



Long-range dependencies of Eastern European stock markets: A dynamic detrended analysis

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HIGHLIGHTS

- A sliding windows DFA is applied to Eastern European stock markets.
- This allows analysis of the evolution of serial dependence over time.
- Hungarian, Czech and Polish indices show lower dependence levels.
- Most of the indices show higher dependence than developed markets.

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ABSTRACT

The analysis of stock markets' behaviour remains a very interesting issue, because it can give investors information about where to apply their money. In this context, a dynamic analysis of 18 Eastern European stock markets is performed, using a sliding windows detrended fluctuation analysis, which will fill a gap in the literature with the inclusion in this study of a larger sample. The results show that most indices are distant from the absence of long-range dependencies, which could be seen as inefficiency. Nevertheless, some countries show a decrease in dependence levels over time, namely the Hungarian, Czech and Polish indices. When compared with other more developed markets, these and Latvia are the only ones to show similar behaviour, regarding the existence of long-range dependencies. This could be related to more developed economic structures as well as the financial system, probably associated with joining the European Union. However, other current European Union members, such as Bulgaria, Slovenia and Lithuania do not show this pattern.

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1. Introduction

Although the study of financial assets' behaviour is relatively old, with one of the pioneer works appearing over a century ago [1], it was the work of Fama, Fama [2,3] which identified the Efficient Market Hypothesis (EMH), the cornerstone of a very rich literature devoted to analysing the behaviour of financial markets. According to Fama [3], 'A market in which prices always "fully reflect" available information is called "efficient". The author considers the possible existence of three different types of efficiency: the weak form (considering the information set as historical prices), the semi-strong form (considering

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all public information about assets) and the strong form (including all the information about assets, both public and private). The concept of EMH was thoroughly scrutinized and even Fama changed his mind over time when defining EMH (see, for example, [4]). This is kept in mind, when the results are discussed.

In the context of weak form efficiency, asset prices are expected to behave randomly, meaning that time series do not show any kind of dependence. The work of Fama [3] is innovative because it defines the concept of market efficiency, but it also reviews other previous work which confirms the apparent efficiency of markets: [5–7] or [8], among others. A common feature of these studies is the fact of concluding about the inexistence of dependence, using linear autocorrelation analysis. More recent studies using that analysis also corroborate these findings (see, for example, [9,10]).

Despite the evidence about the randomness of financial time series, there are some issues regarding the behaviour of assets, such as the possibility of leptokurtic curves. This problem, which means that return rates' distributions have fatter tails when compared with normal distribution, can be found in studies such as those by Mandelbrot [11], Osborne [6] or Mantegna et al. [12], among others. These fat tails are just one of the possible common facts found regularly in financial assets, which were later called stylized facts (see, for example, [13]; or [14], for a review of those stylized facts).

The evidence of stylized facts is usually supported by non-linear analysis of financial markets. Use of these non-linear approaches shows that, even in the absence of linear autocorrelations, the existence of non-linear dependence could affect the possible efficiency of financial markets (see, for example, [15]; or [16]). Furthermore, the development of econometric and statistical techniques, as well as increased computational capacity, allowed researchers to use several different kinds of non-linear methodologies, which are responsible for finding some evidence of long-range dependence in financial markets (the studies by [17–19]; or [20] are just some examples).

The literature contains several non-linear approaches to studying financial markets. This evolution, related with the interdisciplinary interests of some researchers, made some statistical physicists pay more attention to financial markets, which created a new research field called Econophysics (see, for example, the work of Pereira et al. [21], for a recent review on this). In the context of analysing financial markets' behaviour, the use of detrended fluctuation analysis (DFA) to analyse the dependence of time series is one of the most frequently used methodologies. Created by Peng et al. [22], to study DNA behaviour, this methodology is commonly used to analyse financial markets. The seminal studies using DFA in financial markets include those by Vandewalle and Ausloos [23], Liu et al. [24], Ausloos et al. [25], Ausloos [26] and Di Matteo et al. [19]. Over time, many studies have used DFA and its variants in financial markets, to such an extent that a literature review is impossible. However, most of them find evidence of long-term dependence in exchange markets (see, for example, [9,27]; or [28]).

Although no study was able to prove that those dependences could imply the predictability of financial markets, it is still important to analyse stock market dependence. It remains interesting because it could be related to features such as the liquidity of markets and their underdevelopment, which is important information for potential investors.

Aware of the confusion about the concept of EMH and its study by econophysicists, as referred to by Ausloos et al. [4], this study exercises some caution in describing the results. Although it could be included in the extensive literature about EMH, this paper limits the analysis of results to the existence or not of serial dependence.

Based on those issues, this paper analyses the existence of long-range dependence in Eastern European stock markets. These markets were chosen because, despite some previous analyses of their behaviour, the use of DFA, a measure which detects the existence of long-range dependence in time series, is quite rare. For example, Ferreira et al. [29] use some of those countries, even with DFA modifications (an Adaptive Multifractal Detrended Fluctuation Analysis), but do not use such a wide set of Eastern European stock markets. The analysis of a larger sample of countries is a novelty of this paper.

Moreover, as this work applies a sliding windows approach, it is able to analyse their evolution over time, i.e., applying a dynamic analysis regarding those long-range dependencies. Finally, those markets can be ranked according to the dimension of long-range dependencies, which could be very interesting information for investors. This ranking is made with an Efficiency Index (EI), proposed by Kristoufek and Vosvrda [30].¹

Using an extended sample of 18 stock markets (Bosnia, Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Kazakhstan, Latvia, Lithuania, Macedonia, Montenegro, Poland, Romania, Russia, Serbia, Slovakia, Slovenia and Ukraine), the main results show that most of the indices are distant from the absence of long-range dependence level. In recent years, Hungary, the Czech Republic and Poland have shown lower levels of dependence, while Bulgaria, Slovenia, Lithuania and Macedonia have the highest dependence levels. In order to compare the behaviour of these indices and other indices from more developed markets, the same procedure was followed for the main indices of France, Germany, Japan, the UK and the US. The results show that Germany and Japan are always the markets with the lowest levels of dependencies. Considering just the most recent sample, Hungary, the Czech Republic and Poland have similar levels of dependencies to the developed markets. The US index, among the developed markets, is the one with the highest level of dependence and instability in its stock market, which could be caused by the subprime crisis.

The remainder of the paper is organized as follows: Section 2 makes a brief literature review about the behaviour of stock markets in Eastern European countries; Section 3 shows the methodology and the data; Section 4 presents the results; Section 5 concludes.

¹ Although aware, as previously stated, of the problem about studying EMH, it was decided to keep the original definition of EI.

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