Physica A 436 (2015) 147–158

Contents lists available at ScienceDirect

Physica A

journal homepage: www.elsevier.com/locate/physa

Time-varying long term memory in the European Union stock markets[☆,☆☆]

Ahmet Sensoy[a,*], Benjamin M. Tabak[b,c]

[a] Borsa Istanbul, Research & Business Development Department, Emirgan, Istanbul 34467, Turkey

[b] CNPq Foundation, Brasilia, DF, Brazil

[c] Department of Economics, Universidade Catolica de Brasilia, SGAN 916, Modulo B Avenida W5, CEP 70790-160 Brasilia, DF, Brazil

HIGHLIGHTS

- We propose a new efficiency index to model time-varying inefficiency in stock markets.
- We focus on European markets and show that they have different degrees of time-varying efficiency.
- The 2008 global financial crisis has an adverse effect on almost all EU stock markets.
- Eurozone debt crisis has a significant adverse effect only on the markets in France, Spain and Greece.
- For the late members, joining EU does not have a uniform effect on market efficiency.

ARTICLE INFO

Article history:
Received 22 February 2014
Received in revised form 24 March 2015
Available online 12 May 2015

Keywords:
Long memory
European Union
Stock market efficiency
Generalized Hurst exponent
Financial crisis

ABSTRACT

This paper proposes a new efficiency index to model time-varying inefficiency in stock markets. We focus on European stock markets and show that they have different degrees of time-varying efficiency. We observe that the 2008 global financial crisis has an adverse effect on almost all EU stock markets. However, the Eurozone sovereign debt crisis has a significant adverse effect only on the markets in France, Spain and Greece. For the late members, joining EU does not have a uniform effect on stock market efficiency. Our results have important implications for policy makers, investors, risk managers and academics.

1. Introduction

Market efficiency has been widely discussed in financial literature. According to the weak form of Efficient Market Hypothesis (EMH) [1], stock prices follow a random walk, a term to denote the logic asserting that tomorrow's price changes only reflect tomorrow's news where news is assumed to be unpredictable hence price changes must be random [2]. However, as far as financial markets are concerned, the notion of long memory was shown to exist in asset returns first by Mandelbort [3] and then by many others (See Refs. [4–8]).

The presence of long memory brings out several problems: The investors' preferred investment horizon becomes a risk factor [9]; the methods used to price financial derivatives (such as the Black and Scholes [10] model) may no longer be

☆ The views expressed in this work are those of the authors and do not necessarily reflect those of the Borsa Istanbul or their members.

☆☆ Benjamin M. Tabak gratefully acknowledges financial support from CNPq Foundation.

* Corresponding author. Tel.: +90 212 298 27 39; fax: +90 212 298 25 00.
E-mail address: ahmet.sensoy@borsaistanbul.com (A. Sensoy).

http://dx.doi.org/10.1016/j.physa.2015.05.034
0378-4371/

valid[1]; the usual tests based on the Capital Asset Pricing Model and Arbitrage Pricing Theory [12] cannot be applied to series with long memory.[2]

This paper aims to compare the efficiency of all stock markets in European Union (EU) after the introduction of the Euro.[3] This comparison is essential in many ways, for example; since not all EU members use Euro as their currency, it is an important question to answer if such a situation made any difference on the stock market efficiency in the last decade. A similar question arises due to the fact that some of the countries in our analysis joined EU or started to use Euro later than others in the time interval of our study. Furthermore, the study time line includes two major crisis; namely the 2008 global financial crisis and the Eurozone sovereign debt crisis.

In 2008, the US experienced a major financial crisis leading to one of the most serious recessions in history. The crisis spread to many foreign nations, especially in Europe, resulting in a global economic crisis. The crisis has had further developments in countries in Europe with weak fiscal discipline, leading to the European debt crisis. Six of the region's countries; Greece, Portugal, Ireland, Italy, Spain, Cyprus, have struggled to fully pay back their bondholders. Although these six are seen as the most problematic, their possible default has far-reaching consequences beyond their borders. This study will also show the effects these crises have had on the efficiency of European stock markets.

