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Range-based multivariate volatility model with double smooth transition in conditional correlation

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This paper proposes a multivariate model named Double Smooth Transition Conditional Correlation Conditional Autoregressive Range (DSTCC-CARR for short). Determined by two transition variables, the correlations smoothly transit from one state to another. Together with the DSTCC-GARCH model, the model is employed to investigate the interdependence between Hong Kong's and international stock markets. It is proved by the empirical analysis that the DSTCC-CARR model is more credible and efficient than the DSTCC-GARCH model. Linkages among Hong Kong's and other world's markets captured by these two models are testified to be consistent with history, and have meaningful interpretations.

1. Introduction

Since the 1970s, research on volatility model has become a prime and active theme in financial economics and econometrics. One of the most famous theory frames is the ARCH/GARCH family, which was first introduced by Engle (1982) and generalized by Bollerslev (1986). The univariate ARCH/GARCH model, which was extended by many economists on top of the original paper, became one of the most efficient tools in estimating and forecasting in financial markets. For a detailed survey, see Bollerslev, Chou, and Kroner (1992), Engle (2002a) and Engle (2004).

The multivariate ARCH/GARCH model has been developed very promptly during the same period. Researchers focused on conditional variance and covariance and developed the models. CCC-GARCH (Constant

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Conditional Correlation GARCH) model of Bollerslev (1990) made the hypothesis of constant conditional correlation. An extension to CCC-GARCH was introduced by Jeantheau (1998), which relaxes the auto-correlation structure in the original CCC-GARCH model and allow dynamic interactions between the conditional variance equations. Its moment structure was later considered in the paper of He and Teräsvirta (2004). Oppositely, there are some other representative models in early researches, including VECH model of Bollerslev, Engle, and Wooldridge (1988), the BEKK model of Engle and Kroner (1995), which are flexible in allowing time-varying covariance. But these two models have their own disadvantages. Test developed by Tse (2000) and Bera and Kim (2002) often rejects the constancy of conditional correlations as the latter models have difficulty in estimating the parameters.

Both Tse and Tsui (2002) and Engle (2002b) created dynamic conditional correlation GARCH models entitled VC-GARCH and DCC-GARCH respectively. The models set the conditional correlations as well as the conditional variance with the GARCH-type dynamic structure. Because of the conditional correlations generated by first-order GARCH processes with identical parameters, the number of parameters in DCC-GARCH model remains relatively small.

To avoid the difficulty of estimating the parameters in the VC-GARCH and DCC-GARCH models, three types of simplified models are proposed. The first one is the threshold approach, which separates the possible correlations into several states and has been used by Kwan, Li, and Ng (2005) to extend the VC-GARCH model. The second one is the regime-switching approach. Pelletier (2006) constructed a regime switching correlation by an unobserved state variable following a first-order Markov chain. The last one is the smooth transition approach used in models proposed by this paper. The latest researches are Silvennoinen and Teräsvirta (2005, 2007). They built the STCC-GARCH (Smooth Transition Conditional Correlation GARCH) model and the DSTCC-GARCH (Double Smooth Transition Conditional Correlation GARCH) model respectively, in which the correlations vary smoothly among the extreme constant states. The dynamic characteristics are caught by some observed transition variables such as time trend, average of returns, business cycle indices and so on.

Besides the return-based volatility models we introduced above, there is another branch of models named range-based volatility models in estimating the volatility of asset prices. It is proved that using the high/low range data of asset prices to do estimation can acquire more efficient results than the return data based on close prices. The information sets are enlarged and more efficient results regarding the volatility are obtained. The main studies of this branch include Parkinson (1980), Garman and Klass (1980), Wiggins (1991), Rogers and Satchell (1991), Andersen and Bollerslev (1997), Galant, Hsu, and Tauchen (1999), Yang and Zhang (2000), Alizadeh, Brandt, and Diebold (2002), Brandt and Jones (2006), Chou (2005, 2006). Chou proposed the Conditional Autoregressive Range (CARR) model, which combines range analysis and the GARCH model. The CARR model is proved to perform well on dynamical volatility process. Chou, Wu, and Liu (2004) applied this model to the Taiwan stock market and captured some insightful results while Ding and Xia (2005) applied CARR model to the Shanghai stock market and found better-forecast behavior. According to recent studies, we find the range-based univariate volatility model as a good alternative to return-based volatility models.

An extension of CARR model to multivariate framework named the Dynamic Conditional Correlations CARR (DCC-CARR) was proposed by Chou, Wu, and Liu (2009) in which they used a univariate CARR model to replace the standard univariate GARCH structure. The empirical results showed that the DCC model can fit the CARR model as well as the GARCH model, and the range-based DCC model outperformed the return-based models in estimating and forecasting covariance matrices. Zhang Xiaoqing (2007) extended the STCC model using the range-based framework called the STCC-CARR model. It showed that the STCC-CARR model had a better performance in describing the transiting process of the conditional correlations than the STCC-GARCH model.

As we introduce above, there are kinds of methods on estimating the correlations. DCC-GARCH is a popular model for estimating the correlations in recent researches. However, there is little published work on testing the constancy against this model as we know. Moreover, the dynamic structure of the time-varying correlations in the VC-GARCH or DCC-GARCH models is connected with past returns, but it is difficult to introduce the exogenous variables into these models because of the technical limitation. In order to introduce the exogenous variables[1] and make the constant correlation tests more easily, we propose a range-based smooth transition model called the Double Smooth Transition Conditional Correlation CARR

[1] As mentioned in Silvennoinen and Teräsvirta (2008), correlations between markets are affected by some exogenous variables, such as business cycle, market volatilities and so on.