub-region* consists of Botswana, Cote d'Ivoire, Ghana, Kenya, Malawi, Mauritius, Namibia, Nigeria, Swaziland, Tanzania, Uganda and Zambia; and the *Western-Africa sub-region* consists of Cote d'Ivoire, Ghana and Nigeria.

The second set of data is made up of daily national closing stock price indices, which are available in DataStream. Out of the 16 stock markets included in the Africa All Share Index, only eight, namely, Botswana, Egypt, Ghana, Kenya, Mauritius, Morocco, Nigeria and Tunisia are covered in DataStream. Appendix 1 provides full names, acronym/codes and information on sample periods for all stock price indices used.

In examining the weak-form market efficiency, two main hypotheses are tested: The random walk and the martingale difference sequence. The random walk (RW) hypothesis posits that in an efficient market, successive price changes follow that of a gaussian-random variable. Following Campbell *et al.* (1997), a financial asset's price series $(P_t)$ is said to follow a random walk, if;

$$P_t = \mu + P_{t-1} + \varepsilon_t, \;\; \varepsilon_t \sim IDD\ N(0, \partial^2),$$

where $(P_t)$ refers to the log of the stock market index at time (day) *t*; $\mu$ is an arbitrary drift parameter; and the error term $\varepsilon_t \sim IDD\ N(0, \partial^2)$ is independently and identically distributed with zero mean and unit variance $(\partial^2)$.

The hypothesis to be tested for the RW is:

$H_0$ : African sectoral, capitalisation, regional and individual national stock price indices returns follow a random walk.

$H_1$ : African sectoral, capitalisation, regional and individual national stock price indices returns do not follow a random walk.

By contrast, an asset's price series $(P_t)$ is said to follow a martingale difference sequence (MDS) if it satisfies the following condition: $E[P_{t+1} - P_t \mid P_t, P_{t-1}, ...] = 0$, where $(P_t)$ is the log of the asset's price series under consideration (i.e., the returns of African stock markets indices) at time (day) *t*. The major difference between the RW and the MDS hypotheses is that the latter relaxes the gaussian-random variable assumption to permit the possible existence of time-varying volatilities (such as conditional hetereoscedasticity) in an asset's return series. The MDS expects successive residual increments to be independent, but does not necessarily require the residuals to be identically distributed. The hypothesis to be tested for the MDS is:

$H_0$ : African sectoral, capitalisation, regional and individual national stock price indices returns follow a martingale difference sequence.

$H_1$ : African sectoral, capitalisation, regional and individual national stock price indices returns do not follow a martingale difference sequence.

Conventional variance-ratio tests developed by Lo and MacKinlay (1988) have been widely used to test the RW and MDS hypotheses of the weak-form market efficiency (Ayadi and Pyun, 1994; Urrutia, 1995; Smith, 2007). However, Wright (2000) demonstrates that Lo and MacKinlay's (1988) parametric variance-ratio tests lack power when returns of financial assets are non-normal. Therefore, with evidence of non-normality in African stock returns increasing (Appiah-Kusi and Menya, 2003; Jefferis and Smith, 2005), we apply non-parametric variance-ratio tests developed by Wright (2000) to test the RW and MDS hypotheses. Unlike the conventional variance-ratio tests, Wright (2000) shows in empirical test that his non-parametric alternative has power against a wide range of non-normal return behaviour including conditional-hetereoscedasticity.

In statistics, non-parametric tests are generally known to be more powerful in the presence of non-normality (Luger, 2003). On this basis, Wright (2000) extends Lo and MacKinlay's (1988) parametric variance-ratio[8] tests to non-parametric variance-ratio tests. The main difference is that Wright's (2000) non-parametric variance-ratio tests statistics substitute the return differences in the Lo and MacKinlay (1988) tests with return ranks and signs. Following Wright (2000), let $r(p_t)$ be the rank of $p_t$ among $p_1$ , $p_2$ ,..., $p_T$ . Then, $r_{1t}$ and $r_{2t}$ are the ranks of the returns $p_1$ and $p_2$ respectively, defined as:

$$r_{1t} = \left( r\left( p_t - \frac{T+1}{2} \right) \right) \Big/ \sqrt{\frac{(T-1)(T+1)}{12}}, \quad \text{and,}$$

$$r_{2t} = \Phi^{-1}(r(p_t)/(T+1)).$$

According to Wright (2000), the rank series $r_{1t}$ is a simple linear transformation of the ranks, standardized to have zero sample mean and a unit variance. Similarly, the rank series $r_{2t}$, where $\Phi^{-1}$ is the inverse of the standard normal cumulative distribution function, also has zero sample mean and variance approximately equal to one. The rank series $r_{1t}$ and $r_{2t}$ are put in place of $p_t$ in the definition of Lo and MacKinlay (1988) test statistics, which is written as $R_1$ and $R_2$, where:

$$R_1 = \left( \frac{\frac{1}{Tk}\sum_{t=k}^{T}(r_{1t} + \ldots + r_{1t-k+1})^2}{\frac{1}{T}\sum_{t=1}^{T} {r_{1t}}^2} - 1 \right) \times \phi(k)^{-1/2}, \text{ and} \tag{1}$$

$$R_2 = \left( \frac{\frac{1}{Tk}\sum_{t=k}^{T}(r_{2t} + \ldots + r_{2t-k+1})^2}{\frac{1}{T}\sum_{t=1}^{T} {r_{2t}}^2} - 1 \right) \times \phi(k)^{-1/2}, \tag{2}$$

where $\phi(k)$ is defined as: $\phi(k) = \frac{2(2k-1)(k-1)}{3kT}$.

Wright (2000) shows that the distribution of the test statistics is generated under the assumption that the rank $r(p_t)$ is a random permutation of the numbers 1,2,...,$T$, with each having equal probability. Therefore, the exact sampling distribution of $R_1$ and $R_2$ can be simulated to an arbitrary degree of accuracy, for given choices of $T$ and $k$. Due to this, the distribution does not suffer from disturbance parameters. It can therefore be used to construct a test with exact power.

The test statistics based on the signs of returns rather than ranks, $S_1$ and $S_2$, are given by:

$$s_1 = \left( \frac{\frac{1}{Tk}\sum_{t=k}^{T}(s_t + \ldots + s_{t-k+1})^2}{\frac{1}{T}\sum_{t=1}^{T} s_t{}^2} - 1 \right) \times \phi(k)^{-1/2}, \text{ and} \quad (3)$$

$$s_2 = \left( \frac{\frac{1}{Tk}\sum_{t=k}^{T}(s_t(\overline{\mu}) + \ldots + s_{t-k+1}(\overline{\mu}))^2}{\frac{1}{T}\sum_{t=1}^{T} s_t(\overline{\mu})^2} - 1 \right) \times \phi(k)^{-1/2}, \quad (4)$$

where, $\phi(k)$ is defined as: $\phi(k) = \frac{2(2k-1)(k-1)}{3kT}$, $s_t = 2u(p_t, 0), s_t(\overline{\mu}) = 2u(p_t, \overline{\mu}),$ and

$$u(x_t, q) = \begin{cases} 0.5 & \text{if} \quad x_t > q, \\ -0.5 & \text{otherwise}. \end{cases}$$

In a Monte Carlo experiment and empirical testing, Wright (2000) demonstrates that the ranks ($R_1$ and $R_2$) are robust under the assumption of homoscedasticity (RW hypothesis), while the signs ($S_1$ and $S_2$) are powerful under hetereoscedastic (MDS hypothesis) conditions.

## 4. Empirical Results

### 4.1 *Data Properties*

Table 5 contains descriptive statistics and diagnostics of the naturally logged daily returns for the 32 stock price indices investigated. Panels A, B, C, and D present information on African sectoral, size, regional and individual national stock price indices, respectively.

Insert Table 5 about here

Daily mean returns for all the 32 series are small, ranging from a low of -0.02% in the case of manufacturing (Amai) to a high of 0.12% in the case of telecoms and utilities

(Atui). The standard deviation, a measure of a financial asset's volatility, is generally large for all the series. The skewness test statistics indicate that the null hypothesis that the returns are symmetrically distributed is rejected at least at the 10% level for all 32 series examined. Similarly, the kurtosis test statistics suggest that the null hypothesis that returns are mesokurtically distributed is also rejected at least at the 10% level for all 32 series.

