Can emerging African Stock Markets improve their informational efficiency by formally harmonising and integrating their operations?

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Can Emerging African Stock Markets Improve their Informational Efficiency by Formally Harmonising and Integrating their Operations?

By

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Abstract

Despite experiencing rapid growth in their number and size, African stock markets remain highly segmented, small, illiquid and technologically bankrupt, severely affecting their informational efficiency. On this basis, with specific focus on the weak-form of the efficient markets hypothesis, we attempt to empirically ascertain whether African stock markets can improve their informational efficiency by formally harmonising and integrating their operations using a new robust non-parametric variance-ratios test in addition to its parametric alternative. On average, we find that irrespective of the diagnostic used, all the 24 African continent-wide indices applied returns' display better normal distribution properties than those of the 8 individual national stock price indices examined. 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 used irrespective of the test statistic applied. The potential improvement in efficiency to be gained is much higher in economic sectors indices than in size and regional indices. Finally, consistent with prior evidence, (eg., Wright, 2000; Belaire-Franch and Opong, 2005, Ntim, *et al*., 2007), the results of the Lo and MacKinlay (1988) parametric variance-ratios test are ambiguous. By contrast, the ranks and signs alternative offer consistent results throughout.

Keywords: African stock markets, Integration, Efficiency, Variance-ratios, Ranks and signs

Article type: Research paper

1. Introduction

Over the last three decades, there have been a spectacular increase in the number and size of stock markets in emerging Africa. With only 8 active stock markets in 1980, the number of stocks listed on the various African Stock Exchanges have increased to 18 by the end of 2002 (e.g., UNDP, 2003). Currently, there are 26 formal stock markets in Africa, and with new markets proposed to be opened in Congo D.R., Equatorial Guinea, Ethiopia, the Gambia, Lesotho, Madagascar, Mauritania and Sierra Leone (e.g. Moin, 2007; Databank Group, 2008), it is anticipated that more than 64% of the 53 African countries will have formal capital markets by the end of this decade. This phenomenal growth in stock exchanges in Africa can be attributed to the extensive financial sector reforms undertaken by African countries (e.g., Kenny and Moss, 1998). It has been suggested that stock markets promote economic growth. For example, Schumpeter (1911), McKinnon (1973), Shaw (1973), Levine and Zervos (1996), Levine (1997), among others, argue that well-developed capital markets promote higher economic growth through their ability to attract international investments, mobilise domestic savings, provide liquidity, and hence, facilitate efficient allocation of scarce economic resources.

However, despite the rapid development, with the exception of South Africa, stock markets in Africa not only remain uniquely and comparatively different from their developed counterparts, but also pale in comparison to other emerging markets. Firstly, they are small in size. The total value of African stocks outside of South Africa was only 0.62% of world stock market capitalisation, and 1.55% of all emerging markets stocks at the end of 2007, (WFEs, 2008). Similarly, African markets excluding South Africa

accounted for only 2.5% of the total global equity listings in contrast to 10.51% by India for instance alone (WFEs, 2008). Secondly, the stock markets are also small in relation to their own economies. Market capitalisation in Mozambique is only 3.2% of nominal GDP, while Nigeria, Uganda and Tunisia's capitalisations are between 25-52% (WFEs, 2008). These figures are not only much less than developed markets such as Hong Kong (1284.1%), UK (138.9%), US (113.1%), but also other emerging markets in Asia and Latin America like Malaysia (174.4%), India (165.6%) and Brazil (104.3%) (WFEs, 2008). Thirdly, their small size makes them vulnerable to speculation and manipulation (e.g., Magnusson and Wydick, 2002), by insiders at the expense of other investors. More critically, they remain extremely illiquid, thinly traded and less sophisticated, severely affecting their informational efficiencies (e.g., Mlambo and Npieke, 2005). Yet, their ability to effectively perform the above listed roles, which is expected to bolster up economic growth (e.g., Levine, 1997), depends heavily on their level of allocative, operational, and in particular informational efficiency (e.g., Smith *et al*., 2002).

This raises a crucial lingering policy question: Can emerging African stock markets improve their informational efficiency by formally harmonising and integrating their operations?

