Testing the Weak-form Efficiency in African Stock Markets

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Abstract

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

Design/methodology/approach – The study uses conventional variance-ratio tests in addition to tests based on ranks and signs to examine the weak-form efficiency of the index series used in the study.

Findings – On average, we find that irrespective of the test employed, the returns of all the 24 African continent-wide indices examined in the study appear to be more normally distributed compared to the 8 individual national stock price indices examined. We report evidence of statistically significant weak-form informational efficiency in the African continent-wide stock indices over the individual national stock indices irrespective of the test statistic used.

Practical implications – The policy implication of this evidence is that African stock markets sector returns distributional properties may significantly be improved if the continental market operations can be harmonised and integrated. Economically, this can lead to more efficient allocation of capital and risk, which is expected to be a catalyst for economic growth.

Originality/value – The study makes two major contributions to the extant literature. Firstly, since it is still unclear whether existing African stock markets can improve their informational efficiency by harmonising and integrating their current operations, this study fills this gap by providing tentative evidence. Secondly, we offer for the first time a comparative analysis of the informational efficiencies of a sample of national stock indices as against African continent-wide constructed stock price indices.

Keywords: African stock markets, Harmonisation and 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 new stock markets are proposed to be opened in Congo D.R., Equatorial Guinea, Ethiopia, the Gambia, Lesotho, Madagascar, Mauritania and Sierra Leone (Moin, 2007; Databank Group, 2008). It is anticipated that more than 34 of the 53 African countries will have stock markets by the end of this decade (Moin, 2007).

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. It has also been suggested that stock markets can promote economic growth. For example, Shaw (1973), Levine and Zervos (1996) and Levine (1997) have argued that well-developed stock markets promote higher economic growth through their ability to attract international investments and mobilise domestic savings. This can facilitate efficient allocation of scarce economic resources.

Despite the rapid development, stock markets in Africa remain comparatively different from their developed and other emerging counterparts excluding South Africa. Firstly, they are small in size. The total value of African stocks excluding South Africa was only 0.62% of world stock market capitalisation, and 1.55% of all emerging markets stocks at the end of 2007 (WFE, 2008). Secondly, the stock markets are also small in relation to their own economies. For example, stock market capitalisation in Mozambique is only 3.20% of nominal GDP, while Nigeria, Uganda and Tunisia's stock market capitalisations are between 25% and 52% (WFE, 2008). Crucially, they remain extremely

illiquid and thinly traded (Mlambo and Npieke, 2005). This severely affects their informational efficiencies. However, the ability of African stock markets to effectively perform the above listed roles 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 harmonising and integrating their operations.

A priori expectation is that a formal harmonisation and integration[3] of operations of emerging African stock markets may help in overcoming many of the current information challenges facing them (Irving, 2005; Okealaham, 2005). Lugangwa (2006), for example, argues that integration will increase African stock market visibility through a significant improvement in its size while, Fish and Biekpe (2002) suggest that regional integration will create expansion in trading volumes through economies of scale. Similarly, better communicational and technological infrastructure will reduce operational costs by reducing duplication and improve the flow of information in the market (Abumustafa, 2007). These are likely to improve overall market efficiency.

Given the potential benefits that an integrated and harmonised 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. We conduct this study 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, 1965, 1970, 1991). The behaviour of financial asset prices in the context of the weak-form efficiency has been, and continues to be, of immense interests to researchers, regulators, practitioners and

investors alike. This is because if the future price of financial assets can be modelled using information implicit in historical prices, it could make them exploitable.

While the weak-form market efficiency of the major developed and emerging stock markets of Latin America, Eastern Europe, and Asia have been the major focus of researchers in the past (Ayadi and Pyun, 1994; Claessens *et al*., 1995; Urrutia, 1995; Fifield *et al*., 2002, 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 few 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 size and number, the need for reliable evidence on their informational efficiencies is particularly important. Firstly, unlike their developed counterparts, African countries have fledgling economies in which market efficiency still has significant developmental implications. Secondly, emerging African markets excluding South Africa have low correlation with global stock markets (Table 1; Moin, 2007). This offers significant portfolio diversification opportunities for international investors.

Acknowledging the developmental implications of market efficiency with specific focus on the weak-form hypothesis, this study adds to the extant literature by providing further evidence on the behaviour of continent-wide and national stock price indices. This study makes additional further contributions. First, we make use of specially constructed size, sectoral and regional African stock price composite indices. This captures the

average performance of all stock markets in Africa excluding South Africa. A significant innovation in this is that, to the best of our knowledge, this will be the first comprehensive African continent-wide data series examined in any study. Secondly, we offer for the first time, a comparative analysis of the informational efficiencies of a sample of national indices as against African continent-wide constructed stock price indices. The remainder of the paper is organised as follows. Section 2 reviews some of the prior African weak-form market efficiency literature. Section 3 describes the data and research methodology. Section 4 presents empirical results while section 5 concludes.

2. Prior African Weak-Form Market Efficiency Literature

The weak-form efficiency hypothesis has received little attention from researchers in Africa. This is mainly due to the difficulty of obtaining data of sufficient frequency and duration for any meaningful empirical analysis (e.g., 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 show 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) studied the weekly stock return behaviour of 30 listed companies on the Nairobi Stock Exchange from 1979 to 1988. Their reported results could not reject the notion of weak-form market efficiency for stocks listed on the Nairobi Stock Exchange. This was in contradiction to Parkinson (1984), who reported that Kenyan listed equities are not weak-form efficient.

By contrast, Magnusson and Wydick (2002) use a partial-autocorrelation test to examine monthly return behaviour of eight African stock markets indices including Botswana, Cote d'Ivoire, Ghana, Kenya, Mauritius, Nigeria, South Africa and Zimbabwe, in comparison with nine Asian and Latin American markets from 1989 to 1998. Their results suggest that six out of the eight analysed African stock markets indices were weak-form efficient. Ghana and Zimbabwe are reported not to be 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 Chow and Denning's (1993) multiple variance-ratios test to examine the weak-form efficiency in weekly stock market index series from 1990 to 1998 of eight African countries, 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. Their results rejected the notion of weak-form efficiency in the index series of all the examined markets except South Africa.

Appiah-Kusi and Menya (2003) use an EGARCH-M model to investigate the weak-form efficiency in weekly return series of eleven African stock markets indices. Their results show that weekly stock indices in Egypt, Kenya, Morocco, Mauritius, and Zimbabwe are weak-form efficient, while those of Botswana, Ghana, Ivory Coast, Nigeria, South Africa, and Swaziland are not efficient. Finally, using autocorrelation, run, and the multiple variance-ratios tests, Simons and Laryea (2006) examine the weak-form efficiency of weekly equity market indices of Egypt, Ghana, Mauritius and South Africa from 1990 to 2003. Consistent with previous evidence, their results rejected the notion of weak-form efficiency in all the analysed markets 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, and most of these were carried out using data prior to the tremendous surge in interest in African stock markets in the early 1990s (Smith *et al*., 2002). Also, the results of the prior studies on African weak-form market efficiency tests are mixed and most of the studies are based on statistical analyses based on the use of autocorrelation, runs, and unit root tests (Parkinson, 1984; Dickinson and Muragu, 1994). The main problem with these conventional methods is that, by assuming linearity in stock returns, the results lack power and are contradicted by recent evidence (Savit, 1988; Jefferis and Smith, 2005; Ntim, *et al*., 2007).

The current paper differs from existing studies in several ways. First, we offer some evidence on the price behaviour of continent-wide sector indices which may have implications for the economic attempts to integrate and harmonise the economies of the nation states of Africa by the African Union as well as the regional groupings like the Economic Community of West African States (ECOWAS) and Southern African Development Community (SADC). If sector indices are more normally distributed than regional indices, it may imply that some economic benefits could be derived by integration. Also, the success of any future attempts to introduce derivative trading on some of the sector indices will largely depend on their behaviour. Secondly, with some evidence of non-normality and volatility clustering in African equity returns increasing (Appiah-Kusi and Menya, 2003; Jefferis and Smith, 2005; Ntim, *et al*., 2007), we apply the empirically robust Wright (2000) non-parametric variance-ratios test in addition to its Lo and MacKinlay (1988) parametric alternative to analyse the efficiency of national and

African continent-wide constructed stock price indices. Finally, we offer for the first time a comparative analysis of the informational efficiencies of a sample of national indices as against African continent-wide constructed stock price indices.