We also apply the Anderson-Darling goodness-of-fit test . The rationale for its selection is that, unlike the skewness and kurtosis statistics, it is a non-parametric test, which does not require any asymptotic approximation. The Anderson-Darling test consistently rejects the log-normality assumption for all the 32 series investigated at the 1% level.

The evidence of non-normal return behaviour in the series is consistent with findings of previous studies (Jefferis and Smith, 2005; Ntim, *et al*., 2007). Crucially, it justifies the application of Wright's (2000) non-parametric variance-ratio tests, which are robust to many forms of non-normal return behaviour including conditional-hetereoscedasticity.

An important finding, however, is that, irrespective of the diagnostic used, the 24 African continent-wide series are on average less non-normally distributed than the 8 individual national series. This implies that the equity price discovery process may be improved were African stock markets to be integrated rather than continue to operate within national boundaries. Such integration may thus be expected to have a positive impact on the performance of the African economies.

4.2 *Empirical Results*

Table 6 shows the results of Wright's (2000) non-parametric variance-ratio tests for a sample of 8 individual African national stock price indices for which data is available. These include Botswana, Egypt, Ghana, Kenya, Mauritius, Morocco, Nigeria and Tunisia, respectively. As specified in Column 1, we base the analysis on $k$ = 15, 20, 25 and 30 days, where $k$ refers to the number of interval days[9]. Columns 2 to 3 report the test statistics for the ranks ($R_1$, $R_2$), while columns 4 to 5 contain the test statistics for the signs ($S_1$ and $S_2$) based alternative for each index returns series examined. The ranks ($R_1$, $R_2$) are robust under the assumption of homoscedasticity (random walk) while the signs ($S_1$, $S_2$) are powerful under hetereoscedasticity (martingale difference sequence) conditions.

The results for the ranks ($R_1$, $R_2$) suggest that the null hypothesis of the returns series following a random walk (RW) is consistently rejected at the 1% level, for all intervals of $k$, for all 8 countries. Similarly, the signs ($S_1$, $S_2$) based alternative consistently reject the martingale difference sequence (MDS) hypothesis at the 1% level for all intervals of $k$ and for all 8 countries. For Ghana, the rejection of the RW and the MDS hypotheses is consistent with recent evidence (Ntim *et al*., 2007). All rejections are in the upper tail (i.e., have positive signs) of the distribution, which suggests that any serial dependence is positive.

The rejection of weak-form efficiency in the series of the 8 African national indices implies that stock prices are predictable. Past evidence suggests that exploitation of these inefficiencies will be profitable, even after taking into consideration transaction costs (Jun *et al*., 2003; Collins and Abrahamson, 2006).). A greater economic implication,

however, is that financial assets are not appropriately priced at their equilibrium values. This can distort the efficient allocation of capital within the economies of these African countries.

The central question that arises is what factors account for the rejection of the weak-form efficiency in these African stock markets? While it is not our aim to provide a quantitative analysis of the factors affecting the efficiency of these African stock markets, it may be useful to provide indications of what these factors might be. Prior evidence generally suggests that the weak-form efficiency of stock markets depends on a variety of features including the speed and quality of information available to market participants, liquidity, market capitalisation, and the number and size of individual stocks, amongst many others (Urrutia, 1995; Smith, 2007; Chordia *et al*., 2008).

However, as discussed above, African stock markets are small, both in terms of market capitalisation and the number of listed firms. With the exception of Egypt and Nigeria, none of the remaining six African stock markets included in this study has more than 100 listed firms. They are also immature and suffer from low liquidity. For example, while the turnover ratio for most of the liquid markets in the world are well above 100% (Jefferis and Smith, 2005; WFE, 2008), none of the 8 markets we study has an average liquidity ratio over the last eight years of more than 30%. Such low liquidity may not be sufficient to ensure an active price formation process, required for the returns series to be weak-form efficient.

Institutional weaknesses, as reported in Table 3, may also impact negatively on the efficiency of African stock markets. While most of the markets examined have electronic trading systems and trade for 5 days per week, these are recent developments

which may take time to impact on trading efficiency. The exchanges are also characterised by short trading hours, poor international recognition and no derivatives trading. The absence of derivatives trading, for example, means that it will take longer than necessary for potential arbitrage opportunities to be competed away. This makes the equity price discovery process inefficient.

Therefore, in order to ascertain whether there will be potential improvements in the weak-form efficiency of African stock markets if they integrate their operations, we next test the efficiency of African continent-wide stock price indices, again using the Wright's tests. These indices are constructed and were supplied by African Business Research Ltd, an independent professional brokerage and research firm that specialises in African stock markets. While African stock markets are not currently integrated, we would argue that our results based on continent-wide indices provide at least some indications of the potential improvements in market efficiency that may be gained if the various African stock markets were to be integrated.

Insert Table 6 about here

Table 7 presents the results of Wright's (2000) tests for 6 African regional stock price indices. The results obtained from the ranks ($R_1$, $R_2$) are generally mixed whilst those of the signs are more consistent. When $R_1$ is employed, the RW is rejected for the returns series of all six regions at the 5% level, with the exception of Southern-Africa when $k$ = 15. However, using $R_2$, the RW is rejected for some intervals of $k$, but cannot be rejected for others. By contrast, the sign-based alternative tests ($S_1$, $S_2$) consistently reject the MDS hypothesis for the returns series of all six regions at any interval of $k$, at

the 5% level, again with the exception of Southern-Africa when $k$ = 15 or 20. It should be noted that the ranks ($R_1$, $R_2$) are not robust when hetereoscedasticity is present. This means that the mixed results of the ranks ($R_1$, $R_2$) are due to autocorrelation. All rejections are in the upper tail of the distribution, which indicates that the resulting variance-ratios are greater than unity for all six series examined.

Insert Table 7 about here

Table 8 contains the Wright's tests results for 3 African stock price indices classified by market capitalisation. Employing the ranks ($R_1$, $R_2$), the RW cannot be rejected at any reasonable significance level for the return series of the large capitalisation stock price indices, except when $k$ = 25 or 30 for $R_1$. By contrast, the RW is rejected for the returns series of the medium and small capitalisation stock price indices, for any lag of $k$, at the 1% level. Implementing the signs-based alternative tests ($S_1$, $S_2$), the MDS is rejected for all 3 returns series at any interval of $k$, except for the large capitalisation returns series when $k$ = 15. This means that the acceptance of the RW for the large capitalisation returns series is not robust to hetereoscedasticity.

Insert Table 8 about here

Table 9 contains the results of the Wright's tests for six African sectoral stock price indices. Panels A, B, C, D, E and F present the ranks ($R_1$, $R_2$) and signs ($S_1$, $S_2$) tests statistics for the consumer goods, financials, industrials, natural resources, services and utilities economic sub-sectors, respectively. The general evidence from Panels A to F is that the majority (approximately 80%) of the sectoral stock price indices investigated display high levels of weak-form efficiency. Apart from the banks (Abi) in Panel B and telecoms and utilities (Atui) in Panel E, we fail to reject the RW and MDS hypotheses for

the returns series of most of the remaining 13 sectoral stock price indices when the ranks ($R_1$, $R_2$) and signs ($S_1$, $S_2$) are implemented, respectively.

Insert Table 9 about here

A comparison of the results of the individual national stock price indices (Table 6) with the African continent-wide constructed stock price indices (Tables 7 – 9) suggests significant improvements in informational efficiency are likely to be available if African stock markets were to integrate their operations. Generally, the results show that the individual national stock price indices have significantly higher levels of rejections for the RW and MDS hypotheses than do the set of African continent-wide stock price indices, irrespective of the test statistic used.. The potential improvements in efficiency to be gained are, however, much higher in sectoral stock price indices than in market capitalisation or regional stock price indices.