A priori expectation is that a formal harmonisation and integration of operations of emerging African stock markets may help in overcoming many of the current information challenges facing them (e.g., Irving, 2005; Okealaham, 2005). Firstly, it has been argued that (e.g., Lugangwa, 2006), integration will increase their visibility through a significant improvement in size. Secondly, Fish and Biekpe (2002) suggest, for example, that regional integration will create expansion in trading volumes through economies of scale,

which may deliver the required liquidity, thereby, creating the enabling environment for companies to raise funding at a cheaper cost. Thirdly, Irving (2005) indicates that regional cooperation and integration of Eastern and Southern African stock exchanges, for example, will offer greater financial deepening and maximise investor choice as more financial products and services could be made available than before. Fourthly, we argue that a larger stock market with robust regulatory, monitoring and enforcement framework would be less vulnerable to speculation and manipulation by insiders, which may gain the needed credibility and confidence of local and international investors. Fifthly, better communicational and technological infrastructure will reduce operational costs; improve the flow of information and overall market efficiency. Admittedly, while the idea of forming regional Pan-African Markets or even a grand Pan-African stock market led to its formation, and continues to be the main agenda of the African Securities Exchanges Association (ASEA) for almost two decades (e.g., Irving, 2000, 2005; Smith, 2003; SADC, 2007), they have so far paid a lip-service to its implementation despite having explicitly acknowledged the potential benefits of integration (e.g., Lugangwa, 2006).

Given its policy imperative, we address the above question with particular focus on the weak-form market efficiency of the efficient markets hypothesis (EMH). The EMH posits that financial asset prices traded in a market that is informationally efficient in the weak-form cannot be predicted by using information contained in the sequence of past prices (e.g., Fama 1965, 1970, 1991). The statistical implication of this assertion is that financial asset prices series either follow a random walk or a martingale sequence difference. 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 a financial asset can be modelled using information implicit in historical prices, then, it presents investors, for example, with a unique economic opportunity of identifying market inefficiencies that offer exploitable patterns in the asset's returns. A greater economic implication, however, is that financial assets are not appropriately priced at their equilibrium values, and that there may be distortions in the pricing of capital with serious ramifications for the allocation of capital within an economy.

On average, the pre-1980 efficiency evidence mainly from the mature markets of UK-US context, applying conventional techniques such as autocorrelation (e.g., Cowles, 1933; Working, 1934; Kendal1, 1953; Fama, 1965, 1970), failed to reject the weak-form hypothesis. By contrast, post-1980 studies, making use of plethora of advanced and sophisticated methods like variance-ratios, ARCH and GARCH, among others, to re-examine previous evidence (e.g., Summers, 1986; Lo and MacKinlay, 1988; Belaire-Franch and Opong, 2005; Lovatt *et al*., 2008), have rejected the random walks in stock prices of these same developed markets. An empirical consensus that has emerged is that recently developed sophisticated models are more powerful in detecting serial-dependence in financial asset prices than conventional ones.

However, while the efficiency of the major emerging markets of Latin America, Eastern Europe, and Asia have been the major focus of researchers in the past (e.g., Ayadi and Pyun, 1994; Claessens et al., 1995; Urrutia, 1995; Field *et al*., 2005), the weak-form hypothesis has received little attention from researchers in Africa, with none of the few existing studies attempting to provide a continent-wide analysis. Of a crucial note is that the few prior studies also offer contradictory results (e.g. Parkinson, 1984;

Dickinson and Muragu, 1994). Apart from the general mixed evidence, a significant issue is that most of the extant studies are conducted through the use of conventional techniques such as autocorrelation tests, whose robustness have been questioned elsewhere (e.g., Savit, 1988, Hsieh, 1991). But, with 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 equity markets (e.g., Moin, 2007). While this indicates that African equity markets outside of South Africa are yet to formally integrate into the competitive global financial market place on the one hand, on the other hand, it offers significant portfolio diversification opportunities for international investors. Current research (e.g., MSCI/ABRI, 2007) shows, for example, that the recent sub-prime crisis in global equity markets has had a minimal impact on emerging African markets excluding South Africa.

Acknowledging the developmental implications of market efficiency with specific focus on the weak-form hypothesis, this study attempts to ascertain whether emerging African stock markets can improve their informational efficiencies by harmonizing and integrating their market operations. By so doing, we make significant contributions to the extant literature. Firstly, we make use of specially constructed size, sectoral and regional African stock price composite indices, which capture the average performance of all stock exchanges 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

weak-form market efficiency evidence while allowing us to also address a crucial lingering policy issue which has been, and continues to be on the Agenda of the African Securities Exchanges Association (ASEA) with serious developmental implications for Africa. 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. Thirdly, we follow an empirically robust Wright's (2000) non-parametric variance-ratios test in addition to its Lo and MacKinlay (1988) parametric alternative. In this case, we add to a very small, but a growing African weak-form market efficiency studies (e.g., Smith *et al*., 2002; Appiah-Kusi and Menya, 2003; Jefferis and Smith, 2005; Ntim *et al*., 2007), that make use of empirically advanced and robust methodology. Fourthly, we extend the existing African weak-form evidence by using recently available national as well as continent-wide constricted size, sectoral and regional data. Finally, unlike existing studies, we unambiguously investigate the strict random walk (RW), and the relaxed martingale difference sequence (MDS) hypotheses of the weak-form market efficiency. 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 so mainly because of the difficulty of obtaining data of sufficient frequency and duration for any meaningful empirical analysis. Samuels and Yacout (1981) and Parkinson (1984) are among the pioneers to examine the weak-form efficiency in

