ARTICLE IN PRESS

FINANA-00618; No of Pages 10

International Review of Financial Analysis xxx (2013) xxx–xxx

Contents lists available at SciVerse ScienceDirect

International Review of Financial Analysis

Extreme downside risk spillover from the United States and Japan to Asia-Pacific stock markets☆

Lu Liu *

Department of Economics, Lund University, P.O. Box 7082, S-220 07 Lund, Sweden

ARTICLE INFO

Available online xxxx

JEL classification:
C22
C25
G15
G17

Keywords:
Extreme downside risk
Risk spillover
Value at Risk
Granger causality in risk
Markov switching
Extreme value regression

ABSTRACT

This paper proposes a binary response model approach to measure and forecast extreme downside risks in Asia-Pacific markets given information on extreme downside risks in the U.S. and Japanese markets. The extreme downside risk of a market is measured as the occurrence of extreme downside movement—market returns falling below left-tail Value at Risk in a Markov switching framework. The empirical findings are consistent with the following notions. First, extreme downside movements of the S&P 500 and Nikkei 225 are significantly predictive for the likelihood of extreme downside movements in all the investigated Asia-Pacific markets. Second, the majority of Asia-Pacific markets become more sensitive to Japan's extreme downside risk when the Japanese market switches into high volatility periods, whereas the U.S. spillover effect is intensified only on Taiwan during high volatility periods in the U.S. Third, mainland China is the least sensitive to extreme downside risk in the U.S. and Japan, Australia is the most sensitive to the U.S., and Singapore is the most sensitive to Japan.

1. Introduction

As global financial markets are increasingly deregulated and integrated, the risk in one financial market or asset is very likely to be transmitted to other markets or assets. Understanding risk spillover between financial markets is important for asset allocation and risk management. It also has crucial implication for policy making that aims at reducing financial contagion and the instability it causes to the economy. In light of the fast growing Asia-Pacific economies and the increasing liberalization of their financial markets, this paper examines whether and how extreme downside risk is transmitted from the globally dominant stock market (the U.S. market) and the regionally dominant stock market (the Japanese market) to Asia-Pacific stock markets. Specifically, this paper studies the national stock markets of Australia, mainland China, Hong Kong, South Korea, Singapore, and Taiwan, which are the main markets of the Asia-Pacific region judged by market capitalization.

Many important studies focus on correlations between financial markets (e.g., Forbes & Rigobon, 2002; King & Wadhwani, 1990), while others such as Baele (2005) investigate volatility spillover using multivariate GARCH models. However, these applications are subject to significant limitations. First, the importance of large shocks of markets can be underestimated, because volatility represents a small amount of risk only and correlation assigns equal weights to small and large shocks. Moreover, losses and gains are treated symmetrically in the measure of correlation and volatility spillover, whereas investors in reality have downside financial constraints and are downside risk aversed, that is to say, they care more about downside losses than upside gains. Therefore, these applications are inadequate in describing extreme bad scenarios when the dramatic fall of stock returns in one market generates panic and propagates to other markets. Examples include the 1997–1998 Asian crisis and the U.S. subprime mortgage crisis.

To address these issues, some studies have distinguished extreme negative shocks from normal observations. For example, Hartmann, Straetmans, and Vries (2004) look at extremal dependence between markets in distress periods. Asgharian and Bengtsson (2006) and Asgharian and Nossman (2011) analyze risk spillover with Poisson jumps. Other research (e.g., Adrian & Brunnermeier, 2009; Bae, Karolyi, & Stulz, 2003; Christiansen & Ranaldo, 2009) study extreme coexceedance or simultaneous extreme events of financial markets and financial institutions. However, most of these studies focus on the major U.S., Japanese, and European stock markets. Although many studies (e.g., Johnei, Liu, Yang, & Chaung, 1995; Liu & Pan, 1997; Ng, 2000; Wang & Firth, 2004) have shown the integration of Asia-Pacific stock markets with the major markets through volatility

☆ The author is grateful to the editors, the anonymous referee, Hossein Asgharian, Deniz Erdemilioglu, Jonathan Dark, Björn Hansson, Paul Söderlind, Sandy Suardi, Mika Vaihekoski, and seminar participants at Lund University, the University of St. Gallen, Financial Management Association Asian Conference 2011, NFN Research Workshop in Finance 2010, and the 3rd RGS Doctoral Conference in Economics. Bankforskningsinstitutet is gratefully acknowledged for financing this research.