The results of the African continent-wide stock price indices further indicate that the returns series of the large capitalisation stocks follow random walks while those of the medium and small capitalisation stocks do not. This suggests that grouping together Africa's largest listed stocks, which tend to have wide analyst coverage and international institutional investor following, can significantly improve liquidity and pricing efficiency. Practically, the financial economics literature suggests that it can lead to efficient allocation of capital with positive impact on economic growth (Levine, 1997; Kenny and Moss, 1998).

## 5. Summary and Conclusions

The last three decades has witnessed a rapid increase in the number of African stock markets. However, they are segmented and lack operational efficiency, rendering most of them illiquid and small, and on the fringes of the competitive global financial market place. This has a negative impact on their informational and allocative efficiencies. With a specific focus on the weak-form of the efficient markets hypothesis, we have attempted to empirically ascertain whether te distributional properties of African continent-wide stock price indices differ from their national counterparts.

Our results indicate that, irrespective of the diagnostic used, the 24 African continent-wide stock price indices returns are less non-normally distributed than any of the 8 individual national stock price indices studied. We record evidence of statistically significant improvements in the informational efficiency of the African continent-wide stock price indices over the individual national stock price indices. The majority of the African continent-wide stock price indices returns are weak-form efficient against the robust Wright's (2000) ranks and signs tests. By contrast, none of the individual national indices are efficient against the ranks and signs tests.

The policy implication of this evidence is that the African equity price discovery process can be expected to significantly improve if African stock markets integrate their operations. Economically, this is likely to result in improved liquidity and more efficient allocation of capital, which theory suggests will have a positive impact on economic growth.

A starting point may be the harmonisation of listing rules, ideally from regional groupings. In this respect, we acknowledge the efforts of Eastern and Southern African countries to harmonise their listing rules. We would recommend that Western, Central,

and Northern African countries begin similar initiatives. Strategic alliances and co-operations among African stock markets, such as '*Project Orion*' in which the Namibian Stock Exchange is able to access the electronic trading system of the JSE Ltd, is also a step in the right direction. Our research suggests the efficiency of Africa's stock markets are likely to improve with these and similar initiatives to increase the integration of the various national stock exchanges.

**Notes**

1. The 8 stock markets in existence in 1980 were: the Johannesburg Stock Exchange (South Africa, 1887), the Cairo and Alexander Stock Exchange (Egypt, 1888), the Zimbabwean Stock Exchange (Zimbabwe, 1896), the Casablanca Stock Exchange (Morocco, 1929), the Nairobi Stock Exchange (Kenya, 1954), the Nigerian Stock Exchange (Nigeria, 1960), and the Tunisian Stock Exchange (Tunisia, 1969) (Table 1; UNDP, 2003).
2. In the early 1980s, the International Monetary Fund and the World Bank backed African countries to embark on economic recovery programmes (ERP). A central part of the ERP was the financial sector adjustment programme (FINSAP). The main aim of the FINSAP was to help African countries to reform their banking sectors and to develop capital markets (Kenny and Moss, 1998). The stock markets in Mauritius, Botswana, Ghana, Swaziland, Namibia and Zambia are among the early African stock markets that were set up as part of the FINSAP.
3. We define stock market integration as a system which ensures that: (1) any investor can sell or buy shares in any stock market without restrictions, and (2) shares are traded at the same price and cost across markets (Abumustafa, 2007). In this case, African stock markets are envisaged to operate as regional stock markets or as a single continental stock market rather than as fragmented individual national markets.
4. The empirical results are interpreted in relation to developmental characteristics such as liquidity, and market capitalisation.
5. We believe that comparing data and efficiency properties of the African continent-wide and individual national stock price indices is important and appropriate. This is because if the African continent-wide stock price indices were to be less non-normal and inefficient than their national counterparts, it would indicate potential improvements in the equity price formation process are likely from integrating African stock markets. It does not, however, not necessarily imply African continent-wide stock price indices are normally distributed – merely that they are less non-normally distributed than their national counterparts. We therefore analyse both the absolute and the relative level of non-normality in the continent-wide and national stock market indices.
6. For comparability, all stock price indices in this study are quoted in US dollars.
7. ABR is a UK-based independent professional data collection and research company that specialises in African stock markets. We had to rely on ABR's stock price indices because of the non-availability of alternative African regional or continent-wide stock price indices that could have been used for the study.
8. For a detailed description of the parametric variance-ratio tests procedure, see Lo and MacKinlay (1988).
9. According to Lo and MacKinlay (1988), the base lag ($k$) selected can be any equally spaced integer greater than one. The base intervals, 15, 20, 25 and 30 have been widely used in prior studies (e.g., Wright, 2000; Belaire-Franch and Opong, 2005a and b; Ntim *et al*., 2007). We have adopted the same base intervals to help facilitate comparison with these studies.

## 6. References


Abumustafa, N. I. (2007), "Benefiting from Diversity in Middle Eastern Stock Markets", *Applied Financial Economics*, Vol. 18 No. 3, pp.229-237.

African Securities Exchanges Association, (1993), *Memorandum and Article of Association*, Nairobi, Kenya.

African Securities Exchanges Association: http://www.africansea.org/ASEA/Default.aspx, (accessed on 15 May 2008).

Appiah-Kusi, J. and Menyah, K. (2003),"Return Predictability in African Stock Markets", *Review of Financial Economics*, Vol. 12, pp.247-270.

Ayadi, F. O. (1984), "The Random Walk Hypothesis and the Behaviour of Share Prices in Nigeria", *Nigerian Journal of Economic and Social Studies*, Vol. 26 No. 1, pp.57-71.

Ayadi, O. F. and Pyun, C. S. (1994), "An Application of Variance ratio Test to the Korean Securities Market", *Journal of Banking and Finance*, Vol. 18, pp.643-658.

Belaire-Franch, J. and Opong, K. K. (2005a), "A Variance Ratio Test of the Behaviour of Some FTSE Equity Indices Using Ranks and Signs", *Review of Quantitative Finance and Accounting*, Vol. 24, pp.93-107.

Belaire-Franch, J. and Opong, K. K. (2005b) "Some Evidence of Random Walk Behaviour of Euro Exchange Rates Using Ranks and Signs", *Journal of Banking and Finance*, Vol. 29, pp.1631-1643.

Botswana Stock Exchange, available at: http://www.bse.co.bw/abt_us/abt_us.php (accessed on 12 May 2008).

Bourse de Tunis, available at: http://www.bvmt.com.tn/EN/documentation/trading-system/?view=trading-hours (accessed on 12 May 2008).

BRVM, available at: http://www.brvm.org/en/intervenants/sgi/togo.htm (accessed on 14 May 2008)

Campbell, J. Y., Lo, A. W. and MacKinlay, A. C. (1997), *The Econometrics of Financial Markets*, Princeston Universtiy Press, Princeston.

Chordia, T., Roll, R. and Subrahmanyam, A. (2008), "Liquidity and Market Efficiency", *Journal of Financial* Economics, Vol. 87, pp.249-268.

Chow, K. V. and Denning, K. C. (1993), "A Simple Multiple Variance Ratios Test", *Journal of Econometrics*, Vol. 58, pp.385-401.

Claessens, S., Dasgupta, S. and Glen, J. (1995), "Return Behaviour in Emerging Stock Markets", *World Bank Economic Review*, Vol. 9, pp.131-152.

Collins, D. and Abrahamson, M. (2006), "Measuring the Cost of Equity in African Financial Markets", *Emerging Markets Review*, No. 7, pp.67-81.

Dares Salaam Stock Exchange, available at: http://www.darstockexchange.com/history.asp (accessed on 12 May 2008).

Databank Group, (2008), *Africa Stock Markets: 2007 Review & Outlook*, Group Research.

Dickinson, J. P. and Muragu, K. (1994), "Market Efficiency in Developing Countries: A Case Study of the Nairobi Stock Exchange", *Journal of Business Finance & Accounting*, Vol. 21 No. 1, pp.133-150.

