



Asymmetric increasing trends in dependence in international equity markets



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ABSTRACT

This paper investigates asymmetric increasing trends in dependence in major international equity markets. To this end, we develop a multiple-regime smooth-transition copula GARCH model and address several important questions, including the number of regimes and the existence of increasing asymmetric trends in dependence. Our results suggest that two or three regimes are sufficient for describing the dependence trends in international equity markets over the last 35 years with significant asymmetric increases. In addition, the implied time-series of three dependence measures show a wide variety of dynamics, demonstrating the usefulness of our framework to describe asymmetric increasing dependence trends. Finally, we evaluate the economic significance of our empirical finding based on the 99% Value at Risk and expected shortfall. Our result indicates that both risk measures have increased approximately 20% over the last 35 years in major equity markets.

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1. Introduction

The study of time-varying dependence structures in international equity markets has recently attracted increasing attention among theorists, empirical researchers, and practitioners for numerous reasons. For instance, investors need to assess the degree of comovement among international stock returns accurately to construct a well diversified portfolio. In addition, to evaluate risk measures, such as the Value at Risk (VaR) and expected shortfall (ES), risk managers should take into account interdependence in international equity markets. Ignoring an increase in dependence could lead to a considerable under-evaluation of those risk measures. Policy makers also have to pay close attention to contagion, which is caused by dependence between extreme negative shocks across international financial markets. If contagion effects became important, a financial crisis occurring in one country would have substantial effects on other countries, amplifying concerns for policy makers as well as market investors.

Another reason for the existence of a growing number of studies on dynamics of dependence in international equity markets is

associated with financial market integration. Over the last three decades, the circumstances of the world financial markets have changed dramatically. Examples of this include an increase of world economic relations, competition and globalization, development of the world transportation system, reduction of trade barriers, and evolution in information technology. In addition, according to the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER),¹ many industrial countries have experienced a rapid increase in their degree of financial openness since the mid-1980s. One natural consequence of these changes is a promotion of financial market integration. Indeed, the de facto measures recently constructed by Lane and Milesi-Ferretti (2007) indicate that financial integration in industrial countries was promoted gradually throughout the 1970s and 1980s, and accelerated throughout the mid-1990s.² It is not unreasonable to assume that the promotion of financial market integration would affect comovements among international financial markets.

The main contribution of this paper is to investigate asymmetric increasing trends in dependence in international equity markets systematically. In particular, the paper addresses the following questions: (i) Is the multivariate Normal (MVN) model appropriate

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¹ AREAER reports a set of de jure measures of restrictions on cross-border capital flows, and is widely used to measure financial openness.

² See Kose et al. (2009) for details of financial integration and related measures.

for modeling dependence trends in international equity markets? (ii) How many dependence regimes are sufficient to characterize the dependence trends over the last 35 years? (iii) Is there an increasing trend in dependence in international equity markets? (iv) Is there any asymmetry in the dependence trends between the upper and lower tails of the distribution? (v) When did important changes in the dependence trends occur? (vi) Which tail of the distribution contributed most to these changes?

The paper is related to voluminous previous studies investigating time-varying dependence in international equity markets. For instance, [Von Furstenberg and Jeon \(1989\)](#) estimate a VAR model consisting of daily stock returns for four major markets (Japan, Germany, U.K., and U.S.) and detect an increase in correlations since the crash of 1987. [Koch and Koch \(1991\)](#) reach a similar conclusion based on the daily returns across eight different national equity markets. On the other hand, [King et al. \(1994\)](#) claim that their finding of increasing dependence only reflected a transitory increase caused by the 1987 crash. To test an increase in correlation more precisely, [Longin and Solnik \(1995\)](#) estimate a bivariate GARCH model with a trend term in correlations between the US and six major countries. They find a significant increase in correlations for four out of six pairs. [Berben and Jansen \(2005\)](#) model the dynamics of correlation with a smooth transition model and show that correlations among the German, U.K., and U.S. stock markets have doubled, whereas Japanese correlations have remained the same. On the other hand, [Bekaert et al. \(2009\)](#) establish that there is no evidence for an upward trend in international stock return correlations, except for the European stock markets based on parsimonious risk-based factor models. Finally, [Christoffersen et al. \(2012\)](#) examine copula correlations in international stock markets and find a significant increasing trend that can be explained by neither volatility nor other financial and macroeconomic variables. Thus, whereas there has been much empirical work in this area, it is fair to say that there is not enough evidence that dependence in international equity markets is permanently and asymmetrically increasing. This paper will provide another evidence of asymmetric increasing dependence in international equity markets.