2.1 An Overview of African Stock Markets

In a relatively short time, Africa appears to have developed an impressive stock market sector. With only 5 stock markets south of the Sahara, and 3 in the north of Africa by 1980, the number of African markets increased significantly 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) offer a four-tier classification of African equity markets. With the recent increase in the number of markets, however, we extend their four-tier classification to a five-tier classification, to reflect current developments. These are:

1. South Africa – the most infrastructurally developed, the largest as well as the oldest stock market in Africa.
2. A group of medium-size markets, which have been in existence for relatively longer periods of time, consisting of Egypt, Kenya, Nigeria, Morocco, Tunisia and Zimbabwe.
3. A group of new, small, but rapidly growing markets, consisting of Botswana, Cote d'Ivoire, Ghana, Namibia and Mauritius.
4. A group of very small new markets including, Libya, Malawi, Mozambique, Sudan, Swaziland, Tanzania, Uganda, and Zambia, whose existence have been

widely acknowledged (at least recognised by ASEA), but who are struggling to take-off, and finally,

5. A group of six markets, namely, Algeria, Angola, Cameroon, Cape Verde, Gabon, and Rwanda, which either, despite having been in existence for relatively longer time like Algeria (1993), Cameroon (2001), Gabon (2001) and Cape Verde (2005), are not widely known (not even recognised by ASEA), or are not formally known because they are simply too young, such as Angola (September, 2007) and Rwanda (January, 2008).

Insert Table 1 about here

Table 1 provides development statistics of 18 African stock markets as at the end of 2007. For comparative purposes, the statistics for four more-established emerging markets (Brazil, China, India and Malaysia), and three developed markets (Hong Kong, UK and US) are also presented. As Table 1 shows, with the exceptions of South Africa, the medium-size markets of Egypt, Kenya, Nigeria, Morocco, Tunisia and Zimbabwe, and Cote d'Ivoire, none of the remaining 10 African markets is more than 20 years old. By contrast, the UK market is over 300 years old, while both the Indian and Brazilian markets are more than 100 years old. It also shows that the 18 African stock markets are relatively small, both in terms of the number of listed firms and market capitalisation. Barring South Africa, Egypt, and Nigeria, none of the remaining 14 markets has more than 100 listed firms, in sharp contrast to India and the UK, with 4,887 and 3,307 listed firms, respectively.

Further, the total continental market capitalisation excluding South Africa is, as can be seen from Table 1, $375,793m with an average capitalisation of $25,040m. This

does not only constitute a paltry 0.16% of US market capitalisation, but also form a mere 0.68%, 1.80% and 7.70% of China, Brazil and Malaysia's capitalisations, respectively. It is also evident from Table 1 that African stock markets suffer acutely from low liquidity. Liquidity measured as market turnover scaled by market capitalisation, ranges from as low as 0.30% for Tanzania to 51.20% for South Africa with an average excluding South Africa of 28.90%. A comparative liquidity figure for developed markets such as UK is 268.30%, and 191.10% for the US. For some emerging markets like China and Malaysia, the comparative figures are 110.20% and 52.20%, respectively.

Insert Table 2 about here

Table 2 presents institutional, operational and infrastructural development characteristics of 18 African stock markets in comparison with three developed markets and 4 other mainstream emerging markets as at the end of 2007. It shows that most of the 18 African markets have electronic trading systems, making them consistent with international standards. It also indicates that all the 18 African markets have adopted international accounting standards as well as permit the full participation of foreign investors with no restrictions. Similarly, only 7 markets have clearing and settlement period outside the international standard of T+3 trading days. Table 2 indicates further that all the 18 African markets trade for 5 days, but trading hours are relatively short with average trading hours of 2.92 hours. From Table 2, only Namibia and South Africa trade for more than 4 hours. In contrast, it shows that Brazil, Malaysia and the UK, for example, trade for more than 7 hours. Perhaps the small number of listed firms on most African markets justifies the short trading hours. It also means that trading occurs in only a few stocks, accounting for the acute low liquidity. Again, with the exception of South Africa,

Egypt, and Morocco, the markets have poor international recognition. As Table 2 shows, most of the African markets are either not classified at all or classified as frontier markets in the major international stock market classifications. As an indication of poor compliance with global standards, for example, only 3 markets have full membership of the prestigious World Federation of Exchanges (WFEs), with the rest being either affiliates, correspondents or not recognised at all.

Insert Table 3 about here

Despite their operational, institutional and infrastructural weaknesses, however, African markets are still seen as major anchors of economic growth and development (e.g., Okeahalam, 2005). Also, as Table 3 shows, the Africa all-share market index (excluding South Africa), for example, correlates either negatively or lowly with all the major global equity markets (MSCI/ABR, 2007). While this confirms their frontier market status, they present significant diversification opportunities especially for international investors. Further, the World Federation of Exchanges (WFE) 2007 statistics in Table 2 demonstrates that African markets have experienced faster growth in the number of listed firms, market capitalisation and liquidity than their developed and other emerging counterparts. Significantly, they offer competitive real returns. The average US$ adjusted returns for African markets excluding South Africa in 2007 was 47.2% with Malawi and Zambia offering returns well-above 120%. This not only compares favourably against those of developed markets like UK (2.0%), US (6.6%), but also to other emerging markets like Malaysia (31.8%) and Brazil (43.7%).

3. Data and Research Methodology

3.1 *Data*

Two types of datasets[1] 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 constructed and supplied by Africa Business Research Ltd, a UK-based independent professional data collection and research company that specialises in African markets. To be included, countries must meet the following criteria: (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. 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, which is a composite measure of the average performance of all stock exchanges in Africa excluding South Africa. It covers all companies listed on African stock exchanges that conform to the following minimum size and liquidity requirements: (1) must have a minimum market value of $10m at the quarterly index review date, and (2) must achieve a traded turnover of at least 0.01% of its market capitalisation in the quarter preceding the index review date and in at least 2 of the 4 quarters prior to the quarterly review date. The Africa All-Share index is segmented into the following sub-indices:

a. 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.
b. Six major industrial groups consisting of:

i. *Consumer goods sub-sector* which includes automobiles & transport, consumer goods, food & beverages, and pharmaceuticals & health;

ii. *Financials sub-sector* which consists of banks, and financial services excluding banks;

iii. *Industrials sub-sector* that includes chemicals, diversified conglomerates, and manufacturing;

iv. *Natural resources sub-sector* which includes natural resources, and mining & metals;

v. *Services sub-sector* that includes services, media, and retail & general trade; and

vi. *Utilities sub-sector* which includes telecoms & utilities, and transportation.

c. 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 consists of daily national closing stock price indices, which is available in DataStream. Out of the 16 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 index names and

constituents, acronym/codes, sources, sample period, and total number of daily series used.

3.2 *The Random Walk and the Martingale Difference Sequence Hypotheses*

We explicitly test the strict random walk (RW) and the relaxed martingale difference sequence (MDS) hypotheses of the weak-form market efficiency. The random walk (RW) hypothesis posits that in an efficient market, successive price changes follow that of a gaussian-random variable. This means that future price changes cannot be forecast using past price changes. 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 asset's return series under consideration, (i.e., the African stock markets indices returns) at time (day) *t*; μ 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 (∂^2).

The hypothesis to be tested for the strict RW is:

H_1 : African sectoral, size, regional and individual national stock price indices returns 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 African stock markets indices returns) at time (day) *t*. This means the asset's price is equally likely to

rise, as it is to fall, which makes it impossible to predict. The major difference between the RW and the MDS hypotheses, however, is that the latter relaxes the strict gaussian-random variable assumption to permit the possible existence of time-varying volatilities in an asset's return series like conditional-hetereoscedasticity, which though expecting successive residual increments to be independent, does not necessarily require it to be identically distributed. The hypothesis to be tested for the relaxed MDS is:

H_2 : African sectoral, size, regional and individual national stock price indices returns follow a martingale difference sequence.

