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Effects of time dependency and efficiency on information flow in financial markets

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ABSTRACT

We investigated financial market data to determine which factors affect information flow between stocks. Two factors, the time dependency and the degree of efficiency, were considered in the analysis of Korean, the Japanese, the Taiwanese, the Canadian, and US market data. We found that the frequency of the significant information decreases as the time interval increases. However, no significant information flow was observed in the time series from which the temporal time correlation was removed. These results indicated that the information flow between stocks evidences time-dependency properties. Furthermore, we discovered that the difference in the degree of efficiency performs a crucial function in determining the direction of the significant information flow.

1. Introduction

Recently, researchers have become interested in the information flow occurring between financial assets or markets in an effort to understand the nature of the interaction between assets and the pricing mechanism in markets [1–22]. The relationship between spots and derivatives has represented the normal course of study, particularly the manner in which the derivatives that transact with future prices affect the spots [1,2]. The information flow from developed markets to emerging markets is also an issue in which active research is being conducted [3–7]. In addition, the information flow with regard to synchronization, integration and segmentation between financial markets by internal and external events has been assessed [8,9]. Previous studies have attempted to analyze financial data using statistical method including the Granger causality test, the VAR (vector-autoregressive) model, and the GARCH (generalized autoregressive conditional heteroskedasiticity) type [10–12]. However, studies regarding the factors that significantly affect information flow have proven insufficient. Therefore, we have attempted to determine empirically which factors are crucial to the information flow, considering particularly the following factors: the time-dependency property, and differences in the degree of efficiency.

According to the results of previous studies, the financial time series is time-dependent, and the time sequence exerts a significant effect on the information flow. That is to say, in financial markets, there exist many internal and external events

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which, as time passes, induce price changes via the interactions between stocks at the times that these events occur. In other words, the time scale of return performs a crucial function in the information flow. We have noted that the time scale of return corresponds to the time intervals, particularly when the prices are converted into the returns. Also, the efficiency of information is crucial to the pricing mechanism [23]. The price change in a given individual stock differs from that of others, even though the same information is both instantaneously and fully reflected. This suggests that the degree of efficiency differs for each stock. Therefore, the degree of efficiency significantly affects the information flow. The efficiency we assessed in this study is based on the weak-form efficient market hypothesis (EMH), which assumes that the similarity of past price change patterns are useful in predicting future price changes. We have utilized the approximate entropy (ApEn) method in order to observe the randomness in the time series [24]. The ApEn method quantitatively calculates complexity, randomness, and prediction power. As the frequency of similarity patterns in the price changes is high, both the randomness and the ApEn remain low. Previous studies have argued that the ApEn evidences significant information by which the degree of efficiency can be measured [25–27].

We have investigated individual stocks traded in the stock markets of Korea, Japan, Taiwan, Canada, and the USA. The entire interactions between stocks are considered, such that the number of interactions is $N(N-1)/2$, where N is the number of stocks. This technique provides sufficient information flow in the market, allowing us to discover the characteristics of information flow within the context of the whole market. We detected a negative relationship between the time scale of return and the frequency of significant information flow, which supports the notion that the information flow between stocks evidences a time-dependency property. Also, we discovered that the difference in the degree of efficiency between stocks performs a crucial function in determining the direction of the information flow.

In the next section, we describe the data and the methods of the test procedures employed herein. In Section 3, we present the results obtained in accordance with our established research aims. Finally, we have summarized the findings and conclusions of this study.

2. Data and methods

2.1. Data

We have assessed the daily closing prices of individual stocks traded in Korea, Japan, Taiwan, Canada, and the USA over a period of 15 years, from January 1992 to December 2006. However, we have excluded the industries which include four individual stocks or less, in order to obtain sufficient statistical analytical features. Therefore, we utilized the daily prices of 95 stocks listed on the KOSPI 200 market index of the Korean stock market, 175 stocks traded in the Nikkei 225 of the Japanese stock market, 132 stocks on the Taiwanese stock market index, 67 stocks on the TSX of the Canadian stock market, and 359 stocks in the S&P 500 market index of the American stock market. In addition, in order to observe sufficient information flow between stocks, we considered the whole links between stocks, in accordance with the formula. The numbers of whole links between stocks for each country are as follows: 4465 ($N = 95$) links for Korea, 15,225 ($N = 175$) links for Japan, 8646 ($N = 132$) links for Taiwan, 2211 ($N = 75$) links for Canada and 64,261 ($N = 359$) links for the USA. The returns, $R(t) = \ln(P(t)) - \ln(P(t-1))$, are calculated using the logarithmic change of the price, $P(t)$, in which is the stock price at t day.

2.2. The Granger causality model in the information flow

We investigated the empirical evidence in an effort to determine which factors affect the information flow between stocks. In order to find these factors, we have established the three following steps. First, we calculated the various returns according to the changes in the time scale; second, we calculated returns in which the various time scales apply to the causality model, considering the changes of lag length of the past data as independent variables of the model; and third, we evaluated the observed results of the information flow.

In the first step, we created a return series in accordance with the changes in the time scale, as considering the time-dependency property as a possible factor. The time scale k refers to the time intervals, when the prices are converted into the returns. The time interval varies from 1 day to 5 days ($k = 1, \ldots, 5$). The return R_k corresponds to the time scale k and is calculated by $R_k = \sum_{t=1}^{k} R(t)$.

In the second step, we employed the Granger causality model to determine the direction of the significant information flow. In this model, we determined the lag length l of the past data as independent variables, X_{t-l} and Y_{t-l}, in order to explain the current price changes as the dependent variables, X_t and Y_t. Using each return with various time scales, we have assessed the significant information flows as $X \Rightarrow Y$ and/or $Y \Rightarrow X$, considering the lag length of the past data change, $l = 1, \ldots, 5$, which can be defined as:

$$X \Rightarrow Y: \qquad Y_t = C + \sum_{l=1}^{L} \alpha_l Y_{t-1} + \sum_{l=1}^{L} \beta_l X_{t-1} \tag{1}$$

(The null hypothesis H_0 : X does not Granger-cause Y)