Africa using autocorrelation test, 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 price series of 21 listed Nigerian firms from 1977 to 1979, that of Parkinson reject it in monthly price series of 30 listed Kenyan firms from 1974 to 1978. Dickinson and Muragu (1994) studied the weekly stock price behaviour of 30 listed companies on the Nairobi Stock Exchange from 1979 to 1988. Their results rejected previous evidence (e.g., Parkinson, 1984), that Kenyan listed equities are not weak-form efficient.

By contrast, Magnusson and Wydick (2002) use a partial-autocorrelation test to examine monthly price behaviour of eight African stock markets indices, 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. Smith *et al*. (2002) and Jefferis and Smith (2005) have also investigated the price 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 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 all the examined markets except South Africa.

Appiah-Kusi and Menya (2003) use EGARCH-M model to investigate the weak-form efficiency in weekly price series of eleven African stock market 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 equity markets in the late 1990s. Similarly, while the prior African weak-form evidence is so far mixed, with few recent exceptions, application of conventional techniques like autocorrelation, runs, and unit root tests remains a central feature. The main problem with conventional methods, however, is that by contemporaneously assuming linearity in stock returns, they will lack power (e.g., Savit, 1988), in the face a nonlinear stock return behaviour, which recent evidence (e.g., Jefferis and Smith, 2005; Ntim, *et al*., 2007) amply demonstrates that African equity returns are non-normal. It has been argued, however, that (e.g., Lo and MacKinlay, 1988; Fama, 1991), any rejection or acceptance of the EMH will have limited implications unless it is based on a well-specified model. More importantly, with African equity markets astronomically increasing, a crucial policy question, which has been on the agenda of policy-makers, is whether African stock markets can rather improve their informational efficiency by harmonizing and integrating their operations. For apparent lack of data, however, none of the existing studies has addressed such a significant policy question. Further, we argue that the availability of

new robust empirical methods offers new opportunities for empirical re-examination of previous weak-form evidence in both developed and emerging markets alike.

The current paper differs from existing studies in several ways. Firstly, we offer a timely empirical response to a crucial policy issue of whether Africa stock markets can improve their informational efficiency by harmonizing and integrating their operations by using uniquely constructed size, sectoral and regional African stock price composite indices, which capture the average performance of all stock exchanges in Africa excluding South Africa. Secondly, with evidence of non-normality and volatility clustering in African equity returns increasing (e.g., Appiah-Kusi and Menya, 2003; Jefferis and Smith, 2005; Ntim, *et al*., 2007), we apply empirically robust Wright (2000) non-parametric variance-ratios test in addition to its Lo and MacKinlay (1988) parametric alternative to analyse the efficiency of some national and African continent-wide constructed stock price indices. Thirdly, 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. Finally, we provide a comprehensive description of the context and institutional characteristics of African equity markets as well as offer a further five-tier classification of African equity markets. Next, we provide an overview of African Stock Markets.

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 by 1980, the number of African markets increased significantly to 18 by the end of 2002 (e.g., UNDP, 2003), and is currently 26 (e.g., Moin, 2007). As a corollary, African stock markets vary

substantially in statistical, institutional and market infrastructural characteristics. Smith *et al*. (2002) offer a four-tier classification of African equity markets. With recent increase in their number, however, we extend their four-tier classification to a five-tier classification to reflect current developments. These are:

1. South Africa – the most infrastructurally sophisticated, the largest as well as the oldest stock market in Africa.
2. A group of medium-size markets consisting of Egypt, Kenya, Nigeria, Morocco, Tunisia and Zimbabwe, which have been in existence for relatively longer time.
3. Botswana, Cote D'Ivoire, Ghana, Namibia and Mauritius forming a group of new, small, but rapidly growing markets.
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 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).

