Economic Modelling xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Economic Modelling

journal homepage: www.elsevier.com/locate/ecmod

Detecting nonlinear dependencies in eurozone peripheral equity markets: A multistep filtering approach☆

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ARTICLE INFO

Article history:
21 May 2015
30 January 2016
Accepted 3 February 2016
Available online xxxx

Keywords:
Nonlinear filtering
Multivariate GARCH
Spillovers
PIIGS markets

ABSTRACT

This paper assesses the presence of linear and nonlinear dynamic causal relations among the stock markets of the Eurozone peripheral countries, namely Portugal, Ireland, Italy, Greece and Spain (PIIGS countries). In addition to the pairwise analysis, this paper tests causality in a multivariate setting to take into account the effects of all variables by using a three-step multivariate filtering procedure. The paper also investigates the existence of nonlinear causal linkages of VAR/VECM filtered residuals to verify whether the observed causalities are strictly nonlinear and controls for conditional heteroskedasticity using a multivariate Dynamic Conditional Correlation (DCC) GARCH model to test the hypothesis of nonlinear noncausality. Most of the nonlinear causal linkages were purged after multivariate GARCH filtering, a fact which indicates that volatility effects primarily induce nonlinear causality. Yet in some cases that nonlinear links pertained, possibly peripheral stock returns may exhibit statistically significant higher-order moments. Our results may be useful in explaining a significant part of the (non)predictability of peripheral stock markets but more importantly in quantifying the process of financial markets and banking integration in the Eurozone.

1. Introduction

Stock markets around the world have grown more similar during the Great Moderation period, which translated into lower equity market volatility and led to a significantly lower asymmetry in reaction to macroeconomic events (Laopodis, 1998).[4] This period has witnessed a gradual abolition of trade barriers and controls of capital flows, leading to broadly deregulated and liberalized financial markets and more systematic interrelationships among the different financial markets. This dependence is synonym of a large similarity in reaction to financial crises or macroeconomic policies and gave rise to a rich literature exploring stock market linkages.

However, research on this issue has yielded mixed results depending on the adopted theoretical models, data, and methodologies. In this vein, Arshanapalli et al. (1995) and Hamao et al. (1990) provide evidence of strong integration among international stock markets, while Roca (1999) and Smyth and Nandha (2003) find that these markets are not well interlinked. Furthermore, the bulk of studies show that the US market clearly leads other developed financial markets (e.g., King and Wadhwani, 1990). For instance, Egert and Kocenda (2007) examine possible interdependencies between three Central and Eastern European stock markets and interrelationships between Western European and Central and Eastern European equity markets. Their results failed to establish robust cointegration relationships among these markets, but indicate short-run spillover effects between them in terms of stock returns and stock price volatility. Syriopoulos (2007) studied the potential dynamic linkages among main Central European (Czech Republic, Hungary, Poland and Slovakia) and developed (Germany and the US) stock markets. Using an ECVAR modeling to test cointegration relationships, the author's results suggest the presence of a stationary long-term relationship and the existence of a long-term equilibrium path. Strong linkages are only found between each of the Central European markets and mature markets. Kim et al. (2006) empirically

☆ The second author has received funding from the EU Horizon 2020 research and innovation program under the MS-C grant no. 656,136.

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[4] Many authors including Stock and Watson (2003) consider that the period of Great Moderation started in the mid–1980s to end in the early 2000s. This period was characterized by a very low GDP growth volatility of the G7 economies that was by far lower, between 50% and 80% compared with other periods.

http://dx.doi.org/10.1016/j.econmod.2016.02.001
0264-9993/

examine how the European Monetary Union (EMU) influences the dynamic process of equity market integration by using a bivariate EGARCH framework over the period from January 1989 to May 2003. Their results imply the existence of a shift in the integration of the European equity markets following the introduction of the EMU. The authors also show a unidirectional causality, underscoring the importance of the EMU for stock market integration. Moreover, they show that the macroeconomic convergence process due to the EMU and financial development partially drives the increase in global and regional equity market integrations over the period 1989–2003. Vo and Daly (2005) focus on the effect of the economic convergence associated with the EMU on the correlations across EMU stock market returns. The authors use data on seven European stock markets over the 1988–2003 period and employ cointegration, correlation, and causality techniques to describe the behavior of these market returns to answer the question of whether investing in European stock markets can be beneficial to foreign investors following the adoption of the EMU. Jansen and Nahuis (2003) analyze the short-term linkages between the stock markets of eleven European countries. The authors find a positive correlation between stock returns and changes in sentiment for nine out of these countries during 1986–2001. Serletis and King (1997) test for the number of common stochastic trends in ten European equity markets based on monthly economic indicators. They also use the time-varying parameter to measure the extent of convergence of these markets. Ratanapakorn and Sharma (2002) find no long-term relationship among the stock indices of the US, Asia, Europe, Eastern Europe -Middle East, and Latin America during the pre-Asian crisis period. However, for the crisis period, the authors observe one significant cointegrating vector and more short-term relations among the stock indices. They also show that the European markets tend to directly affect the US market during the Asian crisis, while the other regional markets seem to indirectly affect the US market through the European market.