3.3 *Research Methodology*

The weak-form efficiency is tested by first applying the Lo and MacKinlay (1988) parametric variance ratios test, then, followed by the implementation of its non-parametric alternative suggested by Wright (2000). The Lo and MacKinlay (1988) (hereafter LM) variance-ratios test assumes that if a natural logarithm of a time series (p_t) is a pure random walk, then the variance of its *k*-differences in a finite sample grows proportionally with the difference, *k*, where *k* refers to the number days interval such as 15, 20, 25 and 30 days. Following LM (1988), let (p_t) denote a time series consisting of T observations $p_1, p_2, \ldots, p_T$ of asset returns. Then, the variance-ratio of the *k*-th difference, VR(k), is defined as:

$$VR(k) = \frac{\partial^2(k)}{\partial^2(1)}, \tag{1}$$

where, $VR(k)$ is the variance-ratio of an index's *k*-th differences; $\partial^2(k)$ is the unbiased estimator of $1/k$ of the variance of an index *k* difference, under the null hypothesis; $\partial^2(1)$

is the variance of the first-difference of an index returns series, and k is the number of days of base observations intervals or lags[2], where k = 15, 20, 25 and 30 days with regard to this study. The estimated variance, $VR(k)$, values for all k-th lags, under the null hypothesis, are expected to be equal to unity if the observed series truly follow a random walk. Following LM (1988), the estimator of the k-period difference, $\partial^2(k)$, is calculated as:

$\partial^2(k) = \frac{1}{Tk}\sum_{t=k}^{T}(p_t + ... + p_{t-k+1} - k\hat{\mu})^2$, where $\hat{\mu}$ is the estimated arbitrary drift parameter defined as: $\hat{\mu} = \frac{1}{T}\sum_{t=1}^{T} p_t$, and the unbiased estimator of the variance of the first difference, $\partial^2(1)$, is computed as: $\partial^2(1) = \frac{1}{T}\sum_{t=1}^{T}(p_t - \hat{\mu})^2$. The LM (1988) test statistic is implemented in two specifications. The first test statistic, which is construed as testing the strict RW hypothesis with regard to this study, $M_1(k)$ is given by:

$$M_1(k) = \frac{VR(k) - 1}{\phi(k)^{1/2}}, \tag{2}$$

which, under the assumption of homoscedasticity, is normally distributed with zero mean, and unit variance, i.e., $N(0,1)$. The homoscedastic-consistent asymptotic variance of the variance ratio, $\phi(k)$, is given by:

$$\phi(k) = \frac{2(2k-1)(k-1)}{3kT}. \tag{3}$$

The hetereoscedasticity-consistent test statistic, which is understood to constitute the relaxed MDS[3] hypothesis with regard to this study, $M_2(k)$, is given by:

$$M_2(k) = \frac{VR(k) - 1}{\phi^*(k)^{1/2}}, \tag{4}$$

LM (1988) demonstrate that, unlike the M_1, the M_2 test statistic under the null hypothesis is robust to many forms of hetereoscedasticities. A corresponding hetereoscedasticity-consistent asymptotic variance for the M_2 test statistic is defined as:

$$\phi^*(k) = \sum_{j=1}^{k-1}\left[\frac{2(k-j)}{k}\right]^2 \delta(j) \text{ and } \delta(j) = \frac{\sum_{t=j+1}^{T}(p_t - \hat{\mu})^2 (p_{t-j} - \hat{\mu})^2}{\left[\sum_{t=1}^{T}(p_t - \hat{\mu})^2\right]^2}.$$

In statistics, non-parametric tests are generally known to be more powerful (e.g., Luger, 2003). On this basis, Wright (2000) extends LM's (1988) parametric variance-ratios test to a non-parametric variance-ratios test. The main difference is that Wright's (2000) non-parametric variance-ratios test statistics replace the return differences used in LM (1988) 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:

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

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

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 Φ^{-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 LM (1988) test statistics, which is written as R_1 and R_2, where:

$$R_1 = \left(\frac{\frac{1}{Tk}\sum_{t=k}^{T}(r_{1t} + ... + r_{1t-k+1})^2}{\frac{1}{T}\sum_{t=1}^{T} r_{1t}{}^2} - 1 \right) \times \phi(k)^{-1/2}, \text{ and} \tag{5}$$

$$R_2 = \left(\frac{\frac{1}{Tk}\sum_{t=k}^{T}(r_{2t} + ... + r_{2t-k+1})^2}{\frac{1}{T}\sum_{t=1}^{T} r_{2t}{}^2} - 1 \right) \times \phi(k)^{-1/2}, \tag{6}$$

where $\phi(k)$ is defined in (3).

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; hence, it can be used to construct a test with exact power. On the other hand, the test statistic based on the signs of returns rather than ranks, S_1 and S_2, is given by:

$$s_1 = \left(\frac{\frac{1}{Tk}\sum_{t=k}^{T}(s_t + ... + s_{t-k+1})^2}{\frac{1}{T}\sum_{t=1}^{T} s_t{}^2} - 1 \right) \times \phi(k)^{-1/2}, \text{and} \tag{7}$$

$$s_2 = \left(\frac{\frac{1}{Tk}\sum_{t=k}^{T}(s_t(\bar{\mu}) + ... + s_{t-k+1}(\bar{\mu}))^2}{\frac{1}{T}\sum_{t=1}^{T} s_t(\bar{\mu})^2} - 1 \right) \times \phi(k)^{-1/2}, \tag{8}$$

where, $\phi(k)$ is defined in (4), $s_t = 2u(p_t, 0), s_t(\bar{\mu}) = 2u(p_t, \bar{\mu}),$ and

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

4. Empirical Results

4.1 Data Properties

Table 4 contains descriptive statistics and diagnostics of naturally logged computed daily returns for all 32 stock price indices investigated. Panels A, B, C, and D present descriptive statistics and diagnostics of returns of African sectoral, size, regional and individual national stock price indices, respectively.

Insert Table 4 about here

The table shows that daily mean returns for all the 32 series examined are close to zero. With the exception of the manufacturing (Amai) and pharmaceuticals & health (Aphi) sub-sectors in Panel A, the rest of the sector indices reported in Panel A show positive mean returns behaviour. The standard deviation is relatively small for all the 32 analysed series. For symmetry, the standard normal distribution should have zero skewness. For automobiles & transport (Aatei), chemicals (Aci), natural resources (Anri), Services (Asi) and transportation (Ati) sectors in Panel A, the return series appear to be symmetrical. Also, apart from the small company index (Asci) in Panel B, and the eastern- (Eai) and western-Africa (Wai) indices in Panel C, all the African continent-wide series appear to be close to symmetric. By contrast, symmetry is rejected for all the national stock price series in Panel D. With the exception of diversified conglomerates (Adci) and transportation (Ati) sectors in Panel A, the null hypothesis of the kurtosis test statistic conforming to that of a normal distribution is rejected at any reasonable significance level for any of the series investigated.

In addition, Kolmogorov-Smirnov (K-S) and Anderson-Darling (A-D) non-parametric goodness-of-fit tests are implemented. Using the K-S absolute values, the log-

normality assumption is rejected at the 0.10 level, but not at the conventional 0.01 or 0.05 levels, for 13 out of 24 African sectoral, size, and regional series in Panels A, B and C, respectively. The null is rejected for all the 8 national stock price series in Panel D at the conventional 0.05 level. The more powerful A-D statistic, however, consistently reject the null for all the 32 series at the 0.01 level. A critical revelation is that irrespective of the diagnostic used, on comparative basis, the 24 African continent-wide series show less departure from normality than the 8 individual national series. The evidence of a non-normal return behaviour in most of the series is consistent with findings of previous studies (e.g., Jefferis and Smith, 2005; Ntim, *et al*., 2007). Crucially, it justifies the application of non-normality and especially, Wright's (2000) non-parametric variance-ratios test, which is robust to conditional-hetereoscedasticity.