Take in Table 1 Here

Table 1 provides development statistics of African stock markets as at the end of 2007. For comparative purposes, they are immediately related to four more-established

emerging markets (Brazil, China, India and Malaysia), and three developed markets (Hong Kong, UK and US). As table 1 shows, with the exceptions of South Africa, the medium-size markets, and Cote D'Ivoire, no African market is more than 20 years old. By contrast, the UK market is over 300 years old while the Indian and Brazilian markets are more than 100 years old each. It also shows that African stock markets are relatively small both in terms of the number of listed firms and market capitalisation. Barring South Africa, Egypt, and Nigeria, no market has more than 100 listed firms, in sharp contrast to India (4,887) and UK (3,307). The total continental market capitalisation excluding South Africa is $375,793.0m with an average capitalisation of $25,039.6m. This does not only constitute a paltry 0.16% of US market capitalisation, but also form a mere 0.68%, 1.8% and 7.7% of China, Brazil and Malaysia's capitalisations respectively. It is also evident that African stock markets suffer acutely from low liquidity. It ranges from as low as 0.3% for Tanzania to 51.2% for South Africa with an average excluding South Africa of 28.9%. This does not also pale in comparison with the liquidity of developed markets such as UK (268.3%), and US (191.1%), but also significantly lower than other emerging markets like China (110.2%) and Malaysia (52.2%).

Take in Table 2 Here

Table 2 presents institutional, operational and infrastructural development characteristics of African stock markets in comparison with three developed markets and 4 other mainstream emerging markets as at the end of 2007. With Ghana and Botswana scheduled to launch their electronic trading platforms by June 2008, most of the African markets will have electronic trading systems, making them consistent with international standards. The difference though is that with the exceptions of Nigeria (1999) and South

Africa (1996), automated trading has been in operation in most of the markets for less than two-years, which will take time for their full benefits to be reaped. In line with international trends, almost all the 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. This is also explained by the fact that most of them have recently installed electronic trading systems.

On the other hand, while all the African markets trade for 5-days, trading hours are relatively short with average trading hours of 2.92-hours. Only Namibia and South Africa trade for more than 4-hours. In contrast, Brazil, Malaysia and 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. The small number of listed firms also explains why most of the African markets have smaller number of registered stock brokerage firms in comparison with their developed and emerging counterparts. The average number of registered brokerage firms is 19 with 5 markets having less than 4 registered brokerage firms. This is far less than UK with 1,650, US with 1,366 and India with 874 registered brokerage firms. Barring South Africa, no African market has developed stock indices, on which financial derivatives are traded, a trend which is inconsistent with global developments. Again, with the exception of South Africa, Egypt, and Morocco, the markets have poor international recognition. Most of the 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. Egypt, Mauritius, Morocco and South Africa are the only markets included in the FTSE emerging markets composite index. Even the more inclusive and popular MSCI and S&P/IFC emerging markets composite indices currently include only 12 out of the 26 formal African markets, majority of whom are also classified as frontier markets.

Take in Table 3 Here

Despite their operational, institutional and infrastructural weaknesses, however, African markets are still seen as major anchors of economic growth and development. 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. While this confirms their frontier market status, they present significant diversification opportunities especially for international investors. Further, 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 does not only compares favourably against those of developed markets like UK (2.0%), US (6.6%), but also other emerging markets like Malaysia (31.8%) and Brazil (43.7%).

Given their future potentials, but the current informational bottlenecks facing them, arising mainly from their segmented existence, we attempt to ascertain whether emerging African markets can improve their informational efficiency by harmonising and

integrating their operations. This is because while they are expected to foster economic growth through efficient pricing and allocation of capital and risk, the extent to which they succeed depends on their levels of informational efficiency.

3. Data and Research Methodology

3.1 *Data*

Two types of datasets[1] are used for the weak-form efficiency test. 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. 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. Sectoral/Economic Sectors Indices: *consumer goods sub-sector* includes automobiles & transport, consumer goods, food & beverages, and pharmaceuticals & health; *financials sub-sector* includes banks, and financial services excluding banks; *industrials sub-sector* includes chemicals, diversified conglomerates, and manufacturing; *natural resources sub-sector* includes natural resources, and mining & metals; *services sub-sector* includes services, media, and retail & general trade; and *utilities sub-sector* 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, acronym/codes, sources, sample period and total number of 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 a strict gaussian-random variable. This means that future price changes cannot be forecasted 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; $P_t = \mu + P_{t-1} + \varepsilon_t, \quad \varepsilon_t \sim IDD\ N(0, \partial^2)$, where (P_t) refers to the log of the asset's return series under consideration, (i.e., the African stock market indices returns) at time (day) *t*; μ is an arbitrary drift parameter; $IID(0, \partial^2)$ means that the residual term (ε_t) 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 market 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, and, 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*. Let (p_t) denote a time series consisting of T observations p_1 , p_2 ,…, 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 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 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 also computed as follows: $\partial^2(1) = \frac{1}{T}\sum_{t=1}^{T}(p_t - \hat{\mu})^2$. 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:

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

Unlike the M_1, LM (1988) demonstrate that 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 also defined as: $\phi^*(k) = \sum_{j=1}^{k-1}\left[\frac{2(k-j)}{k}\right]^2 \delta(j)$ 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 and better specified (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 $p_1, p_2, \ldots, p_T$. 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 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:

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

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

where $\phi(k)$ is defined in (3). Wright (2000) argues that under the assumption that the rank $r(p_t)$ is a random permutation of the numbers 1,2,...,T, in which each has equal probability, provides the distribution of the test statistics. 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, S_1 and S_2 of returns rather than ranks is given by:

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

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

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

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

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.

Take in Table 4 Here

The table shows that daily mean returns for all the 32 series examined are close to zero. Except the manufacturing (Amai) and pharmaceuticals & health (aphei) sub-sectors in Panel A, all display positive mean returns behaviour. The standard deviation, a measure of financial asset return volatility, is relatively small for all the 32 analysed series.

Take in figure 1 Here

Figure 1 captures the time series trends in the Africa All-Share index (Aasi) over the period of interest. It offers further evidence of a mild volatility clustering in the Aasi's returns. For symmetry, the standard normal distribution should have zero skewness. For automobiles & transport (Aatei), chemicals (Aci), natural resources (Anri), Services (Asi) and transportation (Ati) sub-sectors in Panel A, symmetry cannot be rejected. Also, apart from the small company (Asci) in Panel B, and the eastern- (Eai) and western-Africa (Wai) in Panel C, all African continent-wide series are close to symmetry. 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 value of 3 cannot be accepted at any reasonable significance level for all 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 cannot be rejected at the 0.01 and 0.05 conventional levels for 13 out of 24 African sectoral, size, and regional series in Panels A, B and C respectively. The null is rather 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 significant improvement over 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 period of k = 15, 20, 25 and 30 for each of the six series. Columns 2 to 7 report the test statistics of 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 (RW) while M_2 reports similar critical values under the hetereoscedasticity (MDS) hypothesis. The evidence from M_1 suggests that the RW is accepted for the Africa-All-Share and Northern-Africa series at any probability level for all intervals of k. By contrast, the RW is rejected at the 0.01 level for Eastern- and Southern-Africa at all levels of k. For Sub-Sahara-Africa, the RW is only rejected when k = 15 whilst it can only be accepted for Western-Africa, when k = 30. The results obtained by implementing M_2 indicate that the MDS is also accepted for all the series except Eastern-Africa at the conventional 0.01 and 0.05 significance levels for all lags of k.

Take in Table 5 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) alternative suggested by Wright (2000) are further applied to investigate the RW and the MDS hypotheses respectively from Columns 4 to 7. With the

exception 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 series examined at the 0.01 level. Applying R_2, the RW is rejected for Eastern-Africa for all 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 is accepted 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 all six regions at all intervals of k at the 0.01 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 of the distribution, which suggests that any dependence is positive

Take in Table 6 Here

Table 6 presents the variance-ratios tests results for the African size stock price indices. Applying the traditional M_1 test statistic, the RW is accepted for all lags of k for the large capitalization indices at any reasonable probability level. By contrast, the null is rejected for the medium and small capitalizations indices for all intervals of k at the 0.01 level, except for the medium series when $k = 20$, 25 & 30. Implementation of M_2 shows that the acceptance of the RW is robust to hetereoscedasticity for the large and medium capitalization indices at any probability level. For the small capitalization 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 large size indices, except when $k = 25$ & 30 for R_1. By contrast, the null is rejected for the medium and small size indices for all 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 series at any interval

of k, except for the large capitalization 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.

Take in Table 7 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 majority (80%) of the sectoral indices investigated display high levels of efficiency, even against the powerful Wright's (2000) non-parametric variance-ratios tests. For the automobile & transport sub-sector in Panel A, the M_1 accepts the RW at any probability level for all lags of k. Employing the M_2 statistic, the MDS cannot also be rejected at any reasonable significance level for all 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 consumer goods, food & beverages sub-sector in Panel A, with the exception of M_1 when k = 15 and 20, the RW and MDS hypotheses are consistently accepted by both the parametric and non-parametric variance-ratios tests statistics for all lags of k at any probability level. For the pharmaceuticals & health sub-sector in Panel A, while M_1 rejects the RW at the 0.01 level for all intervals of k, M_2 shows that the rejection is not robust to hetereoscedasticty, as the MDS is strongly accepted at all 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 also be rejected at the conventional 0.01 and

0.05 levels, except when $k = 25$ & 30 for R_1 and S_2. For 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 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 all lags of k, at any significance level. Of special note is that majority of the M_1 rejections are in the lower tail of the distribution, which suggests any serial dependence is negative.