* Tel.: +46 46 222 9528.
E-mail address: Lu.Liu@nek.lu.se.

1057-5219/$ – see front matter © 2013 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.irfa.2013.07.009

and price spillover, few of them have shed light on the downside risk spillover to Asia-Pacific markets.

Different from the previous studies, this paper not only examines whether extreme downside risk spillovers take place, it also quantifies and predicts their likelihood. This paper proposes a binary response model to investigate the spillover of extreme downside risk from dominant stock markets to Asia-Pacific stock markets. The approach is inspired by the concept of Granger causality in risk (Hong, Liu, & Wang, 2009), where an extreme downside risk is said to have occurred at a prespecified level if asset returns fall below the left-tail Value at Risk (VaR) at the given level. While Hong et al. (2009) develop kernel-based tests on extreme downside risk spillover, this paper proposes a regression approach to make ex-ante predictions of extreme downside risk in an Asia-Pacific market given the information about a dominant market (i.e., the U.S. or Japan).

In order to measure extreme downside risk, I forecast VaR via a Markov switching ARCH (SWARCH) model (Cai, 1994; Hamilton & Susmel, 1994), which allows the distribution of the variable to change across regimes. The use of SWARCH serves two purposes. First, SWARCH is expected to be more accurate in forecasting VaR than single-regime (G) ARCH models, because it captures potential shifts of the distribution and alleviates the problems of excess kurtosis and skewness (see Li & Lin, 2004; Timmermann, 2000). Next, previous studies (e.g., Longin & Solnik, 2001) document an increase in spillover in bear markets but not in bull markets. By identifying high volatility regimes and low volatility regimes via SWARCH, we examine whether the degree of the spillover effect also changes when the regime shifts, so as to indicate the necessity of modifying portfolio choices with respect to changes in market condition.

This paper's contribution is threefold: First, its model not only examines whether spillover takes place, but it is also able to predict and quantify the likelihood of extreme downside movement of a market given the information about extreme downside risks in the globally dominant market (the U.S.) and the regionally dominant market (Japan). Second, this paper looks at extreme downside risks and risk-spillover effects from a state-dependent perspective, which is critical for dynamic asset allocation. Third, this paper provides new insights into the sensitivity of Asia-Pacific stock markets to global extreme negative shocks.

The rest of this paper is organized as follows. Section 2 presents the model. It starts by describing the concept of Granger causality in risk following Hong et al. (2009). Based on this concept, a binary response model is proposed for extreme downside risk spillover. Section 3 then presents the estimation procedure, and Section 4 describes the data. Empirical analysis is implemented in Section 5. Section 6 presents the size and power properties of the binary response model approach. Finally, Section 7 concludes.

2. Model of extreme downside risk spillover

This section presents first the concept of Granger causality in risk following Hong et al. (2009), which is the theoretical background for the binary response model of extreme value spillover. Then I elaborate the extreme value model, which predicts extreme downside risk in one market given the occurrence of extreme downside risk in a dominant market.

The concept of Granger causality in risk is designed to test "whether the past history of the occurrences of large risks in one market has predictive ability for the future occurrences of large risks in another market" (Granger, 1969, 1980). Let $r_{j,t}$ and $r_{i,t}$ be the returns of markets i and j. Suppose $\Psi_{t-1} = \{\Psi_{i,t-1}, \Psi_{j,t-1}\}$, where $\Psi_{i,t-1} = \{r_{i,t-1}, r_{i,t-2}, ts\}$ and $\Psi_{j,t-1} = \{r_{j,t-1}, r_{j,t-2}, \ldots\}$ are the information sets available at time t for markets i and j. Define $VaR_{i,t}^{\alpha}$ to be the α-quantile of the probability distribution of $r_{i,t}$ at time t, and $VaR_{j,t}^{\alpha}$ to be the same for $r_{j,t}$.

