

## Essays on Volatility and Volume Modeling

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### **Essay 1: Threshold GARCH Model: Theory and Application (Job Market Paper)**

Modeling the temporal dependencies in the volatility of financial time series has drawn the attention of many econometricians and financial analysts. For decades, researchers have implemented ARCH and GARCH models with a regime switching framework to capture non-linearity in the volatility process. Hidden Markov models, which assume that states of the world are unknown, are widely used regime switching models. While estimation is not difficult, these models often fail to generate accurate predictions due to the unknown state in the future. In this paper, aiming to incorporate the non-linearity and the additional information provided by exogenous variables in regime shifts, we model volatility dynamics as a threshold model with an exogenous trigger, while volatility follows a GARCH process within each regime. This model can be viewed as a special case of the random coefficient GARCH model. We establish theoretical conditions, which ensure that the return process in the threshold model is strictly stationary, as well as conditions for the existence of various moments. A simulation study is further conducted to examine the finite sample properties of the maximum likelihood estimator. Simulation results reveal that the maximum likelihood estimator is approximately unbiased and normally distributed for modest sample sizes when the stationarity conditions hold and the fourth moment of the return series exists. Furthermore, using volatility index and volume as the threshold variable, we employ 20 stocks from Major Market Index (MMI) and find that the threshold model fits the data well.

### **Essay 2: Application of Independent Component Analysis in Finance: Does Time Structure Matter?**

Closely related to principal component analysis, independent component analysis (ICA) is a statistical and computational method for revealing hidden factors that underlie a set of random variables. The increasing demand of multivariate modeling in economics and finance as well as the strength of ICA analysis to extract statistically independent components from multivariate signals have attracted economists and financial analyst's attention to ICA. In standard applications of the ICA model, the components are assumed to be uncorrelated over time. In contrast to this random components assumption, the autocovariances of independent components in time series are well-defined statistics and can be used in estimating the ICA model. Therefore, in this paper, we examine the effect of time structure on the estimation performance of ICA models and provide guidance in applying the ICA model to time series data. We compare the performance of the basic ICA model to the time series ICA model in which the cross-autocovariances are used as a measure to achieve independence. We conduct a simulation study to evaluate the time series ICA model under different time structure assumptions about the underlying components that generate financial time series. Moreover, the empirical data of 20 well-known and highly capitalized stocks in the U.S. market are employed and the results support the use of the time series ICA model.

### **Essay 3: Price and Volume Durations: A Bivariate Modeling of Irregularly Spaced High-Frequency Data. (under construction)**

The availability of high frequency data provides researchers a promising avenue to analyze the underlying economic structure of the financial markets. The distinct feature of the high frequency data is the irregular spacing in time. This