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Information transfer across intra/inter-structure of CDS and stock markets

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HIGHLIGHTS

- We examine trends of transfer entropy in credit default swap and stock markets.
- We analyze the information flow with various k, the Markov order in transfer entropy.
- The information transfer changes abruptly during the financial crises.
- Sudden changes in transfer entropy in CDS market precede those in stock market.

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ABSTRACT

We investigate the information flow between industrial sectors in credit default swap and stock markets in the United States based on transfer entropy. Both markets have been studied with respect to dynamics and relations. Our approach considers the intra-structure of each financial market as well as the inter-structure between two markets through a moving window in order to scan a period from 2005 to 2012. We examine the information transfer with different k, especially $k = 3$, $k = 5$ and $k = 7$. Analysis indicates that the cases with $k = 3$ and $k = 7$ show the opposite trends but similar characteristics. Change in transfer entropy for intra-structure of CDS market precedes that of stock market in view of the entire time windows. Abrupt rise and fall in inter-structural information transfer between two markets are detected at the periods related to the financial crises, which can be considered as early warnings.

1. Introduction

Over the past years, economic and financial system has become a research field of physicists with the aid of the tools and concepts of statistical physics, such as multifractal, complex networks, correlation function, and information theory [1–10]. Many empirical data from the economic and financial system have motivated a lot of studies into this field. Time series analysis based on the correlation between entities to identify properties of the system through the random matrix theory [11,12] or the network analysis [13,14] has been achieved. However, a correlation method is insufficient to reveal the causal relations between entities. Granger causality [15] has been used to investigate the causal relations between time series, which indicates if qualitative information flow exists or not without any quantitative aspect of information flow. Schreiber [16] proposed a new concept of transfer entropy, which measures the information quantity transferred as well as the directionality of information flow between two variables. Transfer entropy has been applied to the social media, dynamical systems, the study of the brain and the economic and financial systems [17–23]. In the research area of

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econophysics, Kwon and Oh applied transfer entropy to nine emerging or mature stock markets to find information flow between the market index and their components [24]. Kwon and Yang analyzed information transfer between the Dow Jones index, S&P 500 index and stock prices of selected 125 individual companies [25] and that between 25 stock indices to identify the information source [26]. Dimpfl and Peter used transfer entropy to quantify information flow between the credit default swap (CDS) market and the corporate bond market, analyzing the data of 27 iTraxx companies [27]. Sensoy et al. investigated interactions of the exchange rates and stock markets in several emerging countries by means of transfer entropy [28]. Kim et al. analyzed the various relations on five macro-economic variables – stock market index, exchange rate, industrial production index (IPI), consumer price index (CPI), and trade balance – for 18 countries using transfer entropy [29].

The aim of the paper is to use the transfer entropy to investigate financial systems in two aspects. First, we focus on information flow in two financial markets, stock and CDS market, and compare the outcome detected in the markets. CDS is a credit derivative which transfers the credit risk of a reference corporate to another company with some payment that would readily take the risk [30]. The protection and premium leg (paid by both parties respectively) can be determined from a CDS spread which is quoted with a contract and affected by the credit rating of a reference corporate. As many countries get to increase the liquidity of CDS, it can depict credit ratings of the reference corporates. CDS has been pointed out as one of the primary factors of occurrence of the 2008 financial crisis. This relationship makes it essential to examine the interactions between stock and CDS market. There have been studies on several financial markets in the crisis period, such as exchange rates and stock markets [28], CDS market and the corporate bond market [27] and the stock market only [21], while study on CDS and stock market with respect to the information flow between them has not briskly carried out. Such an analysis is crucial for risk management issue and investment as well as the dependence structure of two markets. Our observation points towards the lead–lag relation between stock and CDS market.

Second, we investigate the information flow in both markets with various k, the degree of a Markov process. In previous studies, k has been selected to a fixed value [25,26,31] or determined from mutual information [27]. We calculate transfer entropy with different k and compare the results in order to explore the k dependence of transfer entropy.

The paper is organized as follows. In Section 2, the data we treated and brief explanation for the transfer entropy are introduced. Section 3 presents our empirical results with brief discussions. Finally the conclusion will be provided in Section 4.

2. Data and methodology

2.1. Data

In this research, we use daily records of CDS spread and stock price of selected 96 companies in the United States which have been gathered from Bloomberg terminal. The period of the dataset is from January 3, 2005 to March 12, 2012. We adopt companies which had been announced as a CDS spread during the whole period we deal with. Since the number of companies contained in each ICB industry code is different, we employ the method of aggregate data [32] to construct adjusted time series for each sector. We apply it to each dataset of both CDS spread and stock price. First, we take the log returns for the constituent companies and calculate Pearson's correlation matrix for each industrial sector. We find out the eigenvectors and eigenvalues for the matrix. We use the components of the largest eigenvector as the weights for an index $I_i(t)$ for the particular industrial sector since the largest eigenvalue and the corresponding eigenvector can be interpreted as market-wide response of the market [11]. The index related to the collective behavior of a sector is constructed by

$$I_i(t) \equiv \sum_{j=1}^{k_i} R_j^i(t)\, \mathbf{u}_j^{1_i}, \tag{1}$$

where R_j^i is the log return series of the jth company which belongs to the sector i, $\mathbf{u}_j^{1_i}$ is the components of the largest eigenvector and k_i is the number of companies which belong to the sector i. The ICB industry codes used in this paper are as followings: oil & gas, $i = 1$; basic materials, $i = 2$; industrials, $i = 3$; consumer goods, $i = 4$; health care, $i = 5$; consumer services, $i = 6$; telecommunications, $i = 7$; utilities, $i = 8$; financials, $i = 9$; and technology, $i = 10$.

The next step in the analysis is the method of symbolic encoding. Since the transfer entropy only adopts discrete values, we partition the time series $I_i(t)$ into $A_i(t)$:

$$A_i(t) = \begin{cases} 1\,(\textit{fast decrease}) & \textit{for} \quad I_i(t) \le \mu - \sigma \\ 2\,(\textit{decrease}) & \textit{for} \quad \mu - \sigma < I_i(t) \le \mu \\ 3\,(\textit{increase}) & \textit{for} \quad \mu < I_i(t) \le \mu + \sigma \\ 4\,(\textit{fast increase}) & \textit{for} \quad I_i(t) > \mu + \sigma, \end{cases} \tag{2}$$

where μ is the mean and σ is the standard deviation of $I_i(t)$. It is known that an inaccurate transfer entropy can be obtained if too few bins are used [29,33]. Thus the symbolic encoding with four intervals is used in this paper [29].