



Explaining international stock correlations with CPI fluctuations and market volatility

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ABSTRACT

This paper investigates the dynamic correlations among six international stock market indices and their relationship to inflation fluctuation and market volatility. The current research uses a newly developed time series model, the Double Smooth Transition Conditional Correlation with Conditional Auto Regressive Range (DSTCC-CARR) model. Findings reveal that international stock correlations are significantly time-varying and the evolution among them is related to cyclical fluctuations of inflation rates and stock volatility. The higher/lower correlations emerge between countries when both countries experience a contractionary/expansionary phase or higher/lower volatilities.

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1. Introduction

International stock market correlations have attracted more attention with the integration and globalization of financial markets. A wealth of qualitative literatures devoted to the intriguing connection between financial markets and economic fundamentals provide sufficient evidences that co-movement of business-cycle fluctuations impact international financial market correlations. However, the controversy continues. Debates on whether economic fundamentals such as business cycle indicators significantly affect international financial correlations, surfaced in the early 1990s, and have not yet reached a consistent agreement.

Erb et al. (1994) found that correlations between two equity markets vary according to both countries' economic cycles that economic fundamentals significantly affect stock market correlations. They show that among the G-7 countries, the highest correlations appear when both countries stand in the contractionary phase and lowest correlations appear when both countries are in the expansionary phase. Correlations vary between these two extreme states when they are out of phases. Dumas et al. (2003)

highlighted the statistical evidence that output correlations and stock market correlations are positively related. Forbes and Chinn (2004) showed that direct trade is the predominant factor of the world's largest markets that affect financial markets. Yang et al. (2009) investigated dynamic interdependence between international stock and bond markets affected by real economy (represented as the business cycle, the inflation environment and monetary policy stance). Furthermore, they supplied evidence that higher stock-bond correlation coincides with higher short rates and higher inflation rates.

On the contrary, other literatures maintain skeptic upon such association between real economic linkages and financial-market linkages. King et al. (1994) suggested that co-variances between international stock markets are difficult to interpret by observable economic variables, and can reverse by unobservable variables. Ammer and Mei (1996) discovered that contemporaneous co-movement in macroeconomic variables influence co-variances between international stock markets. However, they ignore this relationship because the real linkages are much stronger in the long-run than a short-run perspective. Kizys and Pierdzioch (2006) supported Ammer and Mei, showing that the linkage between monthly conditional international equity correlations and co-movement of business-cycle fluctuations is not significant enough.

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Recent researches have also focused on the linkages between international stock correlations and market volatility. Longin and Solnik (2001) found that correlation increased in bear markets, but not in bull markets and international integration tightens the financial linkage progressively. Connolly et al. (2007) offered plentiful evidence that international stock linkages are likely higher/lower when the level of implied volatility (as a measure of stock uncertainty) stays higher and its variation is larger. Aydemir (2008) indicated that the higher the risk aversion periods, the higher the tendency for market correlations and high market volatility to emerge at the same time.

Besides, Ferreira and Gama (2007) showed that sovereign debt ratings news tends to increase the international stock market correlations. Another literature focuses on the factors explaining the stock-bond correlations. For example, see Kim et al. (2006), Li and Zou (2008) and Panchenko and Wu (2009).

Motivated by earlier conflicting reports, this research restudies the relationship between economic fundamentals as well as global stock volatility and international stock market interdependence. The current work employs a range-based multivariate volatility model by Chou and Cai (2009). The smooth transition in conditional correlation is controlled by some exogenous variables. The model maintains a parsimonious structure while allowing flexibility in specifying the dynamic evolutions of conditional correlations.

This paper is organized as follows. Section 2 introduces the model including model specifications, dynamics and tests. Section 3 discusses the data set used for the empirical research. Section 4 provides empirical results. Section 5 concludes this paper.

2. The model

Following Chou and Cai (2009), consider the Double Smooth Transition Conditional Correlation-Conditional Autoregressive Range (DSTCC-CARR) model. It is an extension of the Dynamic Conditional Correlation (DCC) model of Engle (2002). Two main features of this model are the additional efficiency in using range data (see Chou, 2005; Chou et al., 2009) and the consideration of a flexible mechanism in the correlation dynamics.

2.1. The DSTCC-CARR model

Specifically, the DSTCC-CARR model is constructed with two steps: the CARR specification for estimating volatilities and the smooth transition structure of the conditional correlation allowing more than one explanatory (or transition) variable. For the bivariate case, the CARR specification is defined as Eq. (1):

$$\begin{aligned} \mathfrak{R}_{i,t} &= \lambda_{i,t} \varepsilon_{i,t}, \quad \varepsilon_{i,t} | I_{t-1} \sim f(\cdot); \quad t = 1, 2, \dots, T; \quad i = 1, 2, \\ \lambda_{i,t} &= \varpi_i + \alpha_i \mathfrak{R}_{i,t-1} + \beta_i \lambda_{i,t-1}, \end{aligned} \quad (1)$$