4.2 Empirical Results

Table 5 shows the results of the variance-ratios test for the African regional stock price indices. Column 1 indicates the specific time period, k which is the number of interval days, where k = 15, 20, 25 & 30 days for each of the six series. Columns 2 to 7 report the test statistics for M_1, M_2, R_1, R_2, S_1 and S_2 for each index return series examined. M_1 shows the test statistics suggested by Lo and MacKinlay (1988) under the maintained hypothesis of homoscedasticity (random walk) while M_2 reports similar critical values under the hetereoscedasticity (martingale difference sequence) hypothesis. The reported results for the M_1 test suggests that the null hypothesis of random walk behaviour for the Africa-All-Share and Northern-Africa return series cannot be rejected for any intervals of k tested in the study. RW behaviour is rejected at the 0.01 level for Eastern- and Southern-Africa return series for any intervals of k. For Sub-Sahara-Africa, the RW is

only rejected when *k* equals 15, whilst it cannot be rejected for Western-Africa when *k* = 30. The results obtained by implementing M_2 indicate that the null hypothesis of martingale difference sequence behaviour cannot be rejected for all the return series except the Eastern-Africa return series at the conventional 0.01 and 0.05 significance levels for any lags of *k*.

Insert Table 5 about here

Given the mixed evidence from the conventional variance ratios test, the robust ranks (R_1, R_2) and signs-based (S_1, S_2) alternatives suggested by Wright (2000) are further applied to investigate the RW and the MDS hypotheses, respectively. These results are reported in Columns 4 to 7 in Table 5. With the exception of the return series of Southern-Africa for which the null cannot be rejected when *k* = 15, the RW is rejected when the R_1 is implemented for all six return series examined at least at the 0.05 level. For the R_2, test, the null of RW is rejected for the return series of Eastern-Africa for any lags of *k* at the 0.01 level. For the remaining 5 regions, the evidence is rather mixed as the RW is rejected for some intervals of *k*, but cannot be rejected for others. Unlike the ranks, the results obtained from using the sign-based test statistics, (S_1, S_2) consistently reject the MDS hypothesis for the return series of all six regions at any intervals of *k* at least at the 0.05 level, except for Southern-Africa when *k* = 15 & 20. In contrast to the mixed results of the traditional M_1 and M_2 statistics, all rejections are in the upper tail (have positive signs) of the distribution, which suggests that any serial dependence is positive.

Insert Table 6 about here

Table 6 presents the variance-ratios tests results for the African size stock price indices. The null hypothesis of random walk cannot be rejected using M_1 test for any lags of k for the return series of the large capitalisation indices at any reasonable probability level. By contrast, the null is rejected for the returns series of the medium and small capitalisation indices for all intervals of k at the 0.01 level. Generally, the results show that the large capitalisation return series follows a random walk while medium and small capitalisation returns series do not. An exception is when k = 20, 25 & 30 for the medium capitalisation return series. Implementation of M_2 shows that the acceptance of the RW is robust to hetereoscedasticity for the returns series of the large and medium capitalisation indices at any probability level. For the return series of the small capitalisation indices, M_2 indicates that the MDS is also rejected at the 0.01 level, which suggests that the rejection of the RW is not due to autocorrelation. Employing the powerful ranks-based test statistics (R_1, R_2), the RW cannot be rejected at any reasonable significance level for the return series of the large capitalisation indices, except when k = 25 & 30 for R_1. By contrast, the null is rejected for the returns series of the medium and small capitalisation indices for any lags of k at the 0.01 level.

Implementing the signs-based alternative test statistics (S_1, S_2), the MDS is rejected for all 3 returns series at any interval of k, except for the large capitalisation return series when k = 15. Again, unlike the mixed results of the conventional variance-ratios tests, all rejections by the ranks and signs-based test statistics are in the upper tail of the distribution, suggesting that the resulting variance-ratios are greater than unity for all the series examined. Overall, our results indicate that large capitalisation stocks returns behaviour follow RW and MDS while that of medium and small capitalisation

stocks do not when Lo and MacKinlay (1988) variance-ratios tests are applied. Wrights' (2000) ranks and signs based alternatives, however, reject both the RW and MDS for the returns series of all 3 capitalisation-based stocks price series examined.

Insert Table 7 about here

Table 7 contains the results of the variance-ratios tests for six African sectoral stock price indices. Panels A, B, C, D, E and F present the M_1, M_2, R_1, R_2, S_1 and S_2 test 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 (80%) of the sectoral indices investigated display high levels of weak-form efficiency, even against the powerful Wright's (2000) non-parametric variance-ratios tests. When we apply M_1 to the return series of automobile & transport sub-sector in Panel A, the null hypothesis of RW cannot be rejected at any probability level for any lags of k. Employing the M_2 statistic, the MDS similarly cannot be rejected at any reasonable significance level for any intervals of k. The acceptance of the RW and the MDS remain unchanged even when the ranks (R_1, R_2) and signs-based (S_1, S_2) alternative are implemented.

For the return series of the consumer goods, food & beverages sub-sector in Panel A, with the exception of M_1 when k = 15 & 20, the RW and MDS hypotheses are consistently accepted by both the parametric and non-parametric variance-ratios tests statistics for any lags of k at any probability level. For the return series of the pharmaceuticals & health sub-sector in Panel A, while M_1 rejects the RW at the 0.01 level for any intervals of k, M_2 shows that the rejection is not robust to hetereoscedasticty, as the MDS is strongly accepted at any intervals of k, at any significance level. Employing

the ranks (R_1, R_2) and signs-based (S_1, S_2) alternative, the RW and the MDS hypotheses cannot be rejected at the conventional 0.01 and 0.05 levels, except when k = 25 & 30 for R_1 and S_2. For the returns series of the remaining 12 economic sub-sectors, with the exception of the banks in Panel B and telecoms & utilities in Panel F, evidence of weak-form efficiency is robust irrespective of the test statistic used. For the returns series of the financial services (excluding banks), services, and retail & general trade economic sub-sectors in Panels B, and E, respectively, where the M_1 suggests the RW is rejected, M_2 shows that the rejection is due to autocorrelation rather than hetereoscedasticity, as the MDS hypothesis is accepted for any lags of k, at any significance level. Of special note is that the majority of the M_1 rejections are in the lower tail of the distribution, which suggests any serial dependence is negative. Overall, our results show that the RW and MDS cannot be rejected for the returns series of the majority of the sectoral stock indices whether a parametric or a non-parametric variance-ratios test is implemented.

Insert Table 8 about here

In order to ascertain the potential improvements in the distributional properties of continent-wide stock indices compared to national indices, the tests employed are similarly implemented using national stock index data. Table 8 contains the variance-ratios tests results for a sample of 8 individual African national stock price indices for which data is available, namely, Botswana, Egypt, Ghana, Kenya, Mauritius, Morocco, Nigeria and Tunisia. Generally, while the results of the traditional variance-ratios tests (M_1, M_2) are ambiguous, the results for the ranks (R_1, R_2) and signs (S_1, S_2) alternative are clear. Using the M_1, the null of RW cannot be rejected for any lags of k at the conventional 0.01 and 0.05 for the returns series of any of the 8 countries, with the

exception of Botswana when k = 20 and Ghana when k = 30, where the null is rejected at the 0.10 level. For Egypt and Nigeria, M_2 suggests that the non-rejection of the null is robust to hetereoscedasticity, as the MDS similarly cannot be rejected for any lags of k, at any probability level. M_2 also shows that the MDS is rejected for Botswana, Kenya, Mauritius and Morocco at the 0.01 level when k = 15 & 20 and Ghana when k = 30. The MDS is further not only rejected at the 0.10 level for Ghana when k = 25 and Tunisia when k = 30, but also for Botswana at the 0.05 level when k = 25. For Kenya, Mauritius and Morocco, the MDS is accepted at any probability level when k = 25 & 30.

Unlike the ambiguous results of the conventional parametric variance-ratios tests (M_1, M_2), the ranks (R_1, R_2) and signs (S_1, S_2) alternatives consistently reject the RW and the MDS hypotheses at the 0.01 level for any intervals of k for the returns series of all the 8 countries examined. For Ghana, the rejection of the RW and the MDS is consistent with recent evidence (Ntim *et al*., 2007). Generally, the results obtained by implementing M_1 and M_2 fail to reject the RW and MDS hypotheses. However, with alternative estimation using the ranks and signs, we find strong and consistent evidence to reject the RW and MDS.

