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Credit market Jitters in the course of the financial crisis: A permutation entropy approach in measuring informational efficiency in financial assets

Fotios M. Siokis

University of Macedonia, Thessaloniki, Greece

HIGHLIGHTS

- Permutation entropy quantifiers unveil specific structure in U.S. Financial markets.
- Markets quickly affected by the crisis and around the credit crunch time period.
- Different dynamics are detected reflecting the intensity of market disruptions.
- Money markets are less uncertain whereas Bonds exhibit greater randomness.

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ABSTRACT

We explore the evolution of the informational efficiency for specific instruments of the U.S. money, bond and stock exchange markets, prior and after the outbreak of the Great Recession. We utilize the permutation entropy and the complexity-entropy causality plane to rank the time series and measure the degree of informational efficiency. We find that after the credit crunch and the collapse of Lehman Brothers the efficiency level of specific money market instruments' yield falls considerably. This is an evidence of less uncertainty included in predicting the related yields throughout the financial disarray. Similar trend is depicted in the indices of the stock exchange markets but efficiency remains in much higher levels. On the other hand, bond market instruments maintained their efficiency levels even after the outbreak of the crisis, which could be interpreted into greater randomness and less predictability of their yields.

1. Introduction

There is no doubt that the Great Recession was one of the most virulent periods in the history of the US economy. The burst of the housing bubble caused the worst financial meltdown since the Great Depression. Not only had greatly impacted the US economy, which according to NBER went into a recession in December 2007 and lasted until June 2009, but it was immediately transmitted to the World's financial markets. Consequently, the financial crisis led to a severely impairment of interbank money markets to an unprecedented decline of the liquidity in the fixed income securities, to a serious credit crunch and lastly to a vast turbulence in the stock exchange markets where security prices plunked extraordinarily. The meltdown in prices revived the debate of whether markets are truly efficient, and the celebrated Efficient Market Hypothesis received a concerted attack by many analysts, traders and market strategists. After all, a complex system such as the stock exchange market reveals its structure better when it is under stress.

E-mail address: fsiokis@uom.gr.

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Based on the Efficient Market Hypothesis (EMH), financial prices are described as efficient since they reflect all available information and follow a rather "Random walk" procedure where no one could gain systematically or above average return [1,2]. As the new information arises every day, the market immediately absorbs and incorporates this information into the securities prices. In other words, the stock market has no memory which means that yesterday's price change is not dictating and influencing the behavior of today's price change. But for the last couple of decades a number of economists had put into question the validity of the EMH especially during anxious times. In particular, the so-called dot com crisis – lasted for the period of late 1990 to early 2000 – had convinced many analysts of the existence of pricing irregularities in stock returns for at least a short time of period and consequently of the failure of the EMH.[1] As Grossman and Stiglitz [4] stated because information is costly, prices cannot perfectly reflect the information, which is available, because if it did those who spend resources to obtain it would receive no compensation.[2]

The EMH, which is associated with the idea of a "random walk", did not find supportive evidence in, Barkoulas and Baum [6] who investigated EMH for the US stock returns. In addition Lo and MacKinlay [7] rejected the hypothesis that stock prices behave as true random walk, based on short-run serial correlations which are not zero. Ito and Sugiyama [8] found that the inefficiency level varies through time in the US stock market. Di Matteo et al. [9] studied the scaling properties of daily Foreign Exchange rates, Stock Market indices and fixed income instruments utilizing the Hurst exponent. One interesting finding which is related to our investigation was the strong deviation of the scaling exponent for the 3 months maturity instrument, which according to authors was strongly influenced by the central bank decisions. Bariviera et al. [10] studied the informational efficiency of the corporate and sovereign bond markets of seven EU countries right after the outbreak of the financial crisis of 2007. By analyzing the evolution over time of the Hurst exponent, as a measure of long-range memory and using the DFA approach they detect different memory dynamics in corporate and sovereign bond series after the financial crisis. In particular, the crisis deteriorates the informational efficiency of corporate bonds and enhances the efficiency of the sovereign bond markets. Also the relationship of the degree of efficiency and the predictability in financial time series was a subject of investigation (Eom et al. [11]). By using the Hurst exponent concept for 60 different stock market indices they find a strong positive relationship between market efficiency and predictability.

The entropy concept and in particular the conditional entropy, was utilized by Zhang (1999) [12] in measuring stock exchange efficiency. Zunino et al. [13] used the complexity entropy causality plane, to distinguish the stage of stock market development. They have showed that developed markets exhibit higher permutation entropy and lower complexity values than the emergent markets and revealed the presence of significant time correlations and some degree of order. In addition, they report that the temporal correlations are the main factor of stock market inefficiency. In the same vein, Zunino et al. [14] utilized the complexity-entropy causality plane to unveil the presence of correlations in the daily values of bond indices of developed and emerging markets. They demonstrate that permutation entropy is higher for developed countries than for emerging ones, and market size is correlated with permutation entropy. Bariviera et al. [15] applied the same technique to detect changes in the underlying stochastic/chaotic process that governs the movements of interest rates and especially on Libor rate. Using sliding windows they reveal anomalous behavior in the Libor rate especially around the time of the 2007–2008 crisis. Zunino et al. [16] by applying permutation min-entropy dynamically analyzed the structure of the daily values of European corporate bond indices for the period of 2001 until 2015. They conclude that some sectors of the economy like financial services exhibit less information efficiency due to the 2008 crisis. Lastly, several works applied the entropy concept to quantify the efficiency level in various financial markets [17–21].

The aim of this paper is to study the evolution of the informational efficiency of representative instruments of the U.S. money, bond and stock exchange markets during anxious time. The analysis of such extreme events would provide helpful insights into underlying complexity of the financial system. By identifying the statistical properties of the financial market events under stress, we hope to enhance our understanding of the mechanisms determining the dynamics and to develop diagnostic models in predicting financial meltdowns. In particular we are interested in studying the behavior of the informational efficiency before and after the recent financial crisis of the Great Recession. We utilize the 1, 3 and 6 month yields of the Treasury Bills (TB), the 2, 5 and 10 year sovereign Bond yields and the three main stock exchange indices, namely the Dow Jones Industrial Average, the S& P 500 and the Nasdaq Composite Index. In order to evaluate the degree of informational efficiency we utilize a novel technique based on the entropy concept, which is defined in the next section.

The remainder of the paper is organized as follows. In the following section we describe the information-permutation theory. In Section 3 we describe the data used followed by the presentation and discussion of the empirical results obtained from the different instruments of the financial markets. In Section 4 we summarize the findings of the paper and conclude.

2. Methodology

2.1. Permutation entropy

In the information theory, entropy is used rather as a general concept and it is expressed in terms of a discrete set of probabilities. Therefore, in order to calculate the so-called entropy quantifier, for a specific time series, the associated probabilistic distribution should first be estimated. A number of methodologies have been proposed for estimating the

[1] Robert Shiller [3] Irrational Exuberance, Princeton, Princeton University Press, 2000.

[2] For an extensive discussion on Efficient Market Hypothesis (EMH) please read Burton G. Malkiel (2003) [5].