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Regime switching for dynamic correlations

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Abstract

We propose a new model for the variance between multiple time series, the regime switching dynamic correlation. We decompose the covariances into correlations and standard deviations and the correlation matrix follows a regime switching model; it is constant within a regime but different across regimes. The transitions between the regimes are governed by a Markov chain. This model does not suffer from a curse of dimensionality and it allows analytic computation of multi-step ahead conditional expectations of the variance matrix when combined with the ARMACH model (Taylor (Modelling Financial Time Series. Wiley, New York) and Schwert (J. Finance 44(5) (1989) 1115)) for the standard deviations. We also present an empirical application which illustrates that our model can have a better fit of the data than the dynamic conditional correlation model proposed by Engle (J. Business Econ. Statist. 20(3) (2002) 339).
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1. Introduction

It is a well known fact that the variance and covariance of most financial time series are time-varying. Modeling time-varying variance is not just a statistical exercise where someone tries to increase the value of the likelihood; it has important

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impacts in terms of asset allocation, asset pricing, computation of value-at-risk (VaR). A lot of work has been done to model univariate financial time series since the introduction of the ARCH model by Engle (1982). However, we face additional problems when we try to write a multivariate model of volatility. Not only must the variances be positive, the variance matrix must also be positive semi-definite (PSD) at every point in time. Another important problem is the curse of dimensionality. We want models that can be applied to more than a few time series. This rules out the direct generalizations of univariate GARCH models such as the BEKK model of Engle and Kroner (1995).

The most popular multivariate volatility model so far is certainly the constant conditional correlation (CCC) model of Bollerslev (1990) (a survey of multivariate GARCH model is given by Bauwens et al. (2003)). In this model, the covariances of a vector of returns are decomposed into standard deviations and correlations. The major hypothesis in this model is that the conditional correlations are constant through time. With this hypothesis, it is easy to get PSD variance matrices because we only have to ensure that the correlation matrix is PSD and that the standard deviations are non-negative. It also breaks the curse of dimensionality because the likelihood can be seen as a set of SURE equations, i.e. a two-step estimation procedure where univariate volatility models are estimated in a first step that will yield consistent estimates. However, the hypothesis of constant correlations is not always supported by the data (e.g. Engle and Sheppard, 2001).

In this work, we present a new multivariate volatility model, the regime switching dynamic correlation (RSDC) model. We also decompose the covariances into standard deviations and correlations, but these correlations are dynamic. The correlation matrix follows a regime switching model; it is constant within a regime but different across regimes. The transitions between the regimes are governed by a Markov chain. The CCC model is a special case of ours where we take the number of regimes to be one.

The RSDC model has many interesting properties. First, it is easy to impose that the variance matrices are PSD. Second, it does not suffer from a curse of dimensionality because it can be estimated with a two-step procedure.[1] Third, when combined with the ARMACH model (see Taylor, 1986 and Schwert, 1989) for the standard deviations, this correlation model allows analytic computation of multi-step ahead conditional expectations of the whole variance matrix. Fourth, it can produce smooth patterns for the correlations. We also present an empirical application to exchange rate time series which illustrates that it can have a better fit of the data than the dynamic conditional correlation (DCC) model recently proposed in Engle (2002).

The model of Engle (2002) and the model proposed in Tse and Tsui (2002) use the same decomposition for the variance matrix as in Bollerslev (1990), but instead of taking constant correlations they propose a GARCH-type dynamic. Because a

[1]We say that a model does not suffer from a curse of dimensionality if it is possible to obtain consistent estimates of the parameters even when the number of time series is large. These estimates may not be efficient.