The directionality of the influence in financial markets by using volatility-constrained correlation

Tomoshiro Ochiai[1], and Jose C. Nacher[2]

[1]Department of Social Information Studies, Otsuma Women's University, 2-7-1 Karakida, Tama-shi, Tokyo 206-8540, Japan
[2]Department of Information Science, Faculty of Science, Toho University, Miyama 2-2-1, Funabashi, Chiba 274-8510, Japan

[1]ochiai@otsuma.ac.jp, [2]nacher@is.sci.toho-u.ac.jp

Abstract

Instabilities, fluctuations and crises are inherent features of complex systems such as financial markets. The financial markets influence each other but in the same way financial assets in each market can also determine the main trend of the fluctuations. It would be therefore useful to develop methods that allow us to identify the origin of instabilities and large fluctuations in markets. Although multiple attempts have been done, the directionality of the influence between assets has not been determined using standard correlation methods. In this work, we investigate the correlation between Japan's Nikkei stock average index (Nikkei 225) and other financial markets by proposing a volatility-constrained correlation metric. This metric reveals which asset is more influential than the other and allows us to reveal the directionality of the correlation effect. A theoretical model is also proposed to explain the observed empirical data.

Keyword: Econophysics, Correlation, Volatility

1 Background

The study of complex financial systems using statistical physics and computational methods is increasing thanks to the large volume of data and the availability of data at different time scales. The detailed analysis of market dynamics and correlations of financial products done by asset managers have led to new developments in the asset of financial management such as the tail risk and market crash risk strategies.

Regarding the price dynamics, a series of stylized facts have been discovered showing that markets trends follow well-characterized and predictable pattern when the appropriate metrics are taken into account [1]. The fat tailed return distribution, the absence of autocorrelations of returns, volatility clustering and the aggregational normality. Recent results have added the resistance and breaking-acceleration effects in foreign exchange market to the list of stylized facts [3].

The studies based on correlation analysis between financial assets are numerous and they have focused mainly in terms of the risk and portfolio managements. It has been found that the average correlation among U.S. stocks scales linearly with market stress [2]. This is reflected by the normalized Dow Jones Index Average (DJIA) returns. This finding shows that the correlation between assets become stronger than that in a normal state after the market volatility has increased in response to market stress such a bankruptcy that leads to financial crisis. However, these correlation based analysis have systematically ignored the directionality of the influence between financial assets.

2 Volatility-constrained correlation

In this study, we attempt to identify the directionality between of the influence between Japan's Nikkei 225 financial index and other markets such as the foreign exchange rate of U.S. Dollar and Japanese Yen (USDJPY) and the Dow Jones Index Average (DJIA).

By using real-data we statistically analyze the correlation between these markets using a novel metric that captures the asymmetric correlation phenomena.

It is well-know that, by definition, the standard correlation coefficient $Cor(A, B)$ (Pearson's correlation coefficient) of returns is symmetric by exchanging the two A and B variables. Therefore, a new definition of correlation is needed to be able to determine the directionality of the influence. Here, we propose a metric of correlation of returns that can be computed using a collection of pairs of returns constrained (or filtered) by its standard deviation. This metric contains an asymmetric feature

and allows us to identify which asset (A or B) affects more to the other (B or A), respectively.

By using this method, during crisis or market turbulences, not only the importance of interactions between the markets can be examined but also the directionality of the effects during contagion events. The data analysis shows that the Japan's Nikkei stock average index is more influenced by the Dow Jones Index Average and the foreign exchange rate of the US Dollar and Japanese Yen. Finally, a theoretical model is proposed to investigate the origin of the observed unidirectional correlation effect. The computer simulation of the model shows a fair agreement with observed data and suggests another way to explore directional correlations.

References

[1] R. N. Mantenga and H. E. Stanley, *An introduction to Econophysics*, Cambridge University Press, Cambridge, UK (2000).

[2] T. Preis, D. Y. Kenett, H. E. Stanley, D. Helbing and E. Ben-Jacob, Scientific Reports **2**, 752 (2012).

[3] J.C. Nacher and T. Ochiai, Phys. Rev. E **85**, 056118 (2012).

[4] T. Ochiai and J.C. Nacher, Physica A **393**, 364 (2014).