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Wavelet analysis of the co-movement and lead–lag effect among multi-markets

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HIGHLIGHTS

- The weekly frequency market indices of Japan, Singapore, Hong Kong and China are used.
- Both the co-movement and the lead–lag effect are investigated.
- The Morlet wavelet coherence model is employed.
- There exist a strong co-movement between stock markets of Japan, Singapore.

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ABSTRACT

Recent literature draws attention to the relationship of some financial markets, in particular, both the co-movement and the lead–lag effect. This paper examines the weekly frequency market indices of Japan, Singapore, Hong Kong and China over the period 2000–2013 using wavelet analysis. The Morlet wavelet coherence model is employed since it allows the simultaneous examination of co-movement and lead–lag effect between the two markets in both the time and frequency domains. Our results show there exist a strong co-movement between stock markets of Japan, Singapore, Hong Kong and China in the long run and Japan leads the other markets in the long term.

1. Introduction

Asian financial markets play an important role in a global finance. Historically, many areas, including Hong Kong, Singapore, South Korea, Taiwan, Vietnam, Thailand, India and China, began a period of rapid industrialization in the early 1960s that continued through the 21st Century. These nations entered the global marketplace by exporting mass-produced products and then, over time, many of them evolved their efforts to enter the high-tech arena. With the injection of large amounts of foreign investment capital, the Asian Tiger-Hong Kong, Singapore, South Korea and Taiwan, economies grew substantially between the late 1980s and early-to mid-1990s. In fact, Asian financial markets, particularly within developing economies, are still generally less mature and less regulated than markets in America or Europe. Moreover, regulatory reforms in Asian financial markets also lag Western markets, and political factors can play a role, particularly in less developed economies where government intervention can be heavy.

In fact, before the sub-prime financial crisis, many works have argued that China would decouple from the financial markets of developed countries in Asia. The argument was that the rise of China and an increase in intra-regional trade

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and financial transactions would lead to more integrated markets within the region. However, the sub-prime financial crisis has shown that Chinese economy remains strongly tied to other asian countries. The Chinese stock markets were volatile during the financial crises and have traded closely with the global markets during these periods. As a consequence, business cycles synchronization and stock correlations are expected to rise over time and across countries. Hence, it is reasonable to investigate the relationship of financial markets among China and other Asian countries.

The relationships between different stock markets includes causality, cointegration, co-movement, lead–lag effect and so on. Understanding interrelations among the various markets is therefore important to diversify risk and to derive high return. Among these relationships, the co-movement and the lead–lag effect are important relations. This is because that the analysis of both the co-movement and the lead–lag effect of stock market returns are key issues in finance as they have important practical implications in assert allocation and risk management. Co-movement, defined by Baur [1], means moving together and allows one to measure the relationship between variables in the time-frequency space. In fact, there is a great deal of interest, and a correspondingly large literature, on the co-movement among international financial markets. Bakshi et al. [2] find that co-movements of S&P 500 index options and futures often deviate from perfect positive correlation for call options and perfect negative correlation for put options. Resorting to wavelet analysis, Rua and Nunes [3] provides the co-movement measurement of stock returns for the major developed countries, namely Germany, Japan, United Kingdom and United States over the last four decades. Aslanidis et al. [4] provide evidence of co-movement in monthly US and UK stock returns by investigating time-varying correlations in returns since 1980. Madaleno and Pinho [5] consider the correlation analysis among some stock market indices using the Coherence Morlet Wavelet. Using the wavelet analysis, Li et al. [6] examine the relationship between the U.S. housing and stock markets over the period 1890–2012 and find the robust evidence of co-movement. Liu and Ouyang [7] propose the structural conditional correlation model to analyze the contagion mechanism between the stock markets of the United States and China. Using M-GARCH-DCC, Continuous Wavelet Transforms and Maximum Overlap Discrete Wavelet Transform, Najeeb et al. [8] examine co-movement dynamics of Islamic equity returns to identify international portfolio diversification opportunities. Andrieş et al. [9] investigate the co-movement of exchange rates from Central and Eastern European countries. Jiang et al. [10] consider the dynamic relationship between money growth and inflation in China by applying the wavelet analysis. The researches purporting to examine the relationship between exchange rates and stock prices have also been carried out in the context of different countries. For example, Abdalla and Murinde [11] state that stock prices Granger-cause exchange rates in the Philippines, but the opposite true for Korlea, Pakistan, and India. [12] found that exchange rates lead stock prices in South Korea; but the reverse true in Hong Kong, Malaysia, Philippines, Singapore, Thailand, and Taiwan. Moreover, there are number of researches regarding the co-movement in stock and energy markets (see, for example, [13–19]). Moreover, some general models have been proposed to better capture the features of underlying financial data, such as truncated levy models [20–23].

Although many empirical works on market co-movement have been provided, only a few works are done on the co-movement of Asian financial markets. For example, using the Morlet wavelet coherence and the daily frequency stock market indices of Shanghai, Shenzhen and Hong Kong, Wang et al. [24] examine co-movement and determine the most important role in the financial markets of China. Using the copula modeling approach, Lien et al. [25] investigate the co-movement and tail dependence between Chinese Yuan and New Taiwan Dollar non-delivery forward rates against the U.S. dollar. In fact, since the early 1990s, Hong Kong has became an international financial center, while the Shanghai stock market developed as the main board market in the mainland of China. Both the Korean financial market and Japanese financial market are developed markets. Moreover, the China financial markets have traded more closely with the Korean and Japanese markets in recent years. Understanding the dynamic co-movement between these Asian financial markets have important consequences on stock market return predictability, asset allocation and portfolio diversification. Therefore, it is necessary to investigate the co-movement and the lead–lag effect of financial markets among Japan, Singapore, Hong Kong and China.

This paper extends the existing literature on both the co-movement and the lead–lag effect of stock markets among Japan, Singapore, Hong Kong and China using wavelet coherence. The advantage of wavelet coherence is that the analysis allows a better understanding of the dynamics of the co-movement. The reason for abandoning Fourier analysis is that the time information is lost under the Fourier transform. Moreover, using the Fourier transform is hard to distinguish transient relations or to identify structural changes. Therefore, this technique is only appropriate for stationary time series and wavelet analysis emerges as an alternative. It is well known that wavelet correlation is achieving increasing popularity in financial time series analysis. Although other approaches for improved co-movement analysis (see e.g. [25] for copula-based dependence analysis) have been proposed, the wavelets have acquired the most attention. This is because that wavelet analysis performs the estimation of the spectral characteristics of a time series as a function of time, revealing how its different periodic components change over time. Moreover, the intelligent compromise between time and frequency dimensions of wavelet analysis gives researcher a possibility to separate new relationships from financial time series.

In fact, the wavelet transforms can be divided into the continuous wavelet transform (hereafter CWT) and the discrete wavelet transform (hereafter DWT). The CWT maps a function of time, the original time series, into a function of two variables-time and frequency-providing redundant information. This suggests that it might be possible to compute the wavelet transform for just a "careful" selection of values of the frequency and time parameters and still not loose any information (i.e. it is possible to recover the original time series from its transform). On the other hand, computing the transform for a very special discrete choice of the parameter values for time and frequency is the idea of DWT. This leads to a simple and efficient iterative scheme to compute the transform. The simplicity, ease of implementation and its very low