Fama, E. F. (1970), "Efficient Capital Markets: A Review of Theory and Empirical

Tests", *Journal of Finance*, Vol. 25, pp.382-417.
Fifield, S. G. M., Power, D. M. and Sinclair, D. C. (2002), "Emerging Stock Markets: A More Realstic Assessment of Gains from Diversification', *Applied Financial Economics*, Vol. 12, pp.213-229.
Fifield, S. G. M., Power, D. M. and Sinclair, D. C. (2005), "An Analysis of Trading Strategies in Eleven European Stock Markets", *The European Journal of Finance*, Vol. 11 No. 6, pp.531-548.
Fish, T. and Biekpe, N. (2002), "Regional African Stock Markets Indices", *South African Journal of Business Management*, Vol. 33 No. 1, pp.11-19.
FTSE Annual Country Classification, available at: http://www.ftse.com/Indices/Country_Classification/index.jsp (accessed on 11 May 2008).
Global Stock Markets Clock available at: http://www.marketclocks.com/index.php?login_error=2 (accessed on 10 May 2008).
Hsieh, D. (1991), "Chaos and Nonlinear Dynamics: Application to Financial Markets", *Journal of Finance*, Vol. 46, pp.1839-1877.
IMF, available at: http://www.imf.org/external/ (accessed on 14 May 2008).
Irving, J. (2000), "Africa's Struggling Stock Exchanges: Boost to Economic Development or costly irrelevance?", *African Recovery*, Vol. 14, No. 3, pp.1-5.
Irving, J. (2005), "Regional Integration of Stock Exchanges in Eastern and Southern Africa: Progress and Prospects", Working Paper[WP/05/122], IMF, June 2005.
Jefferis, K. and Smith, G. (2005), "The Changing Efficiency of African Stock Markets", *South African Journal of Economics*, Vol. 73 No. 1, pp.54-67.
JSE Ltd, available at: http://www.jse.co.za/ (accessed on 10 May 2008).
Jun, S-G., Marathe, A. and Shawky, H. (2003), "Liquidity and Stocks Returns in Emerging Equity Markets", *Emerging Markets Review*, No. 4, pp.1-24.
Kenny, C. J. and Moss, T. J. (1998), "Stock Markets in Africa: Emerging Lions or White Elephants?", *World Development*, Vol. 26 No. 5, pp.829-843.
Lesmond, D. A. (2005), "Liquidity of Emerging Markets", *Journal of Financial Economics*, Vol. 77, pp.411-452.
Levine, R. (1997), "Financial Development and Economic Growth: Views and Agenda", *Journal of Economic Literature*, Vol. 35, pp.688-726.
Lo, A. W. and MacKinlay, A. C. (1988), "Stock Market Prices Do Not Follow Random Walks: Evidence from a Simple Specification Test", *The Review of Financial Studies*, Vol. 1 No. 1, pp.41-66.
Lugangwa, E. (2006), "Regional African Stock Exchanges on Agenda, available at: http://www.ibtimes.com/articles/20060920/regional-african-stock-exchanges-on-agenda.htm (accessed on 3 May 2008).
Luger, R. (2003), "Exact Non-parametric Tests for a Random Walk with Unknown Drift under Conditional Hetereoscedasticity", *Journal of Econometrics*, Vol. 115, pp.259-276.
Lusaka Stock Exchange, available at: http://www.luse.co.zm/ (accessed on 12 May 2008).
Magnusson, M. A. and Wydick, B. (2002), "How Efficient Are Africa's Emerging Markets?", *The Journal of Development Studies*, Vol. 38 No. 4, pp.141-156.
Malawi Stock Exchange, available at: http://www.mse.co.mw/

(accessed on 13 May 2008).
Mauritius Stock Exchange, available at: http://www.stockexchangeofmauritius.com/ (accessed on 10 May 2008).
Mlambo, C. and Biekpe, N. (2005): "Thin Trading on African Stock Markets: Implications for Market Efficiency Testing", Investment Analyst Journal, 61, pp.29-40.
Moin, S. (2007), "New Frontier Markets tempt Investors", *African Review of Business and Technology*, Vol. 1, pp.1-7.
Morgan Stanley Capital International/Africa Business Research Ltd (2007), "Why Invest In Africa", A Presentation to the 11th ASEA Conference, Accra Ghana, October 2007.
Mozambique Stock Exchange, available at: http://www.bvm.co.mz/ (accessed on 13 May 2008)
Nairobi Stock Exchange, available at: http://www.nse.co.ke/newsite/ (accessed on 13 May 2008).
Namibia Stock Exchange: http://www.nsx.com.na/
New York Stock Exchange, available at: http://www.nyse.com/ (accessed on 13 May 2008).
Nigeria Stock Exchange, available at: http://www.nigerianstockexchange.com/exchange_members.jsp (accessed on 10 May 2008).
Ntim, C. G., Opong, K. K. and Danbolt, J. (2007), "An Empirical Re-Examination of the Weak Form Efficient Markets Hypothesis of the Ghana Stock Market Using Variance-Ratios Tests", *African Finance Journal*, Vol. 9 No. 2, pp.1-25.
Okealaham, C. C. (2005), "Strategic Alliances and Mergers of Financial Exchanges: The Case of the SADC", *Journal of Southern African Studies*, Vol. 31 No. 1, pp.75-93.
Olowe, R. A. (1999), "Weak Form Efficiency of the Nigerian Stock Market: Further Evidence", *African Development Review*, Vol. 11 No. 1, pp.54-68.
Parkinson, J. M. (1984), "The Nairobi Stock Exchange in the Context of Development of Kenya", *Savings and Development*, Vol. 8 No. 4, pp.363-370.
Piesse, J. and Hearn, B. (2008), "Barriers to the Development of Small Stock Markets: A Case Study of Swaziland and Mozambique", available at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1242444 (accessed on 20 March 2009).
Samuels, J. M. and Yacout, N. (1981), "Stock Exchange in Developing Countries", *Savings and Development*, Vol. 5 No. 4, pp.213-230.
Savit, R. (1988), "When is Random not Random: An introduction to Chaos in Market Prices", *Journal of Futures Markets*, Vol. 8, pp.271-289.
Simons, D. and Laryea, S. A. (2006), "Testing the Efficiency of Selected African Stock Markets", *Finance India*, Vol. 20 No. 2, pp.553-571.
Smith, G., Jefferis, K. and Ryoo, H-J. (2002), "African Stock Markets: Multiple Variance Ratio Tests of Random Walks", *Applied Financial Economics*, Vol. 12, pp.475-484.
Smith, G. (2007), "Random Walks in Middle Eastern Stock Markets", *Applied Financial Economics*, Vol. 17, pp.587-596.

Southern African Development Community, (2007), "Harmonization Initiative for SADC Stock Exchanges", Gabrone, Botswana, April 2007.
Standards and Poors Stock Market Classification, available: http://www2.standardandpoors.com/spf/pdf/index/SP_Emerging_Markets_Indices Methodology_Web.pdf (accessed on 12 May 2008).
Swaziland Stock Exchange, available at: http://www.ssx.org.sz/ (accessed on 12 May 2008).
Ugandan Securities Exchange, available at: http://www.use.or.ug/ (accessed on 10 May 2008).
UNDP, (2003), *African Stock Markets Handbook*, United Nations Development Programme, New York.
Urrutia, J. L. (1995), "Tests of Random Walk and Market Efficiency For Latin American Emerging Equity Markets", *The Journal of Financial Research*, Vol. 18 No. 3, pp,299-309.
World Federation of Exchanges (2008), available at: http://www.worldexchanges.org/WFE/home.asp?menu=436&document=4822/ (accessed on 10 May 2008).
Wright, J. H. (2000), "Alternative Variance-Ratio Tests Using Ranks and Signs", *Journal of Business and Economic Statistics*, Vol. 18, pp.1-9.
Zimbabwe Stock Exchange, available at: http://www.zse.co.zw/ (accessed on 12 May 2008).

