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# European economies in crisis: A multifractal analysis of disruptive economic events and the effects of financial assistance

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## HIGHLIGHTS

- Multifractal detrended fluctuation analysis is tested in European economies under stress.
- Financial rescue programs change the multifractal properties of the time series tested.
- In two of the three economies under investigation the degree of multifractality increases significantly.
- Multifractality is caused by both long memory and fat-tailed distribution, for the time series examined.

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## ABSTRACT

We analyze the complexity of rare economic events in troubled European economies. The economic crisis initiated at the end of 2009, forced a number of European economies to request financial assistance from world organizations. By employing the stock market index as a leading indicator of the economic activity, we test whether the financial assistance programs altered the statistical properties of the index. The effects of major financial program agreements on the economies can be best illustrated by the comparison of the multifractal spectra of the time series before and after the agreement. We reveal that the returns of the time series exhibit strong multifractal properties for all periods under investigation. In two of the three investigated economies, financial assistance along with governments' initiatives appear to have altered the statistical properties of the stock market indexes increasing the width of the multifractal spectra and thus the complexity of the market.



## 1. Introduction

For the last four years, the world crisis has engulfed the euro area in a great economic/debt crisis, threatening its own existence. Owing to the Great Recession in the USA and through a virulent economic contagion, which had disrupted world trade and the financial markets, a number of European countries, with chronic fiscal and structural problems and others with systemic banking crises were among the first and most affected economies to succumb. In particular, the economies of Greece, Ireland and Portugal, in that chronological order, were severely affected: Greece with a mounting sovereign debt crisis and persistent structural problems, Ireland with a fragile banking sector undermining economic credibility and adding a severe burden to acute public finance challenges and Portugal with a deteriorating competitiveness, an unstable financial sector and an increasing public debt.

The aforementioned countries due to severe economic conditions without parallel in their recent history requested financial assistance from the European Commission (EC), European Central Bank (ECB) and the International Monetary Fund

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(IMF) in an attempt to stop the economic downturn and bring their economies back on track. The three entities called "Troika" have answered to the call for cooperative financial assistance to Greece, Ireland and Portugal, based on a signed memorandum of understanding (MoU). The conditionality associated with MoU called for specific procedures and policies (mainly austerity measures associated with spending cuts, tax rate increases and public sector reform) to be implemented by the governments, a necessary condition for continuing receiving financial assistance.

Specifically, in response to insolvency concerns, on April 12, 2010, Troika committed to support Greece and on May 2, 2010 both entities agreed to the first MoU calling for financial assistance equal to 110 € billion. The Economic Adjustment Program aimed at supporting the Greek government's efforts to restore fiscal sustainability, implementing structural reforms and improving the competitiveness of the economy. Ireland on the other hand, on November 21, 2010 appealed for a rescue financial package, which on November 28, 2010 was announced to be 85 € billion, in an attempt to meet the mounting domestic banking problem, which at its peak was five times the size of the economy. Lastly, on April 7, 2011 the government of Portugal requested financial support and on May 3, 2011 negotiated an international bailout package equal to 78 € billion for the period of 2011 to mid-2014.

Based on the above events, we investigate whether the wide ranging financial support provided to the countries along with relevant policy implementations was instrumental in preventing further deterioration in their economic conditions, avoiding thus insolvency and bringing their economies back on a sustainable growth path. In particular, we analyze two different time segments, before and after MoU agreement, in an attempt to observe if the concurrence changed the statistical properties of the time series between the two periods. In testing this hypothesis the stock market general index for each country is employed in view of the fact that it is a forward looking indicator absorbing all available information and investors' expectations and confidence. Consequently, we calculate the market complexity by dividing the sample into two equal parts: the before-MoU period sample and the after-MoU period, each consisting of 300 trading days, sufficient to identify the changes (if any) in the market dynamics and complexity. As the middle point, for dividing the sample into two equal halves we employ the day of the appeal for international financial assistance. Therefore for Greece this is the 12th of April, for Ireland November 21st and April 7th for Portugal.

The stock exchange market – as a complex dynamical system – exhibits nonlinear properties and the stylized facts call for long memory, fat tails and multifractality [1–3]. Particularly in stock exchange time series, fat tails, power-law correlations and multifractality have been documented in a number of cases [4–7].

The purpose of investigating extreme events and in particular the effects of financial support under disruptive economic conditions is based on scientific evidence that such complex systems reveal their structure better when they are under stress than in normal conditions. According to Sornette [8], "such extreme events express more than anything else the underlying 'forces' usually hidden by almost perfect balance and thus provide the potential for a better scientific understanding of complex systems". Therefore, the examination of these economies under stress will shed light on the importance of world financial assistance and consequently on the influence of specific implemented policies on the state of the economies.

The effects of extreme events on the economy or on specific financial markets have received little attention thus far. A related study by Drozdz et al. [9] shows that by analyzing the 30 companies comprised by DAX, within a period of 11 years, drawdowns are always accompanied by a sizable separation of one strong eigenstate of the correlation matrix which, at the same time, reduces the variance of the noise state. The drawups on the other hand turn out to be more competitive. In this case the dynamics spreads more uniformly over the eigenstates of the correlation matrix, resulting in an increase of the total information entropy. Therefore, increases are more competitive, and less collective, and thus more nonlinearly correlated than decreases. Recently, Oswiecimka et al. [10] analyzed periods of upward and downward trends of the DAX index and showed that multifractal spectra are broader during the bull market than during its bear phase where the bear market is more persistent than the bull market irrespective of the sign of fluctuations.[1] D.-H. Wang et al. [12] study the statistical properties of the logarithmic returns of the CIB–CNY Composite Index. By dividing the effective exchange rate of the yuan into two portions — based on a change in the exchange rate regime they find that the two periods possess different degrees of multifractality.

Schmitt et al. [13] report that introduction of the euro had no influence on the statistical properties of the fluctuations of the euro–yuan exchange rate. By separating the sample into three smaller sections they could not find any clear difference in the scaling exponents. This shows that the introduction of the euro had no clear influence on the statistical properties of the fluctuations of the euro–yuan exchange rate. Oh et al. [14] analyze the Asian foreign exchange crisis and its impact on a number of currencies. By dividing the sample into two equal halves they find that some of the neighboring currencies were impacted greatly by the currency crisis in Thailand. Lastly, Siokis [15] analyzes rare events of the New York Stock Exchange Index. The effects of major stock market crashes were best illustrated by the multifractal spectra of the time series before and after the crash. Aftershock periods compared to foreshocks exhibit richer and more complex dynamics while the 1929 event has significantly more increase in multifractality than the 1987 crisis.

## 2. Methodology

We examine the nonlinear features of the Athens Stock Exchange (ASE) index, the Irish Stock Exchange (ISEQ) index and the Portuguese Stock Exchange (BVL) index. We use the multifractal concept as a feature of the financial complex systems

[1] An all around presentation of complex systems as well as review articles of related issues can be found in J. Kwapien and S. Drozdz [11].