Take in Table 8 Here

In order to ascertain the potential improvements in informational efficiencies that African stock markets are likely to gain if they harmonise and integrate their operations, the tests are also implemented using individual African national stock price data instead of the African continent-wide constructed regional, size, and sectoral indices. Table 8 contains the variance-ratios tests results for a sample of 8 individual African national stock price indices for which data was 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, those due the ranks (R_1, R_2) and signs (S_1, S_2) alternative are consistent. Using the M_2, the RW is accepted for all lags of k at the conventional 0.01 and 0.05 for all the 8 countries. The null is, however, rejected at the 0.10 level for Botswana when $k = 20$ and Ghana when $k = 30$. For Egypt and Nigeria, M_2 suggests that the acceptance of the null is robust to hetereoscedasticity, as the MDS cannot also be rejected for all 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 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 rather 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) alternative consistently reject the RW and the MDS hypotheses at the 0.01 level for all intervals of k for all the 8 countries examined. For Ghana, the rejection of the RW and the MDS is consistent with recent evidence (Ntim *et al*., 2007).

Comparing the results of the individual national indices (table 8) with the African continent-wide constructed indices (tables 5-7) reveals significant potential improvements in informational efficiency if they harmonize and integrate their operations. Firstly, irrespective of the test statistic used, and the set of African continent-wide indices that is compared with, the individual national indices display higher levels of rejections. Secondly, the African continent-wide regional and size indices, either display higher levels of efficiency or tendencies towards 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 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.

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, less sophisticated, as well as remain on the fringes of the competitive global financial markets place. As a corollary, their informational efficiency is greatly diminished, severely affecting their ability to allocate capital efficiently. With a specific focus on the weak-form of the efficient markets hypothesis, we have therefore attempted to empirically ascertain whether African stock markets can improve their informational efficiency by harmonising and integrating their operations, using a new robust non-parametric variance-ratios test in addition to its parametric alternative.

Firstly, we find that irrespective of the diagnostic used, the 24 African continent-wide stock price indices returns display better normal distribution properties than those of all the 8 individual national stock price indices. 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 sectors 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, (eg., 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 offer consistent results throughout.

The policy implication of this evidence is that African stock markets can significantly improve their informational efficiency if they harmonise and integrate their operations. Economically, this can lead to more efficient allocation of capital and risk, which is expected to propel 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 Orion in which the Namibian Stock Exchange is able to access the electronic trading system of the JSE Securities Exchange 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. 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.

6. References

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. (2005), "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.

Bombay Stock Exchange, available: http://www.bseindia.com/about/introbse.asp (accessed on 12 May 2008).

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)

Bursa Malaysia, available at: http://www.bursamalaysia.com/website/bm/about_us/the_organisation/history.html (accessed on 11 May 2008).

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

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.

Cowles, A. III. (1933), "Can Stock Market Forecasters Forecast?", *Econometrica,* Vol. 1, pp.309-324.

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

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

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. (1965), "The Behaviour of Stock Market Prices", *Journal of Business,* Vol. 38, pp.34-105.

Fama, E. F. (1970), "Efficient Capital Markets: A Review of Theory and Empirical Tests", *Journal of Finance,* Vol. 25, pp.382-417.

Fama, E. F. (1991), "Efficient Capital Markets: II", *The Journal of Finance*, Vol. XLVI, No. 5, pp.1575-1617.
Fish, T. and Biekpe, N. (2002), "Regional African Stock Markets Indices", *South African Journal of Business Management,* Vol. 33 No. 1, pp.11-19.
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, p.531-548.
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).
Hong Kong Stock Exchange and Clearing, available at: http://www.hkex.com.hk/index.htm (accessed on 11 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 Securities Exchange South Africa, available at: http://www.jse.co.za/ (accessed on 10 May 2008).
Kendall, M. G. (1953), "The Analysis of Economic Time Series", *Journal of the Royal Statistical Society,* Series A, Vol. 116, pp.11-25.
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.
Levine, R. (1997), "Financial Development and Economic Growth: Views and Agenda", *Journal of Economic Literature,* Vol. 35, pp.688-726.
Levine, R. and Zervos, S. (1996): "Stock Market Development and Long Run Growth", World Bank Economic Review, 10(2), pp.323-340.
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.
London Stock Exchange, available at: http://www.londonstockexchange.com/en-gb/ (accessed on 12 May 2008).
Lovatt, D., Boswell, A. and Noor, R. (2008), "A Note on the Predictability of UK Stock Returns", *The European Journal of Finance*, Vol. 13, No. 2, pp.159-164.
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).
McKinnon, R. I. (1973), *Money and Capital in Economic Development*, Brookings Institution, Washington DC.
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 and Africa Business Research (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)
Namibia Stock Exchange: http://www.nsx.com.na/
Nairobi Stock Exchange, available at: http://www.nse.co.ke/newsite/ (accessed on 13 May 2008).
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.
Samuels, J. M. and Yacout, N. (1981), "Stock Exchange in Developing Countries", *Savings and Development,* Vol. 5 No. 4, pp.213-230.
Sao Paulo Stock Exchange, available at: http://www.bovespa.com.br/indexi.asp (accessed on 14 May 2008).
Savit, R. (1988), "When is Random not Random: An introduction to Chaos in Market Prices", *Journal of Futures Markets*, Vol. 8, pp.271-289.
Schumpeter, J. (1911), *The Theory of Economic Development*, Harvard University Press Cambridge.
Shanghai Stock Exchange, available at: http://www.sse.com.cn/sseportal/en_us/ps/home.shtml