A comparison of the results of the individual national indices (table 8) with the African continent-wide constructed indices (tables 5-7) suggests significant potential improvements in informational efficiency if the continental market can be harmonised and integrated in their operations. Firstly, irrespective of the test statistic used, and the set of African continent-wide indices that they are compared with, the individual national indices indicate higher levels of rejections for the RW and MDS hypotheses. Secondly, the African continent-wide regional and size indices, either show higher levels of weak-

form market efficiency or tendencies towards weak-form market efficiency when matched against the individual national indices. Thirdly, the potential improvement in efficiency to be gained is much higher in economic sectors indices than in size and regional indices. Approximately 80% of the African sectoral indices returns series are weak-form efficient even against the robust Wright (2000) non-parametric variance-ratios tests. By contrast, none of the individual national indices are weak-form efficient against the ranks and signs tests and even in the case of the African regional and size indices where the RW and the MDS are rejected for some series, rejection levels are on average 15 times lower than the individual national indices.

5. Conclusion

The last three decades has witnessed a rapid increase in the number and size of African stock markets. However, their segmented existence and lack of economies of scale and operational efficiency render most of them extremely illiquid, small and on the fringes of the competitive global financial markets place. As a corollary, their informational efficiency is greatly diminished, and this severely affects their ability to allocate capital efficiently. With a specific focus on the weak-form of the efficient markets hypothesis, we have attempted to empirically ascertain whether African continent-wide stock markets sector indices distributional properties differ from national ones.

Our reported results indicate that, first, irrespective of the diagnostic used, the 24 African continent-wide stock price indices returns display better normal distributional properties than any of the 8 individual national stock price indices studied. Secondly, we

record evidence of statistically significant improvements in the informational efficiency of the African continent-wide stock indices over the individual national stock indices irrespective of the test statistic used. Thirdly, the potential improvement in efficiency to be gained is much higher in economic sector indices than in size and regional indices examined. Approximately 80% of the African sectoral indices returns are weak-form efficient even against the robust Wright (2000) non-parametric variance-ratios tests. By contrast, none of the individual national indices are efficient against the ranks and signs tests, and even in the case of the African regional and size indices where the RW and the MDS are rejected for some series, rejection levels are on average 15 times lower than the individual national indices. Finally, consistent with prior evidence, (Wright, 2000; Belaire-Franch and Opong, 2005; Ntim, *et al*., 2007), the results of the Lo and MacKinlaly (1988) parametric variance-ratios test are ambiguous. By contrast, the ranks and signs tests offer consistent results throughout.

The policy implication of this evidence is that African stock markets sector returns distributional properties may significantly be improved if the continental market operations can be harmonised and integrated. Economically, this may lead to more efficient allocation of capital and risk, which is expected to be a catalyst for economic growth. A starting point will be the harmonisation of listing rules, ideally from regional groupings. In this case, we acknowledge the efforts of the Committee of SADC Stock Exchanges (COSSE), the East African Securities Exchanges Association (EASEA) and the Common Markets for Eastern and Southern Africa (COMESA) to harmonise the listing rules of Eastern and Southern African countries. West, Central, and Northern African countries can begin similar initiatives. Also, strategic alliances and co-operations

among exchanges like the '*Project Orio*n' in which the Namibian Stock Exchange is able to access the electronic trading system of the JSE Ltd will be a step in the right direction. Similarly, adopting a common financial reporting framework and currency will help the harmonisation and integration process. In this case, adopting the international accounting standards and the US dollar, for example, will be a pragmatic starting point.

Notes

1. The 8 stock markets that were in existence in 1980 include the Johannesburg Stock Exchange (South Africa), the Cairo and Alexander Stock Exchange (Egypt) and the Zimbabwean Stock Exchange (Zimbabwe). The rest are the Casablanca Stock Exchange (Morocco), the Nairobi Stock Exchange (Kenya), the Nigerian Stock Exchange (Nigeria) and the Tunisian Stock Exchange (Tunisia) (Table 1; UNDP, 2003).
1. For comparability purposes, all the 32 stock price indices used in this study are quoted in US dollars.
1. For comparability purposes, all the 32 stock price indices used in this study are quoted in US dollars.
2. According to Lo and MacKinlay (1988, p.46), the arbitrary base lag (*k*) selected, must be any equally spaced integer, which is greater than one. Similarly, the daily base intervals, 15, 20, 25 and 30 have been chosen on that basis.
3. According to Lo and MacKinlay (1988), M_2 is a sufficient, but not a necessary condition for the return series to follow MDS.

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Appendix 1: The Sample Stock Price Indices of the Study

Full Index Name	Acronym/Code	Source	Sample Period	Constituents	Series
African Sectoral/Industrial Stock Price Indices:					
ABR Africa Automobiles & Transport Equipment	Aatei	Africa Business Research	1998-2008	008	2380
ABR Africa Banks	Abi	Africa Business Research	1998-2008	091	2380
ABR Africa Chemicals	Aci	Africa Business Research	1998-2008	021	2380
ABR Africa Consumer Goods, Food & Beverages	Acgfbi	Africa Business Research	1998-2008	054	2380
ABR Africa Diversified Conglomerates	Adci	Africa Business Research	1998-2008	013	2380
ABR Africa Financial Services (excluding banks)	Afsi	Africa Business Research	1998-2008	032	2380
ABR Africa Manufacturing	Amai	Africa Business Research	1998-2008	038	2380
ABR Africa Media	Ami	Africa Business Research	1998-2008	005	2380
ABR Africa Mining & Metals	Ammi	Africa Business Research	1998-2008	007	2380
ABR Africa Natural Resources	Anri	Africa Business Research	1998-2008	027	2380
ABR Africa Pharmaceuticals & Health	Aphi	Africa Business Research	1998-2008	019	2380
ABR Africa Retail & General Trading	Argti	Africa Business Research	1998-2008	014	2380
ABR Africa Services	Asi	Africa Business Research	1998-2008	023	2380
ABR Africa Telecoms & Utilities	Atui	Africa Business Research	1998-2008	028	2380
ABR Africa Transportation	Ati	Africa Business Research	1998-2008	013	2380
African Size/Capitalisation Stock Price Indices:					
ABR Africa Large Company	Alci	Africa Business Research	1998-2008	100	2380
ABR Africa Medium Company	Amci	Africa Business Research	1998-2008	150	2380
ABR Africa Small Company	Asci	Africa Business Research	1998-2008	400	2380
African Regional/Geographic Stock Price Indices:					
ABR Africa All Share (excluding South Africa)	Aasi	Africa Business Research	1998-2008	550	2380
ABR Eastern Africa	Eai	Africa Business Research	1998-2008	087	2380
ABR Northern Africa	Nai	Africa Business Research	1998-2008	265	2380
ABR Southern Africa	Sai	Africa Business Research	1998-2008	045	2380
ABR Sub-Sahara Africa	Ssai	Africa Business Research	1998-2008	285	2380
ABR Western Africa	Wai	Africa Business Research	1998-2008	153	2380

Source: Africa Business Research Limited

Continuation: Appendix 1

Full Index Name	Acronym/Code	Source	Sample Period	Constituents	Series
African National Stock Price Indices:					
Botswana	Iffmbol/Botswana	DataStream	1995-2008		3222
Egypt	Iffmegl/Egypt	DataStream	1997-2008		2937
Ghana	Iffghal/Ghana	DataStream	1995-2008		3222
M Kenya	Iffkenl/Ghana	DataStream	1995-2008		3222
Mauritius	Iffmaul/Mauritius	DataStream	1995-2008		3222
Morocco	Ifgmmol/Morocco	DataStream	1997-2008		2941
Nigeria	Ifgmngl/Nigeria	DataStream	1984-2008		8960
Tunisia	Ifftunl/Tunisia	DataStream	1995-2008		3222

