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The generalized asymmetric dynamic covariance model

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Abstract

In this paper we extend the ADC model of Kroner and Ng [1998. *Review of Financial Studies* 11, 817–844] such that it allows for cross-asymmetries in conditional volatility. That is, the model allows for asymmetries in covariances after shocks of opposite signs. We find evidence for significant cross-asymmetries in the conditional volatility in stock and bond markets.

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1. Introduction

While there exists a large amount of literature on time-varying conditional variances of either stock and bond returns, the number of studies on conditional covariances between these returns is rather limited. One of the most influential studies on modeling time-varying covariances is a study by Kroner and Ng (1998). They introduced the Asymmetric Dynamic Covariance (ADC) model, a multivariate GARCH model that nests several other multivariate models and allows for asymmetric volatility. However, their approach does

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not take into account cross-asymmetric volatilities: the conditional variance and covariance between asset returns can be higher (or lower) after a negative shock in one asset and a positive shock in the other asset, rather than shocks of opposite signs of the same magnitude. Recently, [De Goeij and Marquering \(2004\)](#) showed that cross-asymmetries can be statistically and economically significant in a multivariate GJR ([Glosten et al., 1993](#)) setting. As we concentrate in this note on the interaction between stocks and bonds, we observe many shocks of opposite signs. We propose an extension of the ADC model that incorporates cross-asymmetries in conditional variances and covariances. We refer to this model as the Generalized Asymmetric Dynamic Covariance (GADC) model. To test the appropriateness of the model we examine the asymmetric volatility behavior of stock and bond market returns.

2. The generalized asymmetric dynamic covariance model

Consider the multivariate return equation

$$r_{t+1} = \mu_{t+1} + \varepsilon_{t+1}, \tag{1}$$

where $\mu_{t+1} = E\{r_{t+1} | \mathcal{I}_t\}$ is the conditional mean and \mathcal{I}_t denotes the information known at time t . The error term ε_{t+1} has the properties

$$E\{\varepsilon_{t+1} | \mathcal{I}_t\} = 0, \quad E\{\varepsilon_{t+1}^2 | \mathcal{I}_t\} = H_{t+1},$$

where H_{t+1} is the conditional covariance matrix, consisting of conditional covariances ($h_{ij,t+1}$) and conditional variances ($h_{ii,t+1}$).

Next, define ε_{t-1}^+ as a vector with elements $\varepsilon_{i,t-1}^+ = \max[0, \varepsilon_{i,t-1}]$ and ε_{t-1}^- as a vector with elements $\varepsilon_{i,t-1}^- = \min[0, \varepsilon_{i,t-1}]$. We extend the ADC model by adding symmetric transformations of $(\varepsilon_{t-1}^+ \varepsilon_{t-1}'^-)$ and $(\varepsilon_{t-1}^- \varepsilon_{t-1}'^+)$. The operator $\mathcal{E}(\cdot)$, makes a non-symmetric matrix symmetric, using the elements of the lower-triangle part of the matrix. That is

$$\mathcal{E} \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{pmatrix} = \begin{pmatrix} a_{11} & a_{21} & \cdots & a_{n1} \\ a_{21} & a_{22} & \cdots & a_{n2} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{pmatrix}. \tag{2}$$

The GADC model becomes:

$$H_t = D_t R D_t + \Phi \odot \Theta_t, \tag{3}$$

where

$$H_t = (h_{ij,t}), \tag{4}$$

$$D_t = (d_{ij,t}), \quad d_{ii,t} = \sqrt{\theta_{ii,t}}, \quad \forall i, \quad \text{and} \quad d_{ij,t} = 0, \quad \forall i \neq j, \tag{5}$$

$$\Theta_t = (\theta_{ij,t}), \tag{6}$$

$$R = (\rho_{ij}), \quad \rho_{ii} = 1, \quad \forall i, \quad \text{and} \quad \rho_{ij} = \rho_{ji}, \tag{7}$$

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