Appendix 1: The Sample Stock Price Indices of the Study

| Full Index Name | Acronym/Code | Sample Period |
|---|---|---|
| *African Sectoral/Industrial Stock Price Indices*: | | |
| ABR Africa Automobiles & Transport Equipment | Aatei | 1998-2008 |
| ABR Africa Banks | Abi | 1998-2008 |
| ABR Africa Chemicals | Aci | 1998-2008 |
| ABR Africa Consumer Goods, Food and Beverage | Acgfbi | 1998-2008 |
| ABR Africa Diversified Conglomerates | Adci | 1998-2008 |
| ABR Africa Financial Services (excluding banks) | Afsi | 1998-2008 |
| ABR Africa Manufacturing | Amai | 1998-2008 |
| ABR Africa Media | Ami | 1998-2008 |
| ABR Africa Mining and Metals | Ammi | 1998-2008 |
| ABR Africa Natural Resources | Anri | 1998-2008 |
| ABR Africa Pharmaceuticals and Health | Aphi | 1998-2008 |
| ABR Africa Retail and General Trading | Argti | 1998-2008 |
| ABR Africa Services | Asi | 1998-2008 |
| ABR Africa Telecoms and Utilities | Atui | 1998-2008 |
| ABR Africa Transportation | Ati | 1998-2008 |
| *African Size/Capitalisation Stock Price Indices*: | | |
| ABR Africa Large Company | Alci | 1998-2008 |
| ABR Africa Medium Company | Amci | 1998-2008 |
| ABR Africa Small Company | Asci | 1998-2008 |
| *African Regional/Geographic Stock Price Indices*: | | |
| ABR Africa All Share (excluding South Africa) | Aasi | 1998-2008 |
| ABR Eastern Africa | Eai | 1998-2008 |
| ABR Northern Africa | Nai | 1998-2008 |
| ABR Southern Africa | Sai | 1998-2008 |
| ABR Sub-Sahara Africa | Ssai | 1998-2008 |
| ABR Western Africa | Wai | 1998-2008 |
| *African National Stock Price Indices* | | |
| Botswana | Iffmbol | 1995-2008 |
| Egypt | Iffmegl | 1997-2008 |
| Ghana | Iffghal | 1995-2008 |
| M Kenya | Iffkenl | 1995-2008 |
| Mauritius | Iffmaul | 1995-2008 |
| Morocco | Ifgmmol | 1997-2008 |
| Nigeria | Ifgmngl | 1984-2008 |
| Tunisia | Ifftunl | 1995-2008 |

Sources: the African sectoral, size and regional stock price indices were collected from African Business Research Ltd while the African national stock price indices were collected from DataStream.

Table 1: Development Statistics on African Stock Markets as at the End of 2007

| Market | Date opened | No. of firms | Change% 2006-07 | Market capt.(US$m) | Change% 2006-07 | Turnover (US$m) | Change% 2006-07 | %Main Index return(US$) | GDP (US$m) | Market % of GDP |
|---|---|---|---|---|---|---|---|---|---|---|
| Botswana | 1989 | 31 | 0.0 | 5,445.0[a] | 46.0 | 159.9 | 61.1 | 40.6 | 12,313 | 44.2 |
| Cote D'Ivoire | 1973 | 38 | -5.0 | 8,305.2 | 99.9 | 171.6 | 60.3 | 77.1 | 15,598 | 53.2 |
| Egypt | 1888 | 435 | -26.9 | 139,273.8 | 49.0 | 60,196.4 | 25.2 | 51.3 | 127,930 | 108.9 |
| Ghana | 1989 | 32 | 0.0 | 13,710.1 | 38.1 | 836.3 | 181.7 | 31.8 | 14,863 | 92.2 |
| Kenya | 1954 | 54 | 3.8 | 13,344.6 | 17.3 | 1,389.0 | 1.8 | -3.6 | 29,299 | 45.5 |
| Malawi | 1995 | 12 | 50.0 | 1,260.0 | 39.2 | 9.8 | 226.7 | 120.8 | 3,538 | 35.6 |
| Mauritius | 1988 | 91 | 44.4 | 7,919.1 | 59.7 | 413.5 | 94.9 | 53.8 | 6,959 | 113.8 |
| Morocco | 1929 | 73 | 15.9 | 75,494.5 | 52.9 | 23,172.0 | 135.0 | 33.9 | 73,429 | 102.8 |
| Mozambique | 1999 | 13 | 30.0 | 242.3 | 65.4 | 34.0 | -12.6 | 12.0 | 7,559 | 3.2 |
| Namibia | 1992 | 27 | -3.6 | 1,590.0[a] | 10.0 | 14.3 | 69.5 | 12.2 | 7,400 | 21.5 |
| Nigeria | 1960 | 212 | 5.0 | 87,370.8 | 166.1 | 17,671.1 | 385.7 | 74.7 | 166,778 | 52.4 |
| South Africa | 1887 | 411 | 5.7 | 828,185.3 | 16.4 | 423,731.8 | 36.2 | 16.1 | 282,630 | 293.0 |
| Swaziland | 1990 | 6 | 0.0 | 234.3 | 18.3 | 3.5 | 5710.9 | 15.0 | 2,936 | 8.0 |
| Tanzania | 1996 | 10 | 0.0 | 2,786.3 | 59.9 | 8.1 | 21.8 | 28.2 | 16,184 | 48.1 |
| Tunisia | 1969 | 51 | 6.3 | 10,830.0 | 18.8 | 3,833.6 | 48.9 | 17.3 | 35,010 | 30.9 |
| Uganda | 1997 | 9 | 12.5 | 3,160.0 | 32.2 | 451.2 | 566.1 | 29.9 | 12,227 | 25.8 |
| Zambia | 1993 | 16 | 6.7 | 4,827.0 | 34.0 | 74.8 | 254.1 | 125.0 | 11,156 | 43.3 |
| Zimbabwe | 1896 | 79 | -1.3 | n/a | n/a | n/a | n/a | -82.8 | 641 | n/a |
| *Total(ex South Africa)* | | 1189 | n/a | 375,793.0 | n/a | 108,439.1 | n/a | n/a | 543,820 | 69.1 |
| *Average(ex South Africa)* | | 70 | n/a | 23,487.1 | n/a | 6,777.4 | n/a | 47.2 | 31,989 | 78.3 |
| WFE Total | | 46,509 | 2.9 | 60,874,399.3 | 19.9 | 101,189,135.2 | 44.5 | n/a | 54,311,608 | 112.1 |

Sources: World Federation of Exchanges (WFE) Website, African Securities Exchanges Association (ASEA) Website and Websites of All of Stock Markets. GDP was obtained from International Monetary Fund (IMF). [a]Excludes Blue-chips from South Africa.

Table 2: Liquidity of African Stock Markets (2000 – 2007): Value of Shares Traded to Market Capitalisation Ratio(%)

| Market | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|
| Botswana | 4.78 | 5.61 | 5.04 | 4.36 | 2.30 | 1.81 | 2.39 | 2.94 |
| Cote D'Ivoire | 2.59 | 0.69 | 0.72 | 1.61 | 2.66 | 1.41 | 3.68 | 2.06 |
| Egypt | 34.74 | 14.23 | 16.13 | 13.73 | 17.31 | 42.97 | 55.23 | 43.22 |
| Ghana | 1.48 | 2.65 | 2.47 | 4.12 | 3.24 | 2.24 | 3.42 | 6.10 |
| Kenya | 3.58 | 3.48 | 3.79 | 7.41 | 8.15 | 9.83 | 15.76 | 10.41 |
| Malawi | 0.45 | 0.56 | 0.82 | 1.18 | 0.92 | 1.11 | 0.73 | 0.80 |
| Mauritius | 5.01 | 9.35 | 11.51 | 6.22 | 4.45 | 6.05 | 5.99 | 5.22 |
| Morocco | 9.22 | 10.03 | 10.65 | 6.45 | 9.10 | 15.86 | 32.85 | 30.69 |
| Mozambique | 0.10 | 0.08 | 1.84 | 3.49 | 5.85 | 7.14 | 9.68 | 14.03 |
| Namibia | 4.51 | 3.14 | 5.18 | 0.74 | 4.82 | 1.57 | 4.56 | 0.89 |
| Nigeria | 7.29 | 10.26 | 10.65 | 10.99 | 13.73 | 11.46 | 13.84 | 20.23 |
| South Africa | 33.92 | 37.44 | 78.86 | 44.81 | 47.37 | 39.32 | 49.52 | 51.16 |
| Swaziland | 1.66 | 2.83 | 4.68 | 1.03 | 2.08 | 1.01 | 1.42 | 1.49 |
| Tanzania | 2.43 | 1.85 | 1.95 | 2.12 | 2.29 | 0.82 | 0.56 | 0.29 |
| Tunisia | 23.29 | 12.62 | 13.73 | 7.16 | 9.16 | 16.54 | 15.24 | 35.39 |
| Uganda | 1.89 | 0.55 | 1.46 | 4.65 | 6.18 | 7.65 | 9.23 | 14.27 |
| Zambia | 2.08 | 2.25 | 2.14 | 1.78 | 3.46 | 1.99 | 1.69 | 1.55 |
| Zimbabwe | 10.77 | 29.41 | 19.19 | 26.14 | 9.22 | 15.27 | 7.86 | - |
| *Average(ex S. Africa)* | 6.81 | 6.45 | 6.59 | 6.07 | 6.17 | 8.51 | 10.85 | 11.85 |