This is the first study that compares relative efficiency of all stock markets in EU and we use the Hurst exponent in that purpose. Many previous weak-form EMH studies assume a fixed level of market efficiency throughout the entire estimation period. It is incorrect to assume that the market is perpetually in an equilibrium state [13,14]. Hence, instead of regular static approaches, we use a time-varying approach to see the dynamics of the efficiency. Moreover, instead of the popular R/S [15] and modified R/S [16] statistics approach, we use the generalized Hurst exponent (GHE) introduced by Barabasi and Vicsek [17] and popularized by Di Matteo et al. [18,19], Di Matteo [20]. It combines sensitivity to any type of dependence in the data and simplicity. Furthermore, since it does not deal with maxima and minima, it is less sensitive to outliers than the popular R/S statistics [17,19]. Besides, it is a stylized fact that the stock returns are not normally distributed and are heavy-tailed. Barunik and Kristoufek [21] studies how the sampling properties of the Hurst exponent estimate change with fat tails by comparing the R/S analysis, multifractal detrended fluctuation analysis, detrending moving average and the generalized Hurst exponent approach in estimating the Hurst exponent on independent series with different heavy tails. They show that GHE is robust to heavy tails in the underlying process and provides the lowest variance.[4]

Finally, we contribute to the literature by introducing a time-varying efficiency index that could be useful especially in analyzing the effects of exogenous events on the efficiency level.

The structure of the paper is as follows: Section 2 gives a brief literature review on the efficiency of European stock markets. Section 3 explains the methodology used in this study. Section 4 presents the data and the results. Finally Section 5 includes some discussion and offers a brief conclusion.

2. Review of past studies on the efficiency of European stock markets

The efficiency of stock markets has been a subject of much attention in the empirical finance literature.[5] The literature that focus on European stock markets has employed various methodologies. However, the literature provides mixed evidence. Cheung and Lai [32] found no evidence of long memory in major European stock markets using a modified R/S test and a fractional differencing test. Using the modified R/S statistic, Jacobsen [33] shows that none of the return series of indexes of five major European countries exhibits long memory. Lux [34], applying three different concepts for the identification of long memory effects, virtually found no evidence of such behavior in German stock market returns. Dockery and Kavussanos [35] performs unit root tests using panel data to investigate empirically stock price efficiency of the Athens stock market and their Wald test statistics reject the random walk hypothesis for stock prices. However, using time-varying global Hurst exponents, Cajueiro et al. [36] show that after the financial liberalization in Greece, stock market efficiency has significantly improved in time.

Booth and Koutmos [37] studies four major European stock markets by modeling their returns as conditionally heteroskedastic processes with time dependent serial correlation. Their evidence suggests that returns in these markets are non-linearly dependent on their past history. Vir [38] examines the long memory property in Finnish stock market by various alternative test procedures. The results give some evidence on long memory but do not overwhelmingly support their existence in the Finnish stock market. Areal and Armada [39] find tendencies towards mean aversion and mean reversion in Portuguese stock market using several methodologies, however they notice that results are very sensitive to the methodology used and the significance tests performed. Smith and Ryoo [40] test the assertion that stock prices of five European emerging

[1] Jamdee and Los [11] demonstrates how long memory phenomena can change European option values compared to the Black–Scholes model assumptions.

[2] Mandelbort [3] notes that the arrival of new information cannot be fully arbitraged away in the presence of long memory and asset pricing with martingale models cannot be obtained from arbitrage.

[3] The Euro is the second largest reserve currency as well as the second most traded currency in the world after the United States dollar.

[4] A similar setup of our study was previously used in the work of Sensoy and Hacihasanoglu [22]. In addition to that, our study introduces a novel efficiency index using time-varying generalized Hurst exponents.

[5] For example see Refs. [23–31] for international stock markets.