(accessed on13May 2008).
Shaw, E. S. (1973), *Financial Deepening in Economic Development,* Oxford University Press, New York.
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, R. (2003), "Pan-African Stock Exchange Planned", at available:http://news.bbc.uk/1/hi/business/3163671.stm (accessed on 2 May 2008).
Southern Africa 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).
Summers, L. (1986), "Does the Stock Market Rationally Reflect Fundamental Values?", *Journal of Finance,* Vol. 41, pp.591-601.
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.
Working, H. (1934), "A Random Difference Series for Use in the Analysis of Time Series", *Journal of the American Statistical Association,* Vol. 29, pp.11-24.
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	Source	Sample Period	No. of Series
African Sectoral/Industrial Stock Price Indices:				
ABR Africa Automobiles & Transport Equipment	Aatei	Africa Business Research	1998-2008	2380
ABR Africa Banks	Abi	Africa Business Research	1998-2008	2380
ABR Africa Chemicals	Aci	Africa Business Research	1998-2008	2380
ABR Africa Consumer Goods, Food & Beverages	Acgfbi	Africa Business Research	1998-2008	2380
ABR Africa Diversified Conglomerates	Adci	Africa Business Research	1998-2008	2380
ABR Africa Financial Services (excluding banks)	Afsi	Africa Business Research	1998-2008	2380
ABR Africa Manufacturing	Amai	Africa Business Research	1998-2008	2380
ABR Africa Media	Ami	Africa Business Research	1998-2008	2380
ABR Africa Mining & Metals	Ammi	Africa Business Research	1998-2008	2380
ABR Africa Natural Resources	Anri	Africa Business Research	1998-2008	2380
ABR Africa Pharmaceuticals & Health	Aphi	Africa Business Research	1998-2008	2380
ABR Africa Retail & General Trading	Argti	Africa Business Research	1998-2008	2380
ABR Africa Services	Asi	Africa Business Research	1998-2008	2380
ABR Africa Telecoms & Utilities	Atui	Africa Business Research	1998-2008	2380
ABR Africa Transportation	Ati	Africa Business Research	1998-2008	2380
African Size/Capitalisation Stock Price Indices:				
ABR Africa Large Company	Alci	Africa Business Research	1998-2008	2380
ABR Africa Medium Company	Amci	Africa Business Research	1998-2008	2380
ABR Africa Small Company	Asci	Africa Business Research	1998-2008	2380
African Regional/Geographic Stock Price Indices:				
ABR Africa All Share (excluding South Africa)	Aasi	Africa Business Research	1998-2008	2380
ABR Eastern Africa	Eai	Africa Business Research	1998-2008	2380
ABR Northern Africa	Nai	Africa Business Research	1998-2008	2380
ABR Southern Africa	Sai	Africa Business Research	1998-2008	2380
ABR Sub-Sahara Africa	Ssai	Africa Business Research	1998-2008	2380
ABR Western Africa	Wai	Africa Business Research	1998-2008	2380