Sources: Computed from statistics obtained from the World Federation of Exchanges (WFE), UNDP African Stock Markets Handbook (2003) and African Securities Exchanges Association (ASEA). Liquidity is measured as the ratio of the annual value of shares traded in US dollars to the annual market capitalisation in US dollars and expressed as a percentage. It indicates a stock market's overall annual trading activity relative its size.

Table 3: Institutional, Operational and Infrastructural Development Characteristics of African Stock Markets as at the end of 2007

| Market | Trading Days | Trading Hours | System of Trading | Foreign Invlment. | WFE Status | Derivative Trading | Clearing & Settlement | Accounting Standard |
|---|---|---|---|---|---|---|---|---|
| Botswana | 5 | 1.00 | Manual | Yes | n/a | No | T+4 | Local |
| Cote D'Ivoire | 5 | 4.00 | Electronic | Yes | n/a | No | T+5 | Local |
| Egypt | 5 | 4.00 | Electronic | Yes | Member | No | T+2[a] | International |
| Ghana | 5 | 2.00 | Manual | Yes | Correspondent | No | T+3 | International |
| Kenya | 5 | 2.00 | Electronic | Yes | Correspondent | No | T+3 | International |
| Malawi | 5 | 3.00 | Manual | Yes | Correspondent | No | T+7 | International |
| Mauritius | 5 | 2.50 | Electronic | Yes | Member | No | T+3 | International |
| Morocco | 5 | 4.00 | Electronic | Yes | Affiliate | No | T+3 | International |
| Mozambique | 3[b] | 3.00[b] | Electronic | Yes | n/a | No | T+3 | Local |
| Namibia | 5 | 8.00 | Electronic | Yes | Affiliate | No | T+3 | Local |
| Nigeria | 5 | 2.00 | Electronic | Yes | Affiliate | No | T+3 | International |
| South Africa | 5 | 8.00 | Electronic | Yes | Member | Yes | T+3 | International |
| Swaziland | 5 | 2.00 | Manual | Yes | n/a | No | T+5 | International |
| Tanzania | 5 | 2.00 | Electronic | Yes | n/a | No | T+5[c] | International |
| Tunisia | 5 | 2.67 | Electronic | Yes | n/a | No | T+3 | Local |
| Uganda | 5 | 2.00 | Manual | Yes | Correspondent | No | T+5 | International |
| Zambia | 5 | 2.00 | Electronic | Yes | n/a | No | T+3 | Local |
| Zimbabwe | 5 | 4.00 | Manual | Yes | n/a | No | T+7 | International |

Sources: World Federation of Exchanges (WFE), African Securities Exchanges Association (ASEA), UNDP African Stock Markets Handbook (2003) MSCI/SP/IFC/FTSE Stock Markets Classifications (2007) and Websites of All Exchanges. [a]T+1 for government bonds and T+0 for intra-day trading securities. [b]Obtained from Piesse and Hearn (2008, p.9). [c]T+3 for government bonds.

Table 4: Correlation Matrix between the Africa All Share Index Excluding South Africa and Other Global Equity Indices

| | Africa (ex. S Africa) | Asia Share | Emerging Index | Far East Markets | G7 Index | Latin Countries | South America | World Index |
|---|---|---|---|---|---|---|---|---|
| Asia Index | -.09 | | | | | | | |
| Emerging Markets | -.07 | .88 | | | | | | |
| Far East Index | -.10 | .99 | .86 | | | | | |
| G7 Countries | .12 | .18 | .43 | .17 | | | | |
| Latin America | -.14 | .06 | .44 | .05 | .57 | | | |
| South Africa | .03 | .42 | .58 | .40 | .22 | .07 | | |
| World Index | .14 | .21 | .46 | .20 | .99 | .57 | .24 | |
| World Small Co. | .14 | .22 | .46 | .21 | .90 | .46 | .28 | .90 |

Source: Morgan Stanley Capital International/Africa Business Research Ltd Report 2007

***Table 5*: Descriptive Statistics and Diagnostics of Daily Stock Price Indices Returns**

| Indices | Mean(%) | Std. Dev.(%) | Skewness | Kurtosis | Anderson-Darling | N |
|---|---|---|---|---|---|---|
| Panel A: African Sectoral Stock Price Indices | | | | | | |
| Aatei | 0.022 | 19.212 | 0.01* | 4.20** | 33.11*** | 2379 |
| Abi | 0.062 | 0.854 | 0.73** | 13.94*** | 23.28*** | 2379 |
| Acgfbi | 0.047 | 1.076 | 0.16** | 3.72** | 23.27*** | 2379 |
| Aci | 0.023 | 1.335 | -0.03* | 3.72** | 23.14*** | 2379 |
| Adci | 0.035 | 1.334 | 0.13** | 3.08* | 29.35*** | 2379 |
| Afsi | 0.021 | 2.027 | -0.72** | 539.98*** | 195.26*** | 2379 |
| Amai | -0.016 | 1.335 | -0.48** | 10.71*** | 67.70*** | 2379 |
| Ami | 0.077 | 2.289 | 2.29*** | 54.07*** | 125.68*** | 2379 |
| Ammi | 0.006 | 1.781 | -0.26** | 8.01*** | 44.41*** | 2379 |
| Anri | 0.038 | 1.331 | 0.08* | 3.17** | 32.67*** | 2379 |
| Aphi | -0.002 | 4.607 | -1.63*** | 480.05*** | 475.96*** | 2379 |
| Aregti | 0.022 | 5.580 | -0.33** | 192.89*** | 567.61*** | 2379 |
| Asi | 0.026 | 4.863 | -0.05* | 195.30*** | 564.85*** | 2379 |
| Ati | 0.049 | 1.588 | -0.01* | 3.37** | 42.31*** | 2379 |
| Atui | 0.117 | 1.991 | 1.53*** | 20.43*** | 17.10*** | 2379 |
| Panel B: African Size Stock Price Indices | | | | | | |
| Alci | 0.050 | 1.137 | 0.02* | 13.84*** | 31.41*** | 2379 |
| Amci | 0.056 | 0.872 | -0.02* | 13.84*** | 49.58*** | 2379 |
| Asci | 0.066 | 0.697 | 3.23*** | 67.14*** | 44.41*** | 2379 |
| Panel C: African Regional Stock Price Indices | | | | | | |
| Aasi | 0.053 | 0.938 | 0.09* | 8.20*** | 31.86*** | 2379 |
| Eai | 0.047 | 0.933 | -0.29** | 10.80*** | 62.57*** | 2379 |
| Nai | 0.042 | 1.166 | -0.01* | 8.76*** | 41.28*** | 2379 |
| Sai | 0.073 | 1.394 | -0.01* | 229.56*** | 177.02*** | 2379 |
| Ssai | 0.082 | 1.016 | 0.07* | 4.50** | 53.10*** | 2379 |
| Wai | 0.096 | 1.561 | 0.10** | 4.20** | 62.39*** | 2379 |
| Panel D: African National Stock Price Indices | | | | | | |
| Botswana | 0.099 | 1.234 | 11.93*** | 284.31*** | 1095.88*** | 3221 |
| Egypt | 0.058 | 1.721 | 4.39*** | 83.25*** | 988.31*** | 2936 |
| Ghana | 0.045 | 1.007 | 5.50*** | 140.39*** | 1107.91*** | 3221 |
| Kenya | 0.056 | 1.425 | 3.89*** | 98.80*** | 1085.21*** | 3221 |
| Mauritius | 0.057 | 1.014 | 2.78*** | 130.15*** | 1087.97*** | 3221 |
| Morocco | 0.050 | 1.107 | 2.62*** | 93.94*** | 990.41*** | 2940 |
| Nigeria | 0.018 | 8.109 | -86.21*** | 7862.27*** | 3039.16*** | 8959 |
| Tunisia | 0.007 | 0.094 | 2.71*** | 168.72*** | 1091.43*** | 3221 |