Source: DataStream

Table 1: Some 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	Turnover ratio %	%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	2.9	40.6	12,313	44.2
Cote D'Ivoire	1973	38	-5.0	8,305.2	99.9	171.6	60.3	2.1	77.1	15,598	53.2
Egypt	1888	435	-26.9	139,273.8	49.0	60,196.4	25.2	43.2	51.3	127,930	108.9
Ghana	1989	32	0.0	13,710.1	38.1	836.3	181.7	6.1	31.8	14,863	92.2
Kenya	1954	54	3.8	13,344.6	17.3	1,389.0	1.8	10.4	-3.6	29,299	45.5
Malawi	1995	12	50.0	1,260.0	39.2	9.8	226.7	0.8	120.8	3,538	35.6
Mauritius	1988	91	44.4	7,919.1	59.7	413.5	94.9	5.2	53.8	6,959	113.8
Morocco	1929	73	15.9	75,494.5	52.9	23,172.0	135.0	30.7	33.9	73,429	102.8
Mozambique	1999	13	30.0	242.3	65.4	34.0	-12.6	14.0	12.0	7,559	3.2
Namibia	1992	27	-3.6	1,590.0[a]	10.0	14.3	69.5	0.9	12.2	7,400	21.5
Nigeria	1960	212	5.0	87,370.8	166.1	17,671.1	385.7	20.2	74.7	166,778	52.4
South Africa	1887	411	5.7	828,185.3	16.4	423,731.8	36.2	51.2	16.1	282,630	293.0
Swaziland	1990	06	0.0	234.3	18.3	3.5	5710.9	1.5	15.0	2,936	8.0
Tanzania	1996	10	0.0	2,786.3	59.9	8.1	21.8	0.3	28.2	16,184	48.1
Tunisia	1969	51	6.3	10,830.0	18.8	3,833.6	48.9	35.4	17.3	35,010	30.9
Uganda	1997	09	12.5	3,160.0	32.2	451.2	566.1	14.3	29.9	12,227	25.8
Zambia	1993	16	6.7	4,827.0	34.0	74.8	254.1	1.5	125.0	11,156	43.3
Zimbabwe	1896	79	-1.3	n/a	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	28.9	n/a	543,820	69.1
Average(ex South Africa)		70	n/a	23,487.1	n/a	6,777.4	n/a	28.9	47.2	31,989	78.3
Brazil/Sao Paulo	1890	404	15.4	1,369,711.3	92.8	597,995.3	116.5	4.3	43.7	1,313,590	104.3
China/Shanghai	1990	860	2.1	3,694,348.0	302.7	4,069,485.1	452.7	110.2	96.7	3,250,827	113.6
Hong Kong	1891	1,241	5.8	2,654,416.1	54.8	2,136,910.2	156.7	80.5	38.3	206,707	1284.1
India/BSE	1875	4,887	1.9	1,819,100.5	122.1	343,775.8	60.3	18.9	47.1	1,098,945	165.6
Malaysia/KLSE	1930	986	-3.8	325,290.3	38.1	169,722.8	125.7	52.2	31.8	186,482	174.4
UK/LSE	1698	3,307	1.5	3,851,705.9	1.5	10,333,685.9	36.5	268.3	2.0	2,772,570	138.9
US/NYSE	1792	2,297	-0.8	15,650,832.5	1.5	29,909,993.0	37.3	191.1	6.6	13,843,825	113.1
WFEs Total		46,509	2.9	60,874,399.3	19.9	101,189,135.2	44.5	166.2	n/a	54,311,608	112.1

Sources: World Federation of Exchanges Website, ASEA Website, Websites of All Exchanges, GDP from IMF, [a]Excludes Blue-chips from South Africa

Table 2: 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 Standard
Cote D'Ivoire	5	4.00	Electronic	Yes	n/a	No	T+5	Local Standard
Egypt	5	4.00	Electronic	Yes	Member	No	T+2[a]	Intl. Standard
Ghana	5	2.00	Manual	Yes	Correspondent	No	T+3	Intl. Standard
Kenya	5	2.00	Electronic	Yes	Correspondent	No	T+3	Intl. Standard
Malawi	5	3.00	Manual	Yes	Correspondent	No	T+7	Intl. Standard
Mauritius	5	2.50	Electronic	Yes	Member	No	T+3	Intl. Standard
Morocco	5	4.00	Electronic	Yes	Affiliate	No	T+3	Intl. Standard
Mozambique	n/a	n/a	Electronic	Yes	n/a	No	T+3	Local Standard
Namibia	5	8.00	Electronic	Yes	Affiliate	No	T+3	Local Standard
Nigeria	5	2.00	Electronic	Yes	Affiliate	No	T+3	Intl. Standard
South Africa	5	8.00	Electronic	Yes	Member	Yes	T+3	Intl. Standard
Swaziland	5	2.00	Manual	Yes	n/a	No	T+5	Intl. Standard
Tanzania	5	2.00	Electronic	Yes	n/a	No	T+5[b]	Intl. Standard
Tunisia	5	2.67	Electronic	Yes	n/a	No	T+3	Local Standard
Uganda	5	2.00	Manual	Yes	Correspondent	No	T+5	Intl. Standard
Zambia	5	2.00	Electronic	Yes	n/a	No	T+3	Local Standard
Zimbabwe	5	4.00	Manual	Yes	n/a	No	T+7	Intl. Standard
Other Markets								
Brazil	5	7.25	Electronic	Yes	Member	Yes	T+0	Intl. Standard
China	5	5.75	Electronic	Yes	Member	Yes	T+1[c]	Intl. Standard
Hong Kong	5	6.00	Electronic	Yes	Member	Yes	T+2	Intl. Standard
India	5	7.00	Electronic	Yes	Member	Yes	T+1	Intl. Standard
Malaysia	5	8.00	Electronic	Yes	Member	Yes	T+3	Intl. Standard
UK	5	9.50	Electronic	Yes	Member	Yes	T+0	Intl. Standard
US	5	6.50	Electronic	Yes	Member	Yes	T+0	Local Standard

Sources: World Federation of Exchanges (WFEs), African Securities Exchanges Association (ASEA), UNDP African Stock Markets Handbook, 2003, MSCI/S&P/IFC/FTSE Stock Markets Classifications, 2007, Websites of All Exchanges, [a]T+1 for Government bonds & T+0 for intra-day trading securities, [b]T+3 for bonds, [c]T+3 for B Shares.

Table 3: Correlation Matrix between the Africa All Share Index Excluding South Africa and Other Global Equity Indices

	Africa Share	Asia Index	Emerging Markets	Far East Index	G7 Countries	Latin America	South Africa	World Index	World Small Companies
Africa (ex S. Africa)	1								
Asia Index	-.09	1							
Emerging Markets	-.07	.88	1						
Far East Index	-.10	.99	.86	1					
G7 Countries	.12	.18	.43	.17	1				
Latin America	-.14	.06	.44	.05	.57	1			
South Africa	.03	.42	.58	.40	.22	.07	1		
World Index	.14	.21	.46	.20	.99	.57	.24	1	
World Small Co.	.14	.22	.46	.21	.90	.46	.28	.90	1