Recently, [Kumar and Okimoto \(2011\)](#) propose the two-regime smooth transition copula-GARCH (STCG) model to examine correlation dynamics in international government securities markets. This paper extends their model to the multiple-regime smooth transition asymmetric copula model, differing from the aforementioned previous studies in several ways. First, we use copulas to examine asymmetric tail dependence structures, since recent studies demonstrate that the DCC model or the Markov switching model with Gaussian innovations is inappropriate for capturing asymmetric tail dependences. For example, [Garcia and Tsaftak \(2011\)](#) point out that the asymmetric DCC model by [Cappiello, Engle, and Sheppard \(2006\)](#) cannot reproduce asymmetric tail dependence in the international equity market, but the Markov switching copula model can. In addition, [Okimoto \(2008\)](#) shows that the Markov switching model with Gaussian innovations that has been used to address asymmetric correlation issues (see [Ang and Bekaert \(2002\)](#); [Ang and Chen \(2002\)](#)) is statistically rejected in favor of the Markov switching copula model with asymmetric tail dependences. Thus, it is of great importance to model asymmetric tail dependences using asymmetric copulas, as we do here.

Second, instead of considering correlation, we use three copula-based dependence measures, specifically, Spearman's rho, and upper and lower tail dependences to evaluate dependence. [Embrechts et al. \(2002\)](#) and [Embrechts et al. \(2003\)](#) emphasize that a correlation is not a good measure of dependence for non-elliptical distributions with asymmetric tail dependence such as those considered in this paper. Third, we allow for a number of dependence regimes ranging from one to four. Most previous studies allow only one simple linear or non-linear trend. It is,

however, very questionable whether the dependence trends in international equity markets over the last 35 years can be characterized by one trend, given the many factors affecting the financial market integration mentioned above. Fourth, we investigate the evolutionary paths of upper and lower tail dependences. Given the asymmetries in dependence structures in international equity markets found by a number of studies,³ this could be a very important extension.

We apply the multiple-regime STCG model to four of the largest equity markets, namely French (FR), German (GE), U.K. (UK), and U.S. (US) markets. The results of our empirical analysis are summarized as follows. First, we confirm the importance of capturing the fat-tailed nature of stock returns, showing the inappropriateness of the MVN model employed by most previous studies, such as those of [Longin and Solnik \(1995\)](#) and [Berben and Jansen \(2005\)](#). In addition, our results suggest that the symmetrized Hüsler–Reiss (HR) copula model dominates the Normal and symmetrized Joe–Clayton (JC) copula models. Second, our analysis demonstrates that three dependence regimes are sufficient to describe dependence trends in international equity markets over the last 35 years. Third, our results indicate a significant increase in both upper and lower tail dependences. Fourth, our results provide clear evidence of the asymmetric evolution of upper and lower tail dependences.

Following these empirical findings, we calculate the time series of three copula-based dependence measures to see when the important increases in dependence occurred and which tail contributed most to the increases. The results demonstrate that the FR–GE and FR–UK pairs experienced a rapid increase in dependence between 1986 and 1991, and 2000 and 2004, with lower tail dependence playing the more important role in these increases. On the other hand, dependence in the GE–US and FR–US pairs underwent a gradual increase from 1987 onward, whereas the GE–UK and UK–US pairs' dependence increased almost linearly over the entire sample. Furthermore, our results show that for these four pairs upper tail dependence contributed to increasing dependence more than lower tail dependence.

Lastly, we investigate the economic significance of our empirical findings from a risk management point of view based on the 99% VaR and ES. Our results indicate that both 99% VaR and ES in 2008 are larger by about 20% compared to those in 1973. In addition, the benefits from international diversification to decrease risk have almost vanished in recent years. It is, therefore, critical to recognize our finding of increasing trends in dependence with possible asymmetry in international equity markets.

The remainder of the paper is organized as follows. Section 2 introduces the model and the idea behind our methodology. Section 3 provides the empirical results, followed by some robustness check in Section 4. Implications of our empirical findings for international diversification and risk management are examined in Section 5. Lastly, Section 6 concludes.

2. Model and estimation

The main purpose of this paper is to investigate asymmetric increasing dependence in international equity markets. It is desirable to model the dependence structure and evolutionary process in a flexible way. To this end, we propose using a multiple-regime smooth-transition copula-GARCH (STCG) model. The basic idea behind the model is to use copulas to model the contemporaneous dependence between variables and to specify the dynamics of dependence, or copula parameters, with a multiple-regime smooth-transition model.

³ See [Okimoto \(2008\)](#) and reference therein for a discussion of the asymmetric dependence in international equity markets.

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