If the hypothesis H_0 below holds,

$$H_0 : Pr\left(r_{i,t} < VaR_{i,t}^{\alpha} | \Psi_{i,t-1}\right) = Pr\left(r_{i,t} < VaR_{i,t}^{\alpha} | \Psi_{t-1}\right) \text{ almost surely,} \quad (1)$$

the $r_{j,t}$ does not Granger-cause $r_{i,t}$ in risk at confidence level $1-\alpha$ with respect to the information set Ψ_{t-1}. On the other hand, if

$$H_1 : Pr\left(r_{i,t} < VaR_{i,t}^{\alpha} | \Psi_{i,t-1}\right) \neq Pr\left(r_{i,t} < VaR_{i,t}^{\alpha} | \Psi_{t-1}\right), \quad (2)$$

then $r_{j,t}$ Granger-causes $r_{i,t}$ in risk at level α with respect to the information set Ψ_{t-1}. In this sense, information about an extreme downside movement in $r_{j,t}$ can be used to predict risk in $r_{i,t}$.

To test the hypotheses above, Hong et al. (2009) formulate similar hypotheses on Granger causality in mean by defining a left-tail VaR-related risk indicator by

$$Z_t^{\alpha} \equiv 1\left(r_t < VaR_{i,t}^{\alpha}\right), \quad (3)$$

where $1(\cdot)$ is an indicator function that takes the value 1 when the stock market return is smaller than the VaR, and is 0 otherwise. Thus, the hypothesis (1) can be equivalently stated as

$$H_0 : \mathrm{E}\left(Z_{i,t}^{\alpha} | \Psi_{i,t-1}\right) = \mathrm{E}\left(Z_{i,t}^{\alpha} | \Psi_{t-1}\right) \text{almost surely.} \quad (4)$$

Therefore, the Granger causality in risk between $r_{i,t}$ and $r_{j,t}$ can be viewed as a Granger causality in mean between $Z_{i,t}^{\alpha}$ and $Z_{j,t}^{\alpha}$. The Granger causality test is equivalent to a Granger-type procedure based on the regression

$$Z_{i,t}^{\alpha} = \beta_0 + \sum_{l=1}^{L}\left(\beta_l Z_{j,t-l}^{\alpha}\right) + u_t, \quad (5)$$

which checks whether the coefficients $\{\beta_l\}_{l=1}^{L}$ are jointly zero.

Based on the concept of Granger causality in risk, I develop a simple binary response model for predicting extreme downside risk, analogous to regression (5). I use the left-tail VaR-related risk indicator (defined in Eq. (3)) as the extreme downside risk measure, and set up a binary extreme value regression,

$$\Pr\left(\widehat{Z}_{i,t} = 1 | x_t, \beta\right) = \exp\left\{-\exp\left(-x_t'\beta\right)\right\}, \quad (6)$$

where $x_t'\beta = \beta_0 + \beta_1\widehat{Z}_{j,t-1} + \beta_1\widehat{Z}_{i,t-1}$.

The extreme value regression is based on the cumulative distribution function for the minimum case of standard Gumbel distribution.[1] Thanks to its asymmetrical response curve, an extreme value model is particularly appropriate for this study because the event of a predefined extreme downside risk occurs rarely. Cameron and Trivedi (2009), among many other papers in the literature, has argued for the use of an extreme value model when there is a high proportion of zeros (absence of events) in the binary variable. Symmetric models such as Probit and Logit are inappropriate for this study since their response curves approach zero and one at the same rate.

In Eq. (6), the probability that an extreme downside movement takes place in market i depends on its own past movement and on

[1] The cumulative distribution function of the standard Gumbel distribution (minimum) is $F(x) = 1 - exp\{-exp(x)\}$.

Please cite this article as: Liu, L., Extreme downside risk spillover from the United States and Japan to Asia-Pacific stock markets, *International Review of Financial Analysis* (2013), http://dx.doi.org/10.1016/j.irfa.2013.07.009