Expert Systems With Applications 46 (2016) 164–179

Contents lists available at ScienceDirect

Expert Systems With Applications

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

Tail dependence structure of the foreign exchange market: A network view

Gang-Jin Wang[a,b,c,*], Chi Xie[a,b]

[a] College of Business Administration, Hunan University, Changsha 410082, China
[b] Center of Finance and Investment Management, Hunan University, Changsha 410082, China
[c] Center for Polymer Studies and Department of Physics, Boston University, Boston, MA 02215, USA

ARTICLE INFO

Keywords:
Dependence structure
Foreign exchange market
Network
Copula
Cluster analysis
Community structure

ABSTRACT

Tail dependence of financial entities describes when the price of one financial asset has an extreme fluctuation (e.g., price sharply rises or falls), the degree of its effect on the price fluctuation of another asset. Under the background of the global financial crisis, tail dependence structure of financial entities plays an important role in financial risk management, portfolio selection, and asset pricing. In this paper, we propose a concept of tail dependence networks to investigate the tail dependence structure of the foreign exchange (FX) market. Lower- and upper-tail dependence networks for 42 major currencies in the FX market from 2005 to 2012 are constructed by combing the symmetrized Joe-Clayton copula model and two filtered graph algorithms, i.e., the minimum spanning tree (MST) and the planar maximally filtered graph (PMFG). We also construct the tail dependence hierarchical trees (HTs) associated with the MSTs to analyze the currency clusters. We find that (1) the two series of lower- and upper-tail dependence coefficients present different statistical properties; (2) the upper-tail dependence networks are tighter than the lower-tail dependence networks; and (3) different currency clusters, cliques and communities are respectively found in the two tail dependence networks. The key empirical results indicate that market participants should consider the different topological features at different market situations (e.g., a booming market or a recession market) to make decisions on the investing or hedging strategies. Overall, our obtained results based on the tail dependence networks are new insights in financial management and supply a novel analytical tool for market participants.

© 2015 Elsevier Ltd. All rights reserved.

1. Introduction

The dependence structure of financial markets is a key and debatable issue for financial economists, regulators and investors. It is the useful and important information for some financial activities, such as international portfolio's diversification and risk management, derivative pricing, and market integration (Buccheri, Marmi, & Mantegna, 2013). For example, how to select financial assets in the international portfolio diversification is the crucial step, which needs to examine the dependence of financial asset returns and check whether they have the dependence hierarchical or clustering structure. As such, a growing number of methods are developed to capture the dependence structure among different financial asset returns, while the dependence (or correlation) network analytical tool is one of the most popular and widely used approaches (see, e.g., Brida, Gómez, & Risso, 2009; Brida & Risso, 2010; Fenn et al., 2012; Kwapień & Drożdż, 2012; Kwapień, Gworek, & Drożdż, 2009; Mantegna, 1999; Tumminello, Lillo, & Mantegna, 2010; Wang, Xie, Chen, & Chen, 2013a; Wang, Xie, Han, & Sun, 2012). Different approaches can be used to build the dependence network, such as the minimum spanning tree (MST) approach (Mantegna, 1999), the planar maximally filtered graph (PMFG) method (Tumminello, Aste, Matteo, & Mantegna, 2005), and the correlation threshold method (Boginski, Butenko, & Pardalos, 2005; Onnela, Kaski, & Kertész, 2004), which are designed to select or filter the information presented in the dependence (or correlation) matrix. In other words, before constructing the financial networks, one should build the dependence matrix of the financial asset returns by the dependence measure, while the common practice of the dependence measure is chosen as the Pearson's correlation coefficient (PCC). Although PCC is easy to calculate and widely used, some questions are posed on the practice of using PCC as a universal dependence measure (see, e.g., Rachev, Fabozzi, & Menn, 2005; Wang et al., 2012; Zebende, 2011; Zhou & Gao, 2012). There are at least two drawbacks for PCC as follows. (1) The theoretical assumption of PCC is that the joint distributions of time series

