Continuous wavelet transform and rolling correlation of European stock markets

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ABSTRACT

The purpose of this paper is to assess the level of co-movements, contagion and rolling correlation between the stock markets of the PIIGS and those of the UK and Germany. We thus resort to a novel time–frequency approach, namely the continuous wavelet transform, and we analyze the co-movements of the stock index returns at different frequency-scales. We also test the influence of different macroeconomic factors on stock markets co-movements at different time–frequencies. The wavelet analysis results show that, in the short-run, the correlation level is high only during financial distress episodes, while in the long-run, the co-movements are present for the entire analyzed horizon. In addition, at low-frequency levels, the PIIGS stock markets are more correlated with Germany than with the UK. An opposite result is obtained at high-frequency decomposition levels. We also discover that the stock markets' correlation does not increase after all crisis events and depends on the wavelet decomposition levels.

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1. Introduction

The correlation of stock market returns represents an important topic for researchers in recent years and has been intensively studied in order to understand market behavior and to identify appropriate strategies for investment decisions, risk management and portfolio optimization. However, most of these studies focus on the time dimension of index returns, ignoring the importance of frequency-varying properties of their co-movements.

Under these circumstances, this paper explores the changing magnitude of equity index returns co-movements, using the Continuous Wavelet Transform (CWT), which combines time- and frequency-domain analyses. More precisely, we focus on the rolling wavelet correlation between the stock markets' index returns of the PIIGS (Portugal, Italy, Ireland, Greece and Spain) and of the largest European stock market (UK) and largest economy (Germany) at different frequencies. We focus on this in order to see how the correlation level between PIIGSs' stock markets and the more developed European markets evolves in crisis time. We therefore test if PIIGS' stock markets co-movements with Germany are stronger than those with the UK, given the fact that PIIGS and Germany are Euro area members, and it is assumed that the stock market integration is higher inside the Euro area

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(as Goetzmann, Li and Rouwenhorst (2005) state, the correlation level increases with the economic integration). We also want to see if the co-movements increase after particular crisis episodes. In addition, we explore the macroeconomic determinants of stock markets co-movements.

We discover that PIIGS stock markets are more closely correlated with Germany than with the UK in the long-run (low-frequency levels), while an opposite situation appears in the short-run. These findings can be explained by the fact that, in the long-run, the influence of macroeconomic fundamentals on stock market co-movements is stronger (for a discussion, see Cai, Chou & Li, 2009). On the one hand, it is well known that the business cycles' correlation of the UK and Euro area is weak. On the other hand, it is difficult to document the influence of macroeconomic fundamentals on the stock market co-movements in the very short-run, when investors are guided by noises and speculative actions. Hence, our results offer important insights for international-portfolio management decisions in times of crisis because they facilitate the understanding of financial-shocks' spillovers in the selected European stock markets.

This paper contributes to the existing literature in the following aspects. First, by applying the CWT, we examine the co-movements of the European stock markets in times of crisis in the time–frequency space. Based on this framework, we assess the level of rolling wavelet correlation and contagion between the decomposed time series, at different frequencies or cycles.[1] More precisely, using the wavelet power spectrum, we analyze the evolution of the stock market returns series, their volatility and jumps, which appear in different crisis moments. Furthermore, we apply the wavelet coherence to analyze the stock markets' co-movements, and the phase-differences in order to identify the lead–lag situations. Unlike the more usual time-series approaches, the wavelets allow us to observe nonlinearities and structural breaks in the series. Thus, the correlation level is assessed at different scales and at different moments in time.

This method is then useful in portfolio-management analysis, where agents who focus on daily movements interact in the stock markets, with agents concerned about longer time horizons (Rua & Nunes, 2009). The time–frequency approach considers the duration of a stock cycle. Thus, in order to assess the potential for risk diversification across stock market cycles, it is necessary to consider correlations over the duration of an entire typical stock market cycle and not only on a daily or monthly basis (for a discussion, see Candelon, Piplack & Straetmans, 2008).

Moreover, the wavelet approach offers the possibility to see whether the investment decisions based on Pearson's correlations are misleading or not. Besides the above-mentioned element, the wavelet methodology decomposes a time-series in different frequencies and thus presents considerable advantages over the traditional Dynamic Conditional Correlation Generalized Autoregressive Conditional Heteroskedasticity (DCC-GARCH) models, which dominated the literature in past years, and which assume that the correlation processes have a pre-specified dynamic behavior.

Second, we employ a dynamic, rolling wavelet correlation analysis, choosing a window size of 250 and 125 days for the robustness check. This technique gives us the possibility to compare the level of correlation before and after specific episodes of financial distress, during the recent financial crisis. Even if most of the related papers document increased co-movements during and after financial stress episodes, we should be aware of the fact that each crisis episode has its particularities and that co-movements can vary with the time–frequency scale.

Third, in line with Kiviaho, Nikkinen, Piljak and Rothovius (2014), we analyze whether macroeconomic factors explain the variations of co-movements at different time frequencies, using the wavelet squared coherency. However, different from Kiviaho et al. (2014), we test if macroeconomic fundamentals' co-movements, and not their level, have any influence on stock prices co-movements.

Fourth, we focus on the PIIGS stock markets' case, which is less debated in the literature. In the context of the recent financial turmoil, it is interesting to explore the contagion phenomenon between these stock markets and more developed European ones. In this regard, we compare the level of correlation of the PIIGS stock markets with the largest European stock market (UK) and with the stock market of the largest European economy (Germany), member of the Euro area. The comparison provides important information about the premises of the financial contagion inside the European stock markets, at different time–frequencies.

The rest of the paper is organized as follows. Section 2 presents the review of the literature on the topic of stock markets' correlation and contagion. Section 3 briefly describes the CWT methodology. Section 4 presents the data, the wavelet analysis and the rolling wavelet correlation results. Section 5 is dedicated to the comparison between the correlation level before and after financial turbulence periods, at different decomposition levels and time horizons. Section 6 intends to identify the macroeconomic determinants of stock markets co-movements. Section 7 concludes and highlights the implications of our findings.

2. Literature

Studying the correlation between international stock markets is important for several reasons. First of all, the co-movements of stock market returns are crucial for the risk assessment of investment portfolios. The portfolio theory sustains the necessity of investments diversification in order to avoid the negative impact of contagion and losses associated with a single category of assets (Markowitz, 1952). Thus, if the correlation between stock returns is strong, a loss in one stock is likely to be accompanied by a loss in other stocks as well. Therefore, the benefits of diversification grow higher when the correlation between stock returns is low. In other words, increased co-movements of stock market returns may diminish the advantage of internationally-diversified

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[1] In our case, the contagion is associated with an increase in the rolling wavelet correlation at high-frequencies levels of decomposition during and immediately after episodes of high turbulence. This formulation is in agreement with the popular definition of the contagion given by Forbes and Rigobon (2002). More recent studies bring to light the fact that the correlation increases when there is evidence of financial contagion.