where the high/low range in logarithm type, of the i th asset during time t is denoted as $\mathfrak{R}_{i,t}$, with a conditional mean of the range $\lambda_{i,t}$. The distribution of the disturbance term $\varepsilon_{i,t}$ is assumed to be distributed with a density function $f(\cdot)$ with a unit mean. Next, the unconditional standard deviation $\bar{\sigma}_i$ and the sampling mean of the estimated conditional range $\bar{\lambda}_i$ are used to construct an adjustment term (*adj*) as a ratio. The ratio is used to scale the conditional standard deviation $\lambda_{i,t}^*$ from $\lambda_{i,t}$, the expected range from the CARR model. In other words, denote the i th asset return as $r_{i,t}$ and let $z_{i,t}^*$ be defined as the standardized return:

$$z_{i,t}^* = r_{i,t} / \lambda_{i,t}^*, \quad \text{where } \lambda_{i,t}^* = \text{adj}_i \times \lambda_{i,t}, \quad \text{adj}_i = \bar{\sigma}_i / \bar{\lambda}_i. \quad (2)$$

In the second stage, the standardized returns are then used to compute the conditional correlations. In Engle (2002)'s DCC model, the conditional correlations are allowed to vary according to a

GARCH type dynamics. In our formulation of DSTCC, however, the correlations are governed to move smoothly among four regimes. Specifically, let s_{it} be some exogenous variable, the smooth transition structure of the conditional correlation is defined as following:

$$\begin{aligned} \mathbf{P}_t &= (1 - F_{L1}(s_{1t})) \mathbf{P}_{(1)t} + F_{L1}(s_{1t}) \mathbf{P}_{(2)t}, \\ \mathbf{P}_{(j)t} &= (1 - F_{L2}(s_{2t})) \mathbf{P}_{(j)1} + F_{L2}(s_{2t}) \mathbf{P}_{(j)2}, \quad j = 1, 2, \end{aligned} \quad (3)$$

where both transition functions are logistic:

$$F_{lj}(s_{it}) = (1 + e^{-\gamma_j(s_{it} - c_j)})^{-1}, \quad \gamma_j > 0, \quad j = 1, 2. \quad (4)$$

Two parameters, named as location parameter c_j and speed parameter γ_j , are used to control the transition from one state to the other. The larger γ_j is, the faster the correlation changes from one state to the other. If $\gamma_j \rightarrow \infty$, the transition function becomes a step function. For details, see Chou and Cai (2009).

Therefore, a DSTCC-CARR model supposes that conditional correlation has four extreme states, and switches among these four states ($\mathbf{P}_{(11)}$, $\mathbf{P}_{(21)}$, $\mathbf{P}_{(12)}$ and $\mathbf{P}_{(22)}$) smoothly under the control of two exogenous transition variables.

Once $\gamma_j = 0, j = 1 \text{ or } 2$, a DSTCC-CARR model reduces to an STCC-CARR model. Taking $\gamma_1 = 0$ for example, Eq. (3) should be rewritten as Eq. (5):

$$\mathbf{P}_t = (1 - F_{L2}(s_{2t})) \mathbf{P}_1 + F_{L2}(s_{2t}) \mathbf{P}_2, \quad (5)$$

where

$$\mathbf{P}_1 = \frac{1}{2} (\mathbf{P}_{(11)} + \mathbf{P}_{(21)}), \quad \mathbf{P}_2 = \frac{1}{2} (\mathbf{P}_{(12)} + \mathbf{P}_{(22)}).$$

To complete the model, we follow Silvennoinen and Teräsvirta (2005, 2007) in assuming a Gaussian distribution for the joint density function of the standardized returns. Quasi-maximum likelihood methods are used for estimation of the parameters and covariance matrices. The Gaussian assumption may be relaxed to allow more fat-tailed conditional density functions. Further more, more flexibility can be obtained by using the copula density functions. We do not pursue these approaches in the current study to maintain the tractability of our model.

2.2. Model specification tests

Since estimating a model with unnecessary parameters causes inefficiency, specification tests are useful before estimating the DSTCC-CARR model. The tests may help determine whether the exogenous variables are useful as transition variables. Note that some of the model parameters are not identified under the null hypothesis. Luukkonen et al. (1988) adopt a linearization by first-order Taylor expansion around speed parameters to construct the test statistics. Their strategy is followed here. The detailed specification shows as Eq. (6):

$$F_{Li} \cong 1/2 + 1/4(\gamma_i(s_{it} - c_i)) + o(\cdot), \quad (6)$$

$o(\cdot)$ is the error term above the second-order.

2.2.1. Tests for CCC against a STCC-CARR model

Based on the structure of the STCC-CARR model as in (5), this work performs a first-order Taylor approximation around $\gamma_2 = 0$ to the transition function F_{L2} . The dynamic conditional correlations could be written as (7):

$$\mathbf{P}_t^* = \mathbf{P}_1^* + s_t \mathbf{P}_2^* + o(\cdot). \quad (7)$$

Under the hypothesis: $H_0 : \gamma_2 = 0$, the STCC-CARR model becomes a CCC-CARR model. The current study constructs an LM test for conditional correlation constancy against an STCC-CARR model, and the LM statistics are shown as (8):

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