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Conditional dependence between international stock markets: A long memory GARCH-copula model approach

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ABSTRACT

In this paper, we investigate the relationship between the major international stock markets by taking into account for the long memory in volatility feather under structural shifts. We use the long memory-GARCH-Skewed Student-t models for the marginal distribution modeling and copulas functions for the dependence structure investigation. Using daily international stock market data from 2003 to 2017, the empirical results show that the long memory GARCH-copula models are more appropriates than standard GARCH-copulas in dependence modeling. Moreover, results indicate that the dependence structure increase during the global financial and European debt crisis. Furthermore, a Value-at-Risk application shows that the long memory-GARCH-copula provides more accurate multivariate market risk estimation. Therefore, dependence structure between stock markets is affected by long memory in volatility. These findings have important implications for investors interested in international stock markets for portfolio diversification, risk management, and international asset allocation.

1. Introduction

Modeling the dependence structure between financial assets become one of the most interesting task for academics, fund managers, policymakers and investors, due to its implications for several financial applications. Indeed, modeling dependence is an essential tool for international diversification, risk management, asset pricing and asset allocation. Then, understanding the true dependence between portfolio components helps investors to implement the optimal portfolio diversification and the effective hedging strategy. Additionally, the dependence between assets is an interesting parameter in risk management in the sense that market risk measure, based on Value-at-Risk (VaR) concept, requires modeling dependence between assets returns.

The Modern Portfolio Theory are based on the normality hypothesis, whether for the portfolio or for these components. Moreover, the dependence between these components was, for a long time, measured by the linear correlation coefficient. However, many recent studies argue that the normality hypothesis could not be accepted by finding significant skewness and kurtosis excess caused by markets extreme events such as crisis and regulations. This characteristic can then influence

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the dependence structure between assets. In this context, the recent literature argues that dependence between portfolio components could not be described by linear correlation coefficient. So, dependence structure modeling becomes more and more a difficult task due to the increased volatility and the complex dynamics of financial assets prices. Thus, more sophisticated econometric framework should be used to investigate the real dependence structure between financial assets, especially for stock markets returns.

In the dependence modeling exercise, several approaches have been adopted. However, the most part of the empirical studies use copula theory (Jondeau and Rochkinger, 2006; Righi and Ceretta, 2013; Charfeddine and Benlagha, 2016; Reboredo and Ugolini, 2016; Aloui and Ben Aïssa, 2016; Kayalar et al., 2017, among others). Other authors use the multivariate generalized autoregressive conditional heteroscedasticity (GARCH) framework (Jain and Biswal, 2016; Ben brayek et al., 2015; Truchis and Keddad, 2016). Another methodology was also used to model linkages between financial assets includes the causality and cointegration analysis (Zhang and Wei, 2010; Sari et al., 2010; Ding et al., 2016). Among these approaches, the copula theory takes an interesting framework. Indeed, this approach allows separating the joint distribution from its margins and capturing the non-linearity in the dependence between financial assets. Moreover, copula functions examples are multiples and allow for asymmetric time-varying dependence modeling.

In the context of stock markets dependence modeling, copula theory was largely used in the literature. For instance, Longin and Solnik (2001) use copula theory to investigate the dependence across international equity markets. Hu (2006) employs a mixture copula to investigate the dependence of international stock markets. Jondeau and Rockinger (2003, 2006), Mendes and Kolev (2008), Sun et al. (2009), Ignatievay and Platen (2010) and Chollete et al. (2011) use copulas to study the dependence structure between American and other developed stock markets. Main results of these studies indicate that copula functions are successful tools in dependence modeling task. Nguyen and Bhatti (2012) study the dependence between six international stock markets. Basher et al. (2014) investigate the dependence patterns of returns across six GCC stock markets over the period 2004–2013. They show that GCC stock markets are characterized by volatility persistence and asymmetric dependence. They find also that Abu Dhabi and Dubai stock markets appear as the primary source of asymmetric dependence across the GCC equity market pairs. More recently, Yang et al. (2015) study the relationship between developed, emerging and frontier markets, using the hierarchical Archimedean copula model. Charfeddine and Benlagha (2016) examine the time-varying conditional dependency between commodity markets and international stock markets by applying the rolling-sample technique on the dependence parameter of copula. Many other studies focused on the relationship between stock markets, their findings show the performance of copula functions in modeling dependence structure (see for examples Bekiros and Georgoutsos, 2008; Long et al., 2014; Yang and Hamori, 2013; Zhang et al., 2013; Baumöhl and Lyócsa, 2014; De Groot et al., 2012; Samarakoon, 2011). All these works, among others, show that dependence structure between stock markets returns could not be linear and the linear correlation coefficient is not appropriate to measure this dependence structure.

However, modeling dependence by copula is sensitive to marginal model assumption (Fantazzini, 2008). That is to say, taking into account the stylized facts of financial series like heteroscedasticity, autocorrelation, volatility asymmetry and long memory feathers could offer a more sophisticated framework to better understand the true dependence structure between stock markets returns. In several works, the use of GARCH-copula approach was a successful tool in dependence modeling (Jondeau and Rockinger, 2006; Yang and Hamori, 2013), but they are unaware of the long memory property in marginal distributions modeling.

In this context, several studies focused on the long memory phenomenon in dependence structure modeling problem. For examples, Mendes and Kolev (2008) investigate the effects of long and short rang memory on dependence structures of emerging markets co-exceedances. They find some changes on the dependence structure due to long memory feature. More recently, Janus et al. (2014) studies long memory (fractionally integrated) dependence in daily financial returns of four Dow Jones equities. The overall performance of the new model is better than that of several well-known competing benchmark models. They find that the degree of memory in the volatilities is similar, while the degree of memory in correlations between the series varies significantly. Gong and Zheng (2016) propose a fractionally integrated stochastic copula model to capture long memory in asymmetric dependence in testing the aluminum futures markets of London Metal Exchange and Shanghai Futures Exchange. Boubaker and Sghaier (2013) examine the effect of the presence of long memory on the dependence structure between financial returns and on portfolio optimization. They find empirically that the long memory affects the dependence structure and portfolio variance minimization.

However, all of these studies do not investigate the ability of long memory-GARCH-copula models to capture certain extreme events. Thus, to overcome this shortcoming, we propose to use the fractionary integrated or long memory models to specify the marginal distribution. To our knowledge, the long memory feather, as a well-known stylized fact in financial asset's volatility, could affect dependence structure (Mendes and Kolev, 2008; Boubaker and Sghaier, 2013). Then, we employ these types of models for two objects. Firstly to study the contribution of long memory-copula in dependence structure modeling, secondly to investigate the impact of long memory phenomena on dependence structure and on market risk estimation in a multivariate context. For this ending, we use a FIGARCH-copula and FIEGARCH-copula as alternatives specifications to the standard GARCH-copula approach in the conditional dependence modeling between the major international stock markets. Moreover, we based our analysis on a period covering two international crises to see how long memory-GARCH-copula models are able to capture certain extreme events. So, this paper contributes to the exiting literature in many ways. First, we extend the use of copula in the stock markets relationship analysis by considering long memory feature and structural changes simultaneously. Second, for the best of our knowledge, this is the first time that the effect