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Diversification evidence from international equity markets using extreme values and stochastic copulas

M. Ishaq Bhatti[a,*], Cuong C. Nguyen[b,1]

[a] Department of Finance, La Trobe Business School, La Trobe University, Melbourne, Vic 3086, Australia
[b] Department of Accounting, Economics and Finance, Lincoln University, Lincoln 7647, Christchurch, New Zealand

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ABSTRACT

Tail dependence plays an important role in financial risk management and determination of whether two markets crash or boom together. However, the linear correlation is unable to capture the dependence structure among financial data. Moreover, given the reality of fat-tail or skewed distribution of financial data, normality assumption for risk measure may be misleading in portfolio development. This paper proposes the use of conditional extreme value theory and time-varying copula to capture the tail dependence between the Australian financial market and other selected international stock markets. Conditional extreme value theory enables the model adequacy and the tail behavior of individual financial variable, while the time-varying copula can fully disclose the changes of dependence structure over time. The combination of both proved to be useful in determining the tail dependence. The empirical results show an outperformance of the model in the analysis of tail dependence, which has an important implication in cross-market diversification and asset pricing allocation.

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1. Introduction

The international financial markets have become closely integrated since regulations and barriers have been gradually removed over the past years. This provides investors an opportunity to optimize

* Corresponding author. Tel.: +61 3 9479 2715.
E-mail addresses: i.bhatti@latrobe.edu.au (M.I. Bhatti), Cuong.Nguyen@lincoln.ac.nz (C.C. Nguyen).
[1] Tel.: +64 3 321 8306.

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portfolios by higher returns and lower risk. One of the problems of measuring the risk of a portfolio is to model joint distribution of individual risk factor returns affecting portfolio during a specific period. The joint probability distribution plays a key part in determining dependency among variables. The normal distribution has long dominated the multivariate analysis of statistical modeling in the area of financial risk management. The joint normal distribution was usually assumed in risk analysis because the association between any two random variables can be fully described given the normal marginal distributions and the correlation coefficient which measures the dependence between variables.

However, due to the existence of skewness and kurtosis in financial data, the heavy tails abnormality has been found in financial time series data (Dacorogna and Picctet, 1997; Danielsson and Vries, 1997, 2000). Zivot and Wang (2006) explored the problem of abnormality in BMW and Siemens returns showing that normal distribution cannot capture tail dependence. The alternative multivariate distributions have been investigated in response to the fat-tail problem which might not fully capture dependence structure which expresses the co-movement between variables.

The answer to the problem resorts to Sklar (1959) copula theorem to separate marginal effects from dependence structure. Using the copula model has several advantages in modeling dependence compared to using the joint distribution directly. First, copula functions are very flexible in modeling dependence since they allow to separately model marginals and the corresponding dependence structure. Second, copula functions enable us to directly model tail dependence; and they signify not only the degree but also the structure of the dependence. Third, copula functions are invariant under transformations of the data while the linear correlation is not. Therefore, its flexibility in model specification enable the use of any specified marginal distributions to join with any available copulas, thus creating complex non-normal distributions which can fully capture dependency. Importantly, some copulas can help model tail dependence or co-movements among financial variables. Patton (2006) has extended copula theory to time-varying conditional copula theory, which allow copula parameters to vary over time in terms of evolution equations. This model proves to be informative in analyzing the dynamics of dependence structure, providing better understanding of the fluctuation of dependence over time.

Modeling dependence structure using copula is introduced by a number of authors, including Fantazzini (2007), He (2003), Mendes and Souza (2004), Canela and Collazo (2005), Giacomini and Hardle (2005), Junker and May (2005), Hu (2006), Ane and Labidi (2005), Rosenberg and Schuermann (2006), Ozun and Cifter (2007), Rodriguez (2007), among others. The marginal distributions are modeled separately and then combine with a copula function, which is a multivariate distribution with uniform marginals. According to Nelsen (2006), there is a unique copula representing the dependence structure for every multivariate distribution with continuous marginals. Therefore, modeling marginal distributions before joining them with copula is also an important step since adequate univariate distributions would bring better results for dependence structure after using copula functions.

There are many methods modeling univariate distributions in statistics literature, in which extreme value distributions have been used most in risk analysis because they are based on sound statistical theory and offer parametric form for the tail of a distribution (McNeil and Frey, 2000). With interest of modeling tail dependence for risk management, the paper adopts an approach of combining conditional extreme value theory (C-EVT) and copula theory to capture the dependence structure between financial variables. C-EVT is based on the idea that the conditional return distribution can be easily constructed from the estimated distribution of the residuals and estimates of conditional mean and volatility (GARCH). As results in McNeil and Frey (2000) and Ghorbel and Trabelsi (2007), using C-EVT-based methods will reflect two stylized facts exhibited by most financial return series, namely stochastic volatility and the fat-tailedness of conditional return distributions. The dependence structure, then, will be figured out after joining C-EVT marginals with any available copulas.

Recently, He (2003) used EVT-copula model to capture dependence between equities and found that the copula-base model outperforms others in risk analysis, especially Value-at-risk (VaR) computation. Clemente and Romano (2003) used copula-EVT approach to model operational risk with insurance loss data. They found that the model effectively captures the right tail of the distribution which further implies the risk measures, avoiding every possible underestimate of risk.

When it comes to copula applications in financial market, there are also several papers using copula to capture tail dependence. Hu (2006) used mixed copula model to find the dependence between some

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