* Corresponding author at: College of Business Administration, Hunan University, Changsha 410082, China. Tel.: +86 731 88823890; fax: +86 731 88823670.
E-mail addresses: wanggangjin@hnu.edu.cn, wanggangjin@foxmail.com (G.-J. Wang), xiechi@hnu.edu.cn (C. Xie).

http://dx.doi.org/10.1016/j.eswa.2015.10.037
0957-4174/© 2015 Elsevier Ltd. All rights reserved.

obey Gaussian distribution. However, a large deal of evidence shows that the dependence between different financial asset returns is non-Gaussian (see, e.g., Bae, 2003; Durante, Foscolo, Jaworski, & Wang, 2014; Wang, Xie, Zhang, Han, & Chen, 2014). A good instance is that the dependence of financial asset returns during a recession is larger than during a boom (Zhou & Gao, 2012). Besides, many studies report that the dependence of financial markets comes to a remarkable peak during the largest market shocks and financial crises (see, e.g., Aste, Shaw, & Di Matteo, 2010; Podobnik, Wang, Horvatic, Grosse, & Stanley, 2010; Wang, Xie, Chen, Yang, & Yang, 2013b). (2) PCC is defined to quantify the linear correlation for the whole range of sample. It ignores the fact that the real world data are characterized by a high level of heterogeneity (Wang et al., 2013b). Namely, it neglects the difference between extreme and commonplace observations. It is a fact that as the frequency of financial crisis doubled in recent years, the extreme returns of financial time series occurred increasingly. Therefore, PCC may lose effectiveness and be misleading if the investigated asset returns are heterogeneous and the extreme returns show different patterns of dependence from the remaining returns (Zhou & Gao, 2012). In a word, the previous dependence network methods cannot accurately detect the dependence structure of financial markets, especially during the financial crises (e.g., US sub-prime crisis, 2008 financial crisis, and European debt crisis).

To overcome the shortcomings of linear correlation functions (e.g., PCC), scholars resort to a powerfully and widely used tool—copulas proposed by Sklar's (1959). Copulas are flexible and effective tools to measure dependence structure between two or more variables and model any type of multivariate distributions, which go beyond the linear correlation. Specifically, they allow for the tail dependence that represents the level of dependence among the tails of financial asset distributions (Sun, 2013; Zhou & Gao, 2012). In detail, tail dependence refers to the level of dependence in the lower and upper quadrant tails of a bivariate distribution, so it is a suitable measure of the dependence of extreme events. That is to say, tail dependence can be divided into two measures, namely the lower-tail dependence and upper-tail dependence, which are used respectively to investigate the joint extreme events in financial asset returns during the market downturns and market upturns (Hu, 2010). However, in the common practice of measuring dependence, people usually ignore the extreme returns that hide in the tails and the tail dependence among financial asset returns, which is dangerous for investment portfolios and other financial activities especially during the market downturns. So, more attentions should be paid to the tail dependence of financial markets. Unfortunately, to the best of our knowledge, very little of the existing research considers the tail dependence of the foreign exchange (FX) market from a network point of view.

Therefore, the aim of this paper is to propose a concept of tail dependence network by combing copulas and two network methods (MST and PMFG) for investigating the tail dependence structure of the FX market. We focus our study on the topology and clustering of tail dependence networks (i.e., lower-tail dependence network and upper-tail dependence network) of the FX market. We choose the FX market as the research object because it is the largest and most liquid financial market that directly or indirectly influences all other financial markets (Wang et al., 2014), and thus is a good representative for financial markets. In practical terms, we select the daily FX rates of the set of 42 major currencies in the FX market during the period 2005–2012 as the empirical data. The procedure of constructing the lower- and upper-tail dependence networks mainly consists of three steps.