Notes: Panels A, B, C, and D present descriptive statistics and diagnostics of returns of African Sectoral, Size, Regional, and National stock price indices, respectively. *N* refers to the number of time series observations while Appendix 1 provides full definitions of the names of all 32 stock price indices used. (***), (**), and (*) means that the null hypothesis that the returns are normally distributed is rejected at the 1%, 5%, and 10% significance levels, respectively.

***Tables 6*: Wright's Tests Results for a Sample of Eight Individual African National Stock Price Indices**

| Period | $R_1$ | $R_2$ | $S_1$ | $S_2$ |
|---|---|---|---|---|
| Botswana | | | | |
| *k=15* | 134.09*** | 112.24*** | 161.42*** | 162.77*** |
| *k=20* | 155.13*** | 129.74*** | 186.90*** | 188.46*** |
| *k=25* | 173.72*** | 145.34*** | 209.45*** | 211.16*** |
| *k=30* | 190.40*** | 159.35*** | 229.72*** | 231.57*** |
| Egypt | | | | |
| *k=15* | 140.19*** | 119.59*** | 159.22*** | 160.41*** |
| *k=20* | 161.87*** | 137.88*** | 184.34*** | 185.72*** |
| *k=25* | 181.00*** | 154.12*** | 206.50*** | 208.01*** |
| *k=30* | 198.07*** | 168.59*** | 226.41*** | 228.05*** |
| Ghana | | | | |
| *k=15* | 142.34*** | 121.60*** | 162.22*** | 164.31*** |
| *k=20* | 164.57*** | 140.42*** | 187.84*** | 190.27*** |
| *k=25* | 184.20*** | 157.21*** | 210.51*** | 213.19*** |
| *k=30* | 201.81*** | 172.28*** | 230.91*** | 233.83*** |
| Kenya | | | | |
| *k=15* | 144.28*** | 122.06*** | 166.01*** | 167.09*** |
| *k=20* | 166.85*** | 141.04*** | 192.24*** | 193.50*** |
| *k=25* | 186.51*** | 157.58*** | 215.33*** | 216.72*** |
| *k=30* | 204.11*** | 172.38*** | 236.05*** | 237.56*** |
| Mauritius | | | | |
| *k=15* | 138.01*** | 117.21*** | 163.01*** | 164.56*** |
| *k=20* | 159.49*** | 135.34*** | 188.75*** | 190.56** |
| *k=25* | 178.36*** | 151.29*** | 211.49*** | 213.47*** |
| *k=30* | 195.26*** | 165.60*** | 231.92*** | 231.92** |
| Morocco | | | | |
| *k=15* | 136.44*** | 113.17*** | 156.99*** | 158.37*** |
| *k=20* | 157.44*** | 130.81*** | 181.74*** | 183.34*** |
| *k=25* | 176.59*** | 146.52*** | 203.61*** | 205.38*** |
| *k=30* | 193.30*** | 160.36*** | 223.21*** | 225.13*** |
| Nigeria | | | | |
| *k=15* | 15.23*** | 7.89*** | 161.39*** | 164.95*** |
| *k=20* | 18.10*** | 9.52*** | 187.14*** | 191.26*** |
| *k=25* | 20.79*** | 11.51*** | 210.15*** | 214.74*** |
| *k=30* | 23.12*** | 13.13*** | 230.89*** | 235.89*** |
| Tunisia | | | | |
| *k=15* | 142.38*** | 121.42*** | 167.89*** | 167.89*** |
| *k=20* | 164.56*** | 140.18*** | 194.41*** | 194.41*** |
| *k=25* | 183.97*** | 156.61*** | 217.75*** | 217.75*** |
| *k=30* | 201.24*** | 171.17*** | 238.73*** | 238.73*** |

Notes: A test statistic with *** indicates significance at 1% level. Figures in columns 2-5 give the values of the test statistics $R_1$, $R_2$, $S_1$ and $S_2$ for each index series examined. They are based on Wright's (2000) non-parametric (ranks and signs) variance-ratio tests. The names in the rows are those of the respective African national stock price indices examined.

***Tables 7*: Wright's Tests Results for African Regional Stock Price Indices**

| Period | $R_1$ | $R_2$ | $S_1$ | $S_2$ |
|---|---|---|---|---|
| Africa-All Share (Excluding South Africa) | | | | |
| *k=15* | 2.39** | 1.24 | 1.93* | 2.45** |
| *k=20* | 2.82*** | 1.67* | 2.30** | 3.01*** |
| *k=25* | 3.30*** | 2.12** | 2.85*** | 3.73*** |
| *k=30* | 3.84*** | 2.65*** | 3.29*** | 4.36*** |
| Eastern-Africa | | | | |
| *k=15* | 10.64*** | 8.71*** | 8.18*** | 8.65*** |
| *k=20* | 11.11*** | 9.09*** | 8.63*** | 9.31*** |
| *k=25* | 11.46*** | 9.37*** | 9.01*** | 9.65*** |
| *k=30* | 11.45*** | 9.60*** | 9.37*** | 9.97*** |
| Northern-Africa | | | | |
| *k=15* | 2.46** | 1.32 | 3.69*** | 4.16*** |
| *k=20* | 2.76*** | 1.61 | 3.82*** | 4.39*** |
| *k=25* | 3.22*** | 2.02** | 4.15*** | 4.82*** |
| *k=30* | 3.75*** | 2.56** | 4.46*** | 5.23*** |
| Southern-Africa | | | | |
| *k=15* | 1.38 | 0.68 | 1.02 | 1.24 |
| *k=20* | 2.06** | 1.45 | 1.54 | 1.67* |
| *k=25* | 2.61*** | 1.97** | 2.05** | 2.08** |
| *k=30* | 3.07*** | 2.34** | 2.56** | 2.42** |
| Sub-Sahara-Africa | | | | |
| *k=15* | 4.02*** | 1.33 | 5.06*** | 4.41*** |
| *k=20* | 4.63*** | 2.04** | 5.56*** | 4.78*** |
| *k=25* | 4.99*** | 2.49** | 5.82*** | 4.96*** |
| *k=30* | 5.17*** | 2.78*** | 5.99*** | 5.00*** |
| Western-Africa | | | | |
| *k=15* | 3.62*** | 1.12 | 4.38*** | 4.89*** |
| *k=20* | 3.95*** | 1.60 | 4.30*** | 5.04*** |
| *k=25* | 4.09*** | 1.87* | 3.96*** | 5.03*** |
| *k=30* | 4.07*** | 1.95* | 3.67*** | 4.89*** |

Notes: A test statistic with ***, **, and * indicates significance at 1%, 5%, and 10% levels, respectively. Figures in columns 2-5 give the values of the test statistics $R_1$, $R_2$, $S_1$ and $S_2$ for each index series examined. They are based on Wright's (2000) non-parametric (ranks and signs) variance-ratio tests. The names in the rows are those of the respective regional stock price indices examined.