Source: Africa Business Research Limited

Continuation: Appendix 1

Full Index Name	Acronym/Code	Source	Sample Period	No. of Series
African National Stock Price Indices:				
S&P/IFCf M Botswana	Iffmbol/Botswana	DataStream	1995-2008	3222
S&P/IFCg M Egypt	Iffmegl/Egypt	DataStream	1997-2008	2937
S&P/IFCf M Ghana	Iffghal/Ghana	DataStream	1995-2008	3222
S&P/IFCf M Kenya	Iffkenl/Ghana	DataStream	1995-2008	3222
S&P/IFCf M Mauritius	Iffmaul/Mauritius	DataStream	1995-2008	3222
S&P/IFCf M Morocco	Ifgmmol/Morocco	DataStream	1997-2008	2941
S&P/IFCf M Nigeria	Ifgmngl/Nigeria	DataStream	1984-2008	8960
S&P/IFCg M Tunisia	Ifftunl/Tunisia	DataStream	1995-2008	3222

Source: 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	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: WFEs Website, ASEA Website, Websites of All Exchanges, Nominal GDP from IMF, [a]Excludes Blue-chips from S. 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	No. of Brokers	Foreign Invlment.	WFE Status	MSCI/S&P/IFC Classification	FTSE Classif.	Derivative Trading	Clearing & Settlement	Accounting Standard
Botswana	5	1.00	Manual	03	Yes	n/a	Frontier	n/a	No	T+4	Local Std.
Cote D'Ivoire	5	4.00	Electronic	20	Yes	n/a	Frontier	n/a	No	T+5	Local Std.
Egypt	5	4.00	Electronic	138	Yes	Member	Emerging	S. Emerging	No	T+2[a]	Intl. Std.
Ghana	5	2.00	Manual	16	Yes	Correspondent	Frontier	n/a	No	T+3	Intl. Std.
Kenya	5	2.00	Electronic	20	Yes	Correspondent	Frontier	n/a	No	T+3	Intl. Std.
Malawi	5	3.00	Manual	03	Yes	Correspondent	n/a	n/a	No	T+7	Intl. Std.
Mauritius	5	2.50	Electronic	12	Yes	Member	Frontier	S. Emerging	No	T+3	Intl. Std.
Morocco	5	4.00	Electronic	16	Yes	Affiliate	Emerging	S. Emerging	No	T+3	Intl. Std.
Mozambique	n/a	n/a	Electronic	02	Yes	n/a	n/a	n/a	No	T+3	Local Std.
Namibia	5	8.00	Electronic	06	Yes	Affiliate	Frontier	n/a	No	T+3	Local Std.
Nigeria	5	2.00	Electronic	40	Yes	Affiliate	Emerging	n/a	No	T+3	Intl. Std.
South Africa	5	6.50	Electronic	101	Yes	Member	Emerging	A. Emerging	Yes	T+3	Intl. Std.
Swaziland	5	2.00	Manual	03	Yes	n/a	n/a	n/a	No	T+5	Intl. Std.
Tanzania	5	2.00	Electronic	06	Yes	n/a	n/a	n/a	No	T+5[b]	Intl. Std.
Tunisia	5	2.67	Electronic	24	Yes	n/a	Frontier	n/a	No	T+3	Local Std.
Uganda	5	2.00	Manual	07	Yes	Correspondent	n/a	n/a	No	T+5	Intl. Std.
Zambia	5	2.00	Electronic	03	Yes	n/a	n/a	n/a	No	T+3	Local Std.
Zimbabwe	5	4.00	Manual	12	Yes	n/a	Emerging	n/a	No	T+7	Intl. Std.
Brazil	5	7.25	Electronic	359	Yes	Member	Emerging	A. Emerging	Yes	T+0	Intl. Std.
China	5	5.75	Electronic	152	Yes	Member	Emerging	S. Emerging	Yes	T+1[c]	Intl. Std.
Hong Kong	5	6.00	Electronic	1,145	Yes	Member	Developed	Developed	Yes	T+2	Intl. Std.
India	5	7.00	Electronic	874	Yes	Member	Emerging	S. Emerging	Yes	T+1	Intl. Std.
Malaysia	5	8.00	Electronic	49	Yes	Member	Emerging	S. Emerging	Yes	T+3	Intl. Std.
UK	5	9.50	Electronic	1,650	Yes	Member	Developed	Developed	Yes	T+0	Intl. Std.
US	5	6.50	Electronic	1,366	Yes	Member	Developed	Developed	Yes	T+0	Local Std.

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)	100%								
Asia Index	-09	100%							
Emerging Markets	-07	88	100%						
Far East Index	-10	99	86	100%					
G7 Countries	12	18	43	17	100%				
Latin America	-14	06	44	05	57	100%			
South Africa	03	42	58	40	22	07	100%		
World Index	14	21	46	20	99	57	24	100%	
World Small Co.	14	22	46	21	90	46	28	90	100%

Source: Morgan Stanley Capital International/Africa Business Research Limited 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.

Figure

Figure 1: Trends in the Daily Mean Returns of the Africa All-Share Index