The direction and nature of causal linkages in stock markets, whether linear or nonlinear, is an empirical issue. However, there are no clear-cut findings on the presence of other kinds of nonlinear relationships across equity markets. The empirical findings also vary depending on the methodology used to assess causality. For instance, Lee et al. (2004) apply EGARCH and VAR-based approaches to study information transmission between NASDAQ and Asian second board markets. They find a robust evidence of volatility-spillover effects from the United States to Asia. Bennett and Kelleher (1988), Engle and Susmel (1993) and Hamao, et al. (1990), among many others, provide evidence that US equity market returns and volatility appear to affect those of other economies and that lagged second moment (volatility) spillovers are found prevalent between major stock markets around the world. In the same spirit, King and Wadhwani (1990) show the presence of a global contagion during the crash in New York of October 1987. Using linear causality tests, Dornau (1998) and Peiro et al. (1998) study information transmission mechanism among three stock markets, specifically Germany, Japan and the United States. Baur and Jung (2006) study the decoupling between the US and German equity markets. The authors find that the two markets contemporaneously affect each other without the presence of lagged spillovers from previous days. In recent studies, Lee et al. (2013) illustrated various patterns of lead–lag relationships in stock and bond markets, and Lee and Chang (2013) showed that there is a significantly positive relationship between spillovers of currency carry trade returns and US stock market returns.

The importance of studying linear and nonlinear dependence for investors is paramount, also in conjunction with the presence of heteroskedasticity, unit roots, and structural breaks in the data. In particular, Narayan and co-authors have extensively mentioned this issue in their literature. For instance, in Westerlund and Narayan (2015), it is reported that estimates of exchange rates are important for practical purposes, such as the appropriate policy response, the setting of exchange rate parities, the stock market behavior, and the international comparison of national income levels. Interestingly, in the Westerlund and Narayan (2015) paper where new panel unit root tests are discussed, most of these tests have as the null hypothesis that FX rates or stock market indices have a unit root, which seems like a rather natural formulation. The problem lies with alternative hypothesis, which is typically formulated as that at least some of the market returns are stationary. Furthermore, Narayan et al. (forthcoming, 2015a) in their work stress the importance of inherent heteroskedasticity in financial time series. They mention clearly that studies on structural break unit root tests are based on standard linear models, i.e., with iid innovations. This assumption is inappropriate for modeling unit roots if there is heteroskedasticity. Following this, some studies (e.g., Chan and Wei, 1988; Kim and Schmidt, 1993b; Lucas, 1995; Herce, 1996; Seo, 1999; Ling and Li, 2003) consider testing for unit roots with non-iid errors. They argue that unit root testing models that do not account for heteroskedasticity are likely to suffer from over rejection of the null hypothesis of a unit root, thereby affecting considerably the nature and directionality of detected causalities. To remedy this, Narayan et al. (forthcoming, 2015a) propose a generalized autoregressive heteroskedasticity (GARCH) model that allows for endogenous breaks, leverage effects and fat tails in the data series. In accordance with their study we have included a DCC-GARCH multivariate heteroskedastic modeling approach accompanied by a unit root analysis. It is well-known that time-varying correlation GARCH modeling accounts for the presence of structural breaks therefore does not suffer from over rejection of the null of a unit root. Also, it incorporates leverage effects and fat tails presence in the series.

Furthermore, Westerlund and Narayan (2015) dealt with the question of above-normal profitability for investors based on the detected causalities. Westerlund and Narayan's (2015) approach builds on the link between technical trade and the order of integration of the price of the underlying asset. Their results are in accordance with Ratner and Leal (1999), namely, that as technical trading strategies attempt to benefit through the identification of directional patterns in past price data, trading strategies would be ineffective if markets truly followed a random walk. In their paper, Narayan et al. (forthcoming, 2015a) claimed that investors are willing to pay different amount of fees to extract information related to the nature of causalities, albeit conditional on whether or not stock prices are mean reverting. These are fresh insights on investor behavior from the point of view of market efficiency. Finally, in the Westerlund and Narayan (2015) paper, the authors concluded that for technical trade to be effective, it has to be based on prices that are stationary, which in the current context means stationary stock market returns, namely, for PIIGS in our study.

Our study contributes to the literature in several ways. First, prior literature on stock market co-movements mainly relies on the Granger causality test (Granger, 1969). One of the assumptions of this test is that it supposes that the conditional mean is set as a parametric linear time series model. Its appealing side is that it consists in testing whether the lags of one variable enter into the equation for another variable. While this test performs well when applied to linear models, it fails when data exhibit nonlinear properties. Baek and Brock (1992), for instance, show a lower power for the parametric linear Granger causality tests when compared to nonlinear alternatives. The literature proposes many nonparametric causality tests. One example is the modified version of the Baek and Brock (1992) test that was developed by Hiemstra and Jones (1994). This test is for nonlinear dynamic relationships and is able to test the presence of nonlinear Granger-causal relations between variables by assessing whether the past values of a given variable affect its present and future values.

Second, the main objective of this study is to assess the presence of linear and nonlinear causal linkages i.e., the nature and directionality of interdependencies among the Eurozone peripheral countries. The principal reason for studying the PIIGS markets is that they behave differently from other Western European markets since they were shaken by the recent major sovereign debt crisis that unfolded at the end of 2009. Hence, it might be more useful to analyze their interrelationships

Please cite this article as: Avdoulas, C., et al., Detecting nonlinear dependencies in eurozone peripheral equity markets: A multistep filtering approach, Econ. Model. (2016), http://dx.doi.org/10.1016/j.econmod.2016.02.001