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

***Table 4*: Descriptive Statistics and Diagnostics of Daily Stock Price Indices Returns**

Indices	Mean	Std. Dev.	Skewness	Kurtosis	K-S[1]	A-D[1]	N[1]
Panel A: African Sectoral Stock Price Indices							
Aatei	0.00022	0.19212	0.01	4.20	0.07*	33.11***	2379
Abi	0.00062	0.00854	0.73	13.94	0.06*	23.28***	2379
Acgfbi	0.00047	0.01076	0.16	3.72	0.06*	23.27***	2379
Aci	0.00023	0.01335	-0.03	3.72	0.07*	23.14***	2379
Adci	0.00035	0.01334	0.13	3.08	0.08*	29.35***	2379
Afsi	0.00021	0.02027	-0.72	539.98	0.18**	195.26***	2379
Amai	-0.00016	0.01335	-0.48	10.71	0.11**	67.70***	2379
Ami	0.00077	0.02289	2.29	54.07	0.14**	125.68***	2379
Ammi	0.00006	0.01781	-0.26	8.01	0.10**	44.41***	2379
Anri	0.00038	0.01331	0.08	3.17	0.09*	32.67***	2379
Aphi	-0.00002	0.04607	-1.63	480.05	0.29**	475.96***	2379
Aregti	0.00022	0.05580	-0.33	192.89	0.33**	567.61***	2379
Asi	0.00026	0.04863	-0.05	195.30	0.33**	564.85***	2379
Ati	0.00049	0.01588	-0.01	3.37	0.09*	42.31***	2379
Atui	0.00117	0.01991	1.53	20.43	0.06*	17.10***	2379
Panel B: African Size Stock Price Indices							
Alci	0.00050	0.01137	0.02	13.84	0.07*	31.41***	2379
Amci	0.00056	0.00872	-0.02	13.84	0.09*	49.58***	2379
Asci	0.00066	0.00697	3.23	67.14	0.09*	44.41***	2379
Panel C: African Regional Stock Price Indices							
Aasi	0.00053	0.00938	0.09	8.20	0.08*	31.86***	2379
Eai	0.00047	0.00933	-0.29	10.80	0.10**	62.57***	2379
Nai	0.00042	0.01166	-0.01	8.76	0.09*	41.28***	2379
Sai	0.00073	0.01394	-0.01	229.56	0.17**	177.02***	2379
Ssai	0.00082	0.01016	0.07	4.50	0.10**	53.10***	2379
Wai	0.00096	0.01561	0.10	4.20	0.11**	62.39***	2379
Panel D: African National Stock Price Indices							
Botswana	0.00099	0.01234	11.93	284.31	0.50**	1095.88***	3221
Egypt	0.00058	0.01721	4.39	83.25	0.49**	988.31***	2936
Ghana	0.00045	0.01007	5.50	140.39	0.48**	1107.91***	3221
Kenya	0.00056	0.01425	3.89	98.80	0.49**	1085.21***	3221
Mauritius	0.00057	0.01014	2.78	130.15	0.49**	1087.97***	3221
Morocco	0.00050	0.01107	2.62	93.94	0.49**	990.41***	2940
Nigeria	0.00018	0.08109	-86.21	7862.27	0.43**	3039.16***	8959
Tunisia	0.00007	0.00094	2.71	168.72	0.47**	1091.43***	3221

[1]Notes: *A-D* and *K-S* represent Anderson-Darling and Kolmogorov-Smirnov goodness-of-fit absolute values with ***, **, and * means that the log-normality assumption is rejected at the 1%, 5%, and 10% levels, respectively. 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.

***Tables 5*: Variance Ratios Tests Results for African Regional Stock Price Indices**

Period	M_1	M_2	R_1	R_2	S_1	S_2
Africa-All Share (Excluding South Africa)						
k=15	0.19	0.14	2.39**	1.24	1.93*	2.45**
k=20	0.62	0.47	2.82***	1.67*	2.30**	3.01***
k=25	1.05	0.81	3.30***	2.12**	2.85***	3.73***
k=30	1.58	1.23	3.84***	2.65***	3.29***	4.36***
Eastern-Africa						
k=15	2.85***	1.84*	10.64***	8.71***	8.18***	8.65***
k=20	3.26***	2.19**	11.11***	9.09***	8.63***	9.31***
k=25	3.52***	2.43**	11.46***	9.37***	9.01***	9.65***
k=30	3.68***	2.60***	11.45***	9.60***	9.37***	9.97***
Northern-Africa						
k=15	-0.04	-0.03	2.46**	1.32	3.69***	4.16***
k=20	0.27	0.20	2.76***	1.61	3.82***	4.39***
k=25	0.64	0.48	3.22***	2.02**	4.15***	4.82***
k=30	1.16	0.88	3.75***	2.56**	4.46***	5.23***
Southern-Africa						
k=15	-6.24***	-1.20	1.38	0.68	1.02	1.24
k=20	-5.09***	-1.12	2.06**	1.45	1.54	1.67*
k=25	-4.34***	-1.06	2.61***	1.97**	2.05**	2.08**
k=30	-3.83***	-1.02	3.07***	2.34**	2.56**	2.42**
Sub-Sahara-Africa						
k=15	-2.50**	-1.74*	4.02***	1.33	5.06***	4.41***
k=20	-1.60	-1.13	4.63***	2.04**	5.56***	4.78***
k=25	-0.99	-0.72	4.99***	2.49**	5.82***	4.96***
k=30	-0.53	-0.39	5.17***	2.78***	5.99***	5.00***
Western-Africa						
k=15	-2.85***	-1.93*	3.62***	1.12	4.38***	4.89***
k=20	-2.12**	-1.45	3.95***	1.60	4.30***	5.04***
k=25	-1.64*	-1.13	4.09***	1.87*	3.96***	5.03***
k=30	-1.32	-0.92	4.07***	1.95*	3.67***	4.89***

Note: A test statistic with ***, **, and * indicates significance at 1%, 5%, and 10% levels respectively. Figures in columns 2-7 give the values of the test statistics M_1, M_2, R_1, R_2, S_1 and S_2 for each index series. M_1 and M_2 are based on Lo and MacKinlay's (1988) parametric variance-ratio tests while R_1, R_2, S_1 and S_2 are based on Wright's (2000) non-parametric variance-ratio tests. The names in the rows are those of the respective regional stock price indices used.

***Tables 6*: Variance Ratios Tests Results for African Size Stock Price Indices**

Period	M_1	M_2	R_1	R_2	S_1	S_2
Africa-Large companies						
k=15	-0.16	-0.11	1.32	0.41	1.52	1.82*
k=20	0.09	0.06	1.53	0.65	1.64*	2.12**
k=25	0.36	0.26	1.81*	0.93	1.98**	2.72***
k=30	0.77	0.59	2.15**	1.33	2.25**	3.18***
Africa-Medium Companies						
k=15	-2.26**	-0.99	4.29***	2.24**	3.40***	4.85***
k=20	-1.25	-0.60	5.08***	3.04***	4.03***	5.51***
k=25	-0.44	-0.22	5.84***	3.79***	4.64***	6.29***
k=30	0.24	0.14	6.61***	4.49***	5.32***	7.13***
Africa-Small Companies						
k=15	2.92***	2.40**	6.99***	4.90***	6.80***	7.09***
k=20	3.84***	3.08***	7.90***	5.88***	7.75***	7.95***
k=25	4.38***	3.42***	8.47***	6.47***	8.34***	8.41***
k=30	4.87***	3.71***	9.06***	7.06***	8.93***	8.91***

Note: A test statistic with ***, **, and * indicates significance at 1%, 5%, and 10% levels respectively. Figures in columns 2-7 give the values of the test statistics M_1, M_2, R_1, R_2, S_1 and S_2 for each index series. M_1 and M_2 are based on Lo and MacKinlay's (1988) parametric variance-ratio tests while R_1, R_2, S_1 and S_2 are based on Wright's (2000) non-parametric variance-ratio tests. The names in the rows are those of the respective size stock price indices used.