Firstly, we compute the lower- and upper-tail dependence coefficients among 42 major currencies by a copula method. In this step, we first use the AR(1)-GARCH(1,1)-t model to characterize the marginal distributions of FX rate returns and then employ the symmetrized Joe-Clayton (SJC) copula proposed by Patton (2006) to calculate the lower- and upper-tail dependences. The motivations that lead us to choose the SJC copula to analyze the tail dependence structure of the FX market can be summarized as follows (Sun, 2013; Zhou & Gao, 2012). (1) SJC is a flexible copula approach to modeling the tail dependence because it can accommodate different types of dependence patterns that range from tail dependence to tail independence for both the lower and upper tails. (2) It allows for the asymmetric tail dependence and nests symmetry as a special case. More recently, the SJC copula has been widely applied in finance and economics (Basher & Nechi, 2014; Hammoudeh, Mensi, Reboredo, & Nguyen, 2014; Hoesli & Reka, 2015; Huang & Wu, 2015; Jammazi, Tiwari, Ferrer, & Moya, 2015; Ning, Xu, & Wirjanto, 2015; Yang & Hamori, 2014a). For example, Basher and Nechi (2014) study the tail dependences across Gulf Arab stock markets by the SJC copula and find that the lower-tail dependence is larger than the upper-tail dependence. Yang and Hamori (2014a) use the SJC copula to examine the tail dependence structure between gold prices and FX rates and observe that the upper-tail dependences of GBP/gold and JPY/gold are greater than the lower-tail dependences. Hoesli and Reka (2015) investigate the tail dependences between REIT and stock markets by the SJC copula and further research their contagion channels. Jammazi et al. (2015) analyze the tail dependences between stock and government bond returns for various countries and find that the tail dependences for most countries are asymmetric. From the aforementioned literature, we conclude that the JSC copula is a powerful tool to investigate the tail dependence structure of financial entities, which motives our choice for the SJC copula.

Secondly, on basis of the lower- and upper-tail dependence coefficients of the set of 42 currencies in the FX market, we construct the lower- and upper-tail dependence matrices, which are denoted as $\mathbf{T}^L$ and $\mathbf{T}^U$, respectively. Then, we transform the two tail dependence matrices into lower- and upper-tail distance (or dissimilarity) matrices, which are labeled as $\mathbf{D}^L$ and $\mathbf{D}^U$, respectively.

Finally, we transform the two tail distance matrices into lower- and upper-tail dependence networks by the MST and PMFG approaches, which are respectively called as lower- and upper-tail dependence MSTs and PMFGs. The choice of the MST and PMFG methods is motivated by the following reasons. On the one hand, the MST is a simple and robust method, which connects N nodes with $N-1$ stronger edges such that no loops are produced (Onnela, Chakraborti, Kaski, Kertesz, & Kanto, 2003; Wang et al., 2013a). On the other hand, the PMFG maintains the hierarchical structure of the MST but contains more information in comparison to the MST, which links N nodes with $3(N-2)$ edges (Tumminello et al., 2005). At the same time, we also present the lower- and upper-tail dependence hierarchical trees (HTs) associated with the MSTs to analyze the hierarchical structure of the FX market. Since Mantegna (1999) proposes the MST and Tumminello et al. (2005) develop the PMFG to study the dependence structure of financial entities, these two approaches are frequently chosen for construing financial networks (see, e.g., Birch, Pantelous, & Soramäki, 2015; Ji & Fan, 2014; Mai, Chen, & Meng, 2014; Matesanz & Ortega, 2014; Matesanz, Torgler, Dabat, & Ortega, 2014; Wang & Xie, 2015; Wang et al., 2014; Yan, Xie, & Wang, 2015). For instance, Matesanz and Ortega (2014) investigate the co-movements of 28 major currencies in the period of 1992–2002 in the FX market via combining the phase synchronous coefficient and MST. Ji and Fan (2014) study the topological network of 24 major crude oil markets from 2000 to 2011 by using the MST and HT tools and find that the global crude oil markets are clustered by geographical and organizational features. Matesanz et al. (2014) construct the HT and MST network for a sample of 32 commodity prices during the period 1993–2010 to examine the co-movement of commodity markets. Mai et al. (2014) analyze the constituent stocks of China Securities Index 300 (CSI 300) from 28 September 2009 to 30 March 2012 and build the PMFG network for the CSI 300 market, in which the CSI 300 market is found as a scale-free network. Wang and Xie (2015) construct the HT, MST and PMFG networks of 20 country indices in international real

Download English Version:

https://daneshyari.com/en/article/382215

Download Persian Version:

https://daneshyari.com/article/382215

Daneshyari.com