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Modelling stock returns in Africa's emerging equity markets

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ABSTRACT

We investigate the behaviour of stock returns in Africa's largest markets namely, Egypt, Kenya, Morocco, Nigeria, South Africa, Tunisia and Zimbabwe. The validity of the random walk hypothesis is examined and rejected by employing a battery of tests. Secondly we employ smooth transition and conditional volatility models to uncover the dynamics of the first two moments and examine weak form efficiency. The empirical stylized facts of volatility clustering, leptokurtosis and leverage effect are present in the African data.

> But this is the age of globalisation, when investors feel free to boldly go where they had not gone before. After all, places that were previously regarded as exotic, from Bulgaria to Vietnam, are integrated into the global economy. Now it may be Africa's turn. Economist 29/6/2007.

1. Introduction

The Efficient Markets Hypothesis (EMH) holds that asset prices and returns are determined by the outcome of supply and demand in a competitive market, peopled by rational traders. These rational traders rapidly assimilate any information that is relevant to the determination of asset prices or returns, hence current prices (returns) fully reflect all available information (Fama, 1970). The notion that current prices fully reflect all available information implies that successive price changes (returns) are independent. Further, successive price changes are identically distributed. These two requirements constitute the cornerstone of the random walk model (Fama, 1970, pp 386–87).

At the same time there is growing evidence that stock returns exhibit stylized facts: first, the empirical distribution of stock returns appears to be excessively leptokurtic (Fama, 1965; Mandelbrot, 1963; Nelson, 1991). Second, short-term stock returns exhibit volatility clustering. These processes have been modelled successfully by ARCH-type models (see Bollerslev, Chou, & Kroner, 1992, for a review). Third, changes in stock prices tend to be inversely related to changes in volatility (Bekaert & Wu, 2000; Black, 1976; Christie, 1982). Most of the empirical work on these stylized facts has focused primarily on developed economies and a few emerging markets.

For investors seeking opportunities in developing countries however, little is known about the dynamic characteristics of stock returns (see Appiah-Kusi & Menyah, 2003; Magnusson & Wydick, 2000; Mecagni & Sourial, 1999; Smith & Jefferis, 2005 and Lim, 2007 who address some of these issues in African markets). Work on testing the weak form of market efficiency where nonlinearities are taken into account is limited and international evidence includes Brooks (2007), Lim, Brooks, and Kim (2008) and Panagiotidis (2005) and the references therein. An extensive review of the institutional characteristics of the African stock markets appears in Irving (2005) and in Yartey (2008). With increasing globalisation and world-wide integration of financial systems, interest has been rekindled in African stock markets largely on account of their low correlations with the rest of the world and the role they play in portfolio diversification. In 1994, African markets posted the biggest gains in U.S. dollar terms among all markets worldwide — Kenya (75%), Ghanaian stocks (70%), Zimbabwe (30%), Egypt (67%). In 1995, African stock exchanges gained about 40%, with the value of stocks on the Nigerian Stock Markets and Côte d'Ivoire's bourse registering over 100% increase in dollar terms. Average returns on African stocks in 2004 reached 44%. This

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compares favourably with a 30% return by the Morgan Stanley Capital International (MSCI) global index; 32% in Europe; 26% in the U.S. (Standard & Poor's); and 36% in Japan (Nikkei).[1] Additionally, African stock markets provide benefits of portfolio diversification as they tend to have zero or sometimes negative correlation with developed markets (see Harvey, 1995 for evidence on Nigeria and Zimbabwe). Recently, the Economist characterized Africa as globalization's final frontier for investors (29/7/07) and asking them to "Buy Africa" (19/2/2008).

This paper examines empirically the validity of the efficient markets hypothesis in African markets. Market efficiency is important because efficient stock prices allow agents to diversify their sources of investment capital and spread investment risk (see Caprio & Demirguc-Kunt, 1998). Also efficient stock prices and yields provide benchmarks against which the cost of capital for and returns on investment projects can be judged (Green, Maggioni, & Murinde, 2000 and also Green, Kirkpatrick, & Murinde, 2005). Furthermore, since stock prices are forward looking, they provide a unique record of shifts in investors' views about the future prospects of companies as well as the economy (Green et al., 2005).

The main objective of this paper is to investigate whether the stylized facts observed in major advanced markets are present in African stock markets. We investigate the validity of the random walk hypothesis and employ smooth transition regressions (STR) and conditional volatility (GARCH) models to uncover the dynamics of the first two moments of the series. First, a linear random walk (RW) is estimated for each market and the residuals are subjected to a battery of tests to investigate whether they are independently and identically distributed (*iid*). Models of the STR and GARCH family are then fitted. Our results show that the random walk is not adequate to capture the dynamics of the data. However, rejecting the random walk does not necessarily imply market inefficiency since market efficiency is a joint hypothesis (independent *and* identically distributed). We find evidence of volatility clustering in all countries (see also Brooks, 2007). In Kenya and Morocco, a change in stock prices is inversely related to volatility. Finally, we find a positive relationship between expected returns and risk in Tunisia, Kenya, Morocco and Zimbabwe. Thus, investors who venture into these markets are appropriately rewarded with higher returns for assuming greater risks.

The next section outlines the econometric methodology. Section 3 presents the data. The penultimate section is analysis of empirical results and Section 5 concludes.

2. Econometric methodology

Given the nature of the data, we avoid the temptation of imposing directly any specific data generating mechanism (infinite candidates). The methodology followed consists of the following steps:

i. The random walk is employed for the returns of each of the countries and test for *iid* through a battery of tests: McLeod and Li (1983) and Engel (1982) test for (G)ARCH effects; Brock, Hsieh, and Lebaron (1991), Brock, Dechert, Scheinkman, and LeBaron (1996) BDS tests for randomness; Hinich (1996) and Hinich and Patterson (1995) bicovariance test for third order non-linear dependence and Tsay (1986) for threshold effects in the data (for a detailed discussion of these tests see Patterson & Ashley, 2000 and Ashley & Patterson, 2006). All these tests share a common principle: once any linear serial dependence is removed from the data, any remaining dependence must be due to non-linearities in the data generating mechanism. Additionally, we investigate whether the dynamics could be explained by a smooth transition model (STR) by employing the linearity test proposed by Luukkonen, Saikkonen, and Teräsvirta (1988).

ii. If both the RW and the STR fail to explain the behaviour of the data and there is strong evidence against the null hypothesis of *iid*, then we will proceed with employing GARCH-type of models.

The (logarithmic) random walk model is given by

$$\log P_t = \log P_{t-1} + \varepsilon_t \tag{1}$$

where P_t is the price of a stock at time t, P_{t-1} is the price of the stock in the immediately preceding period and ε_t is a stochastic error term with $E[\varepsilon_t]=0$, $E[\varepsilon_t^2]=\sigma^2$ and $E[\varepsilon_t\varepsilon_s]=0\ \forall s\neq t$. Thus $\varepsilon_t=\log P_t-\log P_{t-1}$, which being white noise, is unpredictable from previous price changes. To test the assumptions implied by the random walk, the following equation is estimated by least squares

$$\Delta\log P_t = \mu + \varepsilon_t \tag{2}$$

Under the RW log P_t should be $I(1)$ ($\Rightarrow$ $\Delta\log P_t \sim I(0)$), the estimate of the constant μ should be insignificantly different from zero and the resultant residuals should be *iid*. This can however be positive if the stock market is growing. If the null of *iid* cannot be accepted, the implication is that the residuals contain some hidden, possibly non-linear structure.

At the same time, it is evident that volatility clustering, leptokurtosis and leverage effect are stylized features of financial data that linear models are unable to capture. The mean equation of stock prices (returns) could be described as

$$\begin{aligned}&\Delta\log P_t = \mu + \sum \phi_i \Delta\log P_{t-i} + \varepsilon_t\\ &\varepsilon_t\,|\,\Omega_{t-1} \sim NID(0,h_t)\end{aligned} \tag{3}$$

The disturbance term ε_t is conditionally heteroscedastic $\varepsilon_t = z_t\sqrt{h_t}$ where z_t is *iid* with zero mean and unit variance. The conditional variance evolves according to the standard GARCH representation

$$\begin{aligned}h_t &= \omega + \sum_{i=1}^{q}\alpha_i\varepsilon_{t-i}^2 + \sum_{i=1}^{p}\beta_i h_{t-i}\\ &= \omega + \alpha(L)\varepsilon_t^2 + \beta(L)h_t\end{aligned} \tag{4}$$

The ϕ_i parameter in Eq. (3) is included in the mean equation to take into account the autocorrelation induced by non-synchronous trading in the assets that make up a market index (see Lo & McKinlay, 1988; Scholes & Williams, 1977). The parameters in $\alpha(L)=\alpha_1L+\ldots\alpha_qL^q$ and $\beta(L)=\beta_1L+\ldots+\beta_pL^p$ are equivalent to an ARMA (p,q) if all the roots of $1-\beta(L)$ lie outside the unit circle, and restrictions of $\omega>0$, $\alpha_i>0$ and $\beta_i\geq 0$ are imposed to ensure $h_t\geq 0$. Although, it is useful to specify a GARCH (p,q), empirically, in most cases a lag structure of $p=q=1$ is adequate (see Bollerslev et al., 1992).

However many models of asset pricing relate expected returns to some measure of risk. The GARCH-in-Mean (GARCH-M) model of Engel, Lillien, and Robins (1987) can be used to explicitly parameterize the conditional expectation of asset returns as a function of volatility. To this end, Eq. (3) now becomes

$$\Delta\log P_t = \mu + \sum \phi_i \Delta\log P_{t-i} + \delta h_t + \varepsilon_t \tag{5}$$

Thus δ is interpreted as a risk premium so that a positive and significant δ indicates that return is positively related to volatility.

The notion of asymmetry has its origins in the work of Black (1976), French, Schwert, and Stambaugh (1987), Nelson (1991) and Schwert (1990). A model that captures asymmetry is the exponential GARCH (EGARCH) model of Nelson (1991)

$$\ln(h_t) = \omega + \alpha_1 z_{t-1} + \gamma_1(|z_{t-1}| - E(|z_{t-1}|)) + \beta_1\ln(h_{t-1}) \tag{6}$$

The natural log formulation of EGARCH ensures positive variances, thus dispensing with the need for parameter restrictions; also volatility at time t depends on both the size and sign of the normalized errors.

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[1] See the Economist, June 11, 1994: "Stalking Africa's Fledgling Stock Markets".