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Non-linear dependencies in African stock markets: Was subprime crisis an important factor?

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HIGHLIGHTS

- It is applied the DFA to analyse the behaviour of 12 African stock indices.
- The results point to the existence of statistically significant serial dependence.
- Dependence is higher in African stock markets, when compared with other indices.

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ABSTRACT

The historical dependence in stock markets it is a very explored issue, especially in developed markets. In this paper we try to address the question of global dependency in African stock markets, and for that purpose we use a global approach able to capture the long-term dependencies being linear or non-linear ones. Are there significant differences in terms of results compared to the major international markets? Results point to an affirmative answer. The Hurst exponent shows that long-term dependence is probably linked not only to size or liquidity.

1. Introduction

Serial dependence in financial markets is a commonly studied problem in the financial literature. This is important for the issuers of financial assets but also for actual and potential investors, since the knowledge of time patterns may be the basis for arbitrage actions, compromising the possible efficiency of the respective stock market. In fact, there is a close relationship between dependence and efficiency. Besides the fact that efficiency is not the specific theme of this work, it is almost impossible to do not mention the theory its implications. In fact, the subject of market efficiency is not new: at the beginning of the 1970s, Fama [1] stated that returns of financial assets have no memory — this is the Efficient Market Hypothesis (EMH) in its weak form, which implies that return rates should not have any kind of dependence.

Several different tests of serial dependence are found in the finance literature. When using linear autocorrelations, generally those studies conclude that return rates do not suffer from dependence or, if so, even in the short run that dependence disappears (see, for example, [2]). However, when studies involve nonlinear dependences, these could be persistent.

One of the methodologies to analyse nonlinear dependence in data is the use of the Hurst exponent, which could be estimated through different methodologies. One of those methodologies is detrended fluctuation analysis (DFA), able to

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detect long-range dependences in time series even if they are non-stationary. If the EMH is verified, return rates behave like a random walk, meaning that they have no memory. However, if we find persistence in a given asset's time series, it could be interpreted as a sign of possible inefficiency. Further studies should prove whether such divergence from the random walk could imply some capacity to predict return rates.

In this paper, we will use the Hurst exponent, derived from DFA, to analyse the behaviour of 12 African stock indices: Botswana, Ivory Coast, Egypt, Kenya, Mauritius, Morocco, Namibia, Nigeria, South Africa, Tunisia, Uganda and Zambia. For each stock market, we analyse the behaviour of the time series from 3rd August 2004 to 13th April 2016, divided in three sub-periods. Furthermore, we are interested in analysing not only the behaviour of each stock market in the whole sample but also to analyse whether the global crisis caused by the Lehman Brothers bankruptcy changed the efficiency pattern of the markets. So we divided the series in three sub-periods: the first sub-period is the "before crisis period" from the 3rd August till 12th September (1074 observations), the second sub-period, the "crisis period", from 15th September to 14th September 2012 (1045 observations); and the third sub-period, the "calm period", from 17th September 2012 till 13th April 2016 (933 observations) and applied DFA again for each series. The cut-off time for the identification of the crisis period was used, among others, by Silva et al. [3].

Although most trading of stocks takes place in the markets of developed countries (mainly USA, European countries and Japan), African markets may show interesting behaviour, (for confirmation, see the results section). In order to compare the behaviour of African markets with other developed indices, we will also analyse the stock indices of Japan, UK and United States and use it as a comparison term.

The main innovation of this research is based on the use of a global approach to evaluate serial dependence in African stock markets, comparing to some developed countries behaviour. Our main results point to the existence of statistically significant serial dependence, in almost all countries, in the period under analysis. This dependence could be caused by the small size and liquidity of those markets.

The remainder of the paper is organized as follows: Section 2 contains a literature review on this topic, concerning studies using both African and non-African stock markets; Section 3 presents the data and the methodology used; Section 4 shows the results; Section 5 concludes and discusses those results.

2. Serial dependence in stock markets: a brief review

Speaking about serial dependencies in stock markets is strongly related with the concept of efficiency is its weak form.

Studies analysing the behaviour of financial assets go back more than a century: the study by Bachelier [4], devoted to analysing the probability distribution of stock prices, is one of the studies on this topic (the author concludes on the normality of the data, as expected). Fama [5] explained that in an efficient market, on average, competition will cause the full effects of new information on intrinsic values to be reflected "instantaneously" in actual prices. He concluded that stock market prices follow a random walk. In 1970, Fama, defined an efficient market as "a market whose prices always fully reflect available information is called efficient". Later studies confirm the behaviour of financial markets as random walks, mainly if the linear behaviour of autocorrelations is studied. This is found in older studies (see, for example, [6,7] or [8]) or even in more recent work (see, for example, [9,10]).

However, and also with these results, financial markets are found to be affected by some features that the literature calls stylized facts. These facts frequently appear associated with financial data, such as the existence of fat tails in returns, asymmetries between gains and losses, volatility clustering, leverage effect, correlation between trading volumes and volatility or autocorrelation in the variance. These features can be found in several studies and are surveyed, for example, by Cont [11] or Parisi et al. [12].

The use of methodologies that perform not only linear but also nonlinear analysis reveals some of those stylized facts.

Several studies analyse the behaviour of financial markets using nonlinear approaches: Mandelbrot [13], Barkoulas and Baum [14], Darbellay [15], Sadique and Silvapulle [16], Granger et al. [17] or Christodoulou-Volosa and Siokis [18] use different methodologies, studying, for example, fractional analysis, mutual information, measures of entropy, cointegration or scaling analysis. They find common evidence about long-range dependence in financial markets.

The DFA, the methodology used in this paper, is also common in analysing financial data. Although DFA was created to study the behaviour of DNA [19], it was extended to study other phenomena, including the behaviour of financial series. Studies such as Ferreira and Dionísio [9], Kristoufek [20], Cao and Zhang [21] or Anagnostidis et al. [22] are just some examples of relatively recent studies that analyse stock markets using DFA, and also find common evidence of long-term dependence.

Regarding African stock markets, some studies analyse their behaviour through time. The South African stock market is probably the most studied African market, due to it being one of the largest. Smith et al. [23], Smith and Jefferis [24], Magnusson and Wydick [25] or Jefferis and Smith [26] did not find evidence of serial dependence in this particular market. The same studies also analyse other stock indices, finding different results for Botswana, Ghana, Ivory Coast, Egypt, Morocco and Mauritius. The results are corroborated by Mlambo and Biekpe [27] or Smith [28] in these and other African markets (Botswana, Ivory Coast, Egypt, Ghana, Kenya, Mauritius, Morocco, Nigeria, South Africa, Tunisia and Zimbabwe) or by Dickinson and Muragu [29], in Kenya.

Stock market efficiency is detected by Appiah-Kusi and Menyah [30] in some markets: Kenya, Zimbabwe, Egypt, Morocco and Mauritius are examples (curiously, this study points to inefficiency in the South African market). Mlambo and Biekpe