***Tables 7*: Variance Ratios Tests Results for African Sectoral Stock Price Indices**

Period	M_1	M_2	R_1	R_2	S_1	S_2
Panel A: Consumer Goods Sub-sector						
Africa-Automobiles & Transport						
k=15	1.61	1.26	0.53	1.14	-0.32	-0.11
k=20	0.98	0.78	0.20	0.67	-0.51	-0.26
k=25	0.49	0.40	-0.07	0.29	-0.70	-0.42
k=30	0.29	0.24	-0.18	0.12	-0.72	-0.41
Africa-Consumer Goods, Food & Beverages						
k=15	-2.12**	-1.55	0.28	-0.89	0.92	0.78
k=20	-1.75*	-1.29	0.42	-0.67	1.00	0.83
k=25	-1.39	-1.03	0.63	-0.39	0.84	0.77
k=30	-1.02	-0.76	0.85	-0.10	0.85	0.86
Africa-Pharmaceuticals & Health						
k=15	-3.41***	-1.03	1.36	0.73	0.91	1.42
k=20	-2.91***	-0.99	1.76*	1.24	1.17	1.71*
k=25	-2.84***	-1.06	2.05**	1.50	1.48	1.96**
k=30	-2.77***	-1.10	2.37**	1.81*	1.76*	2.23**
Panel B: Financials Sub-sector						
Africa-Financial Services (Excluding Banks)						
k=15	-7.45***	-1.03	0.86	-0.04	0.81	0.83
k=20	-6.43***	-1.02	1.07	0.21	0.80	0.74
k=25	-5.67***	-1.00	1.35	0.55	0.88	0.83
k=30	-5.10***	-0.98	1.56	0.80	0.93	0.90
Africa-Banks						
k=15	0.07	0.06	2.37**	0.93	2.82**	4.00***
k=20	0.58	0.47	3.15***	1.64*	3.40***	4.57***
k=25	1.06	0.86	3.71***	2.20**	3.80***	5.04***
k=30	1.65*	1.34	4.32***	2.82***	4.13***	5.53***
Panel C: Industrials Sub-sector						
Africa-Chemicals						
k=15	-0.31	-0.25	-0.20	-0.09	-0.36	-0.19
k=20	-0.29	-0.24	-0.17	-0.09	-0.17	-0.08
k=25	-0.24	-0.20	-0.13	-0.08	-0.12	-0.06
k=30	-0.04	-0.03	0.03	-0.12	-0.04	-0.02
Africa-Diversified Conglomerates						
k=15	-2.10**	-1.60	-0.53	-1.36	0.61	1.14
k=20	-1.98**	-1.53	-0.25	-1.18	1.08	1.67*
k=25	-1.77*	-1.38	-0.11	-1.02	1.31	1.93*
k=30	-1.50	-1.18	0.04	-0.84	1.55	2.19**
Africa- Manufacturing						
k=15	-2.54**	-1.83	0.40	-0.52	1.97**	1.18
k=20	-1.70*	-1.23	0.77	0.03	2.36**	1.35
k=25	-1.07	-0.78	1.08	0.46	2.64***	1.56
k=30	-0.58	-0.43	1.39	0.86	2.89***	1.73*

Continuation: Table 7

Panel D: Natural Resources Sub-sector						
Africa-Natural Resources						
k=15	-1.19	-0.86	0.45	-0.41	0.88	1.97**
k=20	-0.79	-0.57	0.65	-0.10	0.88	1.87*
k=25	-0.60	-0.44	0.69	0.00	0.79	1.82*
k=30	-0.38	-0.28	0.76	0.14	0.69	1.76*
Africa-Mining & Metals						
k=15	0.18	0.16	-0.39	-0.13	-0.11	-0.47
k=20	-0.00	-0.00	-0.29	-0.15	0.07	-0.26
k=25	0.04	0.04	-0.12	-0.01	0.19	-0.10
k=30	0.26	0.25	0.22	0.31	0.47	0.20
Panel E: Services Sub-sector						
Africa-Service						
k=15	-9.49***	-1.09	-0.55	-1.48	-0.51	-0.66
k=20	-8.24***	-0.99	-0.22	-1.12	-0.29	-0.42
k=25	-7.42***	-0.94	0.07	-0.81	-0.08	-0.18
k=30	-6.81***	-0.90	0.29	-0.55	0.09	0.02
Africa-Media						
k=15	1.13	0.78	1.78*	2.07**	1.32	4.90***
k=20	1.23	0.89	1.62	1.95*	1.40	5.54***
k=25	1.16	0.84	1.45	1.81*	1.46	6.21***
k=30	0.96	0.68	1.32	1.64*	1.52	6.76***
Africa-Retail & General Trade						
k=15	-9.33***	-1.10	-1.49	-2.55**	0.22	0.46
k=20	-8.09***	-1.00	-0.93	-1.95*	0.57	0.83
k=25	-7.29***	-0.94	-0.48	-1.43	0.79	1.05
k=30	-6.69***	-0.91	-0.07	-0.97	1.12	1.39
Panel F: Utilities Sub-sector						
Africa-Telecoms & Utilities						
k=15	4.24***	3.49***	5.31***	5.55***	3.07***	1.64*
k=20	3.86***	3.18***	5.38***	5.40***	3.44***	1.90*
k=25	3.28***	2.70***	4.98***	4.86***	3.59***	1.86*
k=30	3.17***	2.61***	4.86***	4.74***	3.77***	1.95*
Africa-Transportation						
k=15	-1.70*	-1.27	-0.78	-1.19	-0.37	0.03
k=20	-1.40	-1.05	-0.70	-1.01	-0.30	0.17
k=25	-1.05	-0.80	-0.45	-0.72	-0.01	0.46
k=30	-0.76	-0.58	-0.19	-0.46	0.28	0.68

Note: A test statistic with ***, **, and * indicates significance at 1%, 5%, and 10% levels respectively. Figures in columns 2-7 give the values of the test statistics M_1, M_2, R_1, R_2, S_1 and S_2 for each index series. M_1 and M_2 are based on Lo and MacKinlay's (1988) parametric variance-ratio tests while R_1, R_2, S_1 and S_2 are based on Wright's (2000) non-parametric variance-ratio tests. The names in the rows are those of the respective sectoral stock price indices used

***Tables 8*: Variance-Ratios Tests Results for a Sample of Individual African National Stock Price Indices**

Period	M_1	M_2	R_1	R_2	S_1	S_2
Botswana						
k=15	-1.53	-13.15***	134.09***	112.24***	161.42***	162.77***
k=20	-1.73*	-14.93***	155.13***	129.74***	186.90***	188.46***
k=25	-0.83	-2.30**	173.72***	145.34***	209.45***	211.16***
k=30	-0.04	-0.05	190.40***	159.35***	229.72***	231.57***
Egypt						
k=15	0.41	0.66	140.19***	119.59***	159.22***	160.41***
k=20	0.32	0.57	161.87***	137.88***	184.34***	185.72***
k=25	0.41	0.72	181.00***	154.12***	206.50***	208.01***
k=30	0.77	1.21	198.07***	168.59***	226.41***	228.05***
Ghana						
k=15	0.32	0.62	142.34***	121.60***	162.22***	164.31***
k=20	0.20	0.43	164.57***	140.42***	187.84***	190.27***
k=25	0.92	1.86*	184.20***	157.21***	210.51***	213.19***
k=30	1.74*	2.74***	201.81***	172.28***	230.91***	233.83***
Kenya						
k=15	-0.58	-3.24***	144.28***	122.06***	166.01***	167.09***
k=20	-2.59	-3.62***	166.85***	141.04***	192.24***	193.50***
k=25	-0.09	-0.35	186.51***	157.58***	215.33***	216.72***
k=30	-0.34	0.83	204.11***	172.38***	236.05***	237.56***
Mauritius						
k=15	-0.54	-6.10***	138.01***	117.21***	163.01***	164.56***
k=20	-0.64	-7.36***	159.49***	135.34***	188.75***	190.56**
k=25	-0.26	-0.96	178.36***	151.29***	211.49***	213.47***
k=30	0.18	0.39	195.26***	165.60***	231.92***	231.92**
Morocco						
k=15	-0.38	-5.65***	136.44***	113.17***	156.99***	158.37***
k=20	-0.44	-6.64***	157.44***	130.81***	181.74***	183.34***
k=25	-0.13	-0.52	176.59***	146.52***	203.61***	205.38***
k=30	0.03	0.07	193.30***	160.36***	223.21***	225.13***
Nigeria						
k=15	0.07	0.30	15.23***	7.89***	161.39***	164.95***
k=20	0.07	0.29	18.10***	9.52***	187.14***	191.26***
k=25	0.03	0.11	20.79***	11.51***	210.15***	214.74***
k=30	0.04	0.19	23.12***	13.13***	230.89***	235.89***
Tunisia						
k=15	0.10	0.29	142.38***	121.42***	167.89***	167.89***
k=20	0.08	0.27	164.56***	140.18***	194.41***	194.41***
k=25	0.57	1.50	183.97***	156.61***	217.75***	217.75***
k=30	0.96	1.76*	201.24***	171.17***	238.73***	238.73***

Note: A test statistic with ***, **, and * indicates significance at 1%, 5%, and 10% levels respectively. Figures in columns 2-7 give the values of the test statistics M_1, M_2, R_1, R_2, S_1 and S_2 for each index series. M_1 and M_2 are based on Lo and MacKinlay's (1988) parametric variance-ratio tests while R_1, R_2, S_1 and S_2 are based on Wright's (2000)

non-parametric variance-ratio tests. The names in the rows are those of the respective African national stock price indices used.