***Tables 8*: Wright's Tests Results for African Stock Price Indices by the Size of Market Capitalisation**

| Period | $R_1$ | $R_2$ | $S_1$ | $S_2$ |
|---|---|---|---|---|
| Africa-Large companies | | | | |
| *k=15* | 1.32 | 0.41 | 1.52 | 1.82* |
| *k=20* | 1.53 | 0.65 | 1.64* | 2.12** |
| *k=25* | 1.81* | 0.93 | 1.98** | 2.72*** |
| *k=30* | 2.15** | 1.33 | 2.25** | 3.18*** |
| Africa-Medium Companies | | | | |
| *k=15* | 4.29*** | 2.24** | 3.40*** | 4.85*** |
| *k=20* | 5.08*** | 3.04*** | 4.03*** | 5.51*** |
| *k=25* | 5.84*** | 3.79*** | 4.64*** | 6.29*** |
| *k=30* | 6.61*** | 4.49*** | 5.32*** | 7.13*** |
| Africa-Small Companies | | | | |
| *k=15* | 6.99*** | 4.90*** | 6.80*** | 7.09*** |
| *k=20* | 7.90*** | 5.88*** | 7.75*** | 7.95*** |
| *k=25* | 8.47*** | 6.47*** | 8.34*** | 8.41*** |
| *k=30* | 9.06*** | 7.06*** | 8.93*** | 8.91*** |

Notes: A test statistic with ***, **, and * indicates significance at 1%, 5%, and 10% levels, respectively. Figures in columns 2-5 give the values of the test statistics $R_1$, $R_2$, $S_1$ and $S_2$ for each index series examined. They are based on Wright's (2000) non-parametric (ranks and signs) variance-ratio tests. The names in the rows are those of the respective size stock price indices examined.

***Tables 9*: Wright's Tests Results for African Sectoral Stock Price Indices**

| Period | $R_1$ | $R_2$ | $S_1$ | $S_2$ |
|---|---|---|---|---|
| Panel A: Consumer Goods Sub-sector | | | | |
| Africa-Automobiles and Transport Equipment | | | | |
| *k=15* | 0.53 | 1.14 | -0.32 | -0.11 |
| *k=20* | 0.20 | 0.67 | -0.51 | -0.26 |
| *k=25* | -0.07 | 0.29 | -0.70 | -0.42 |
| *k=30* | -0.18 | 0.12 | -0.72 | -0.41 |
| Africa-Consumer Goods, Food and Beverages | | | | |
| *k=15* | 0.28 | -0.89 | 0.92 | 0.78 |
| *k=20* | 0.42 | -0.67 | 1.00 | 0.83 |
| *k=25* | 0.63 | -0.39 | 0.84 | 0.77 |
| *k=30* | 0.85 | -0.10 | 0.85 | 0.86 |
| Africa-Pharmaceuticals and Health | | | | |
| *k=15* | 1.36 | 0.73 | 0.91 | 1.42 |
| *k=20* | 1.76* | 1.24 | 1.17 | 1.71* |
| *k=25* | 2.05** | 1.50 | 1.48 | 1.96** |
| *k=30* | 2.37** | 1.81* | 1.76* | 2.23** |
| Panel B: Financials Sub-sector | | | | |
| Africa-Financial Services (Excluding Banks) | | | | |
| *k=15* | 0.86 | -0.04 | 0.81 | 0.83 |
| *k=20* | 1.07 | 0.21 | 0.80 | 0.74 |
| *k=25* | 1.35 | 0.55 | 0.88 | 0.83 |
| *k=30* | 1.56 | 0.80 | 0.93 | 0.90 |
| Africa-Banks | | | | |
| *k=15* | 2.37** | 0.93 | 2.82** | 4.00*** |
| *k=20* | 3.15*** | 1.64* | 3.40*** | 4.57*** |
| *k=25* | 3.71*** | 2.20** | 3.80*** | 5.04*** |
| *k=30* | 4.32*** | 2.82*** | 4.13*** | 5.53*** |
| Panel C: Industrials Sub-sector | | | | |
| Africa-Chemicals | | | | |
| *k=15* | -0.20 | -0.09 | -0.36 | -0.19 |
| *k=20* | -0.17 | -0.09 | -0.17 | -0.08 |
| *k=25* | -0.13 | -0.08 | -0.12 | -0.06 |
| *k=30* | 0.03 | -0.12 | -0.04 | -0.02 |
| Africa-Diversified Conglomerates | | | | |
| *k=15* | -0.53 | -1.36 | 0.61 | 1.14 |
| *k=20* | -0.25 | -1.18 | 1.08 | 1.67* |
| *k=25* | -0.11 | -1.02 | 1.31 | 1.93* |
| *k=30* | 0.04 | -0.84 | 1.55 | 2.19** |
| Africa- Manufacturing | | | | |
| *k=15* | 0.40 | -0.52 | 1.97** | 1.18 |
| *k=20* | 0.77 | 0.03 | 2.36** | 1.35 |
| *k=25* | 1.08 | 0.46 | 2.64*** | 1.56 |
| *k=30* | 1.39 | 0.86 | 2.89*** | 1.73* |

**Continuation: Table 9**

| Period | $R_1$ | $R_2$ | $S_1$ | $S_2$ |
|---|---|---|---|---|
| Panel D: Natural Resources Sub-sector | | | | |
| Africa-Natural Resources | | | | |
| *k=15* | 0.45 | -0.41 | 0.88 | 1.97** |
| *k=20* | 0.65 | -0.10 | 0.88 | 1.87* |
| *k=25* | 0.69 | 0.00 | 0.79 | 1.82* |
| *k=30* | 0.76 | 0.14 | 0.69 | 1.76* |
| Africa-Mining and Metals | | | | |
| *k=15* | -0.39 | -0.13 | -0.11 | -0.47 |
| *k=20* | -0.29 | -0.15 | 0.07 | -0.26 |
| *k=25* | -0.12 | -0.01 | 0.19 | -0.10 |
| *k=30* | 0.22 | 0.31 | 0.47 | 0.20 |
| Panel E: Services Sub-sector | | | | |
| Africa-Services | | | | |
| *k=15* | -0.55 | -1.48 | -0.51 | -0.66 |
| *k=20* | -0.22 | -1.12 | -0.29 | -0.42 |
| *k=25* | 0.07 | -0.81 | -0.08 | -0.18 |
| *k=30* | 0.29 | -0.55 | 0.09 | 0.02 |
| Africa-Media | | | | |
| *k=15* | 1.78* | 2.07** | 1.32 | 4.90*** |
| *k=20* | 1.62 | 1.95* | 1.40 | 5.54*** |
| *k=25* | 1.45 | 1.81* | 1.46 | 6.21*** |
| *k=30* | 1.32 | 1.64* | 1.52 | 6.76*** |
| Africa-Retail and General Trade | | | | |
| *k=15* | -1.49 | -2.55** | 0.22 | 0.46 |
| *k=20* | -0.93 | -1.95* | 0.57 | 0.83 |
| *k=25* | -0.48 | -1.43 | 0.79 | 1.05 |
| *k=30* | -0.07 | -0.97 | 1.12 | 1.39 |
| Panel F: Utilities Sub-sector | | | | |
| Africa-Telecoms and Utilities | | | | |
| *k=15* | 5.31*** | 5.55*** | 3.07*** | 1.64* |
| *k=20* | 5.38*** | 5.40*** | 3.44*** | 1.90* |
| *k=25* | 4.98*** | 4.86*** | 3.59*** | 1.86* |
| *k=30* | 4.86*** | 4.74*** | 3.77*** | 1.95* |
| Africa-Transportation | | | | |
| *k=15* | -0.78 | -1.19 | -0.37 | 0.03 |
| *k=20* | -0.70 | -1.01 | -0.30 | 0.17 |
| *k=25* | -0.45 | -0.72 | -0.01 | 0.46 |
| *k=30* | -0.19 | -0.46 | 0.28 | 0.68 |

Notes: A test statistic with ***, **, and * indicates significance at 1%, 5%, and 10% levels, respectively. Figures in columns 2-5 give the values of the test statistics $R_1$, $R_2$, $S_1$ and $S_2$ for each index series examined. They are based on Wright's (2000) non-parametric (ranks and signs) variance-ratio tests. The names in the rows are those of the respective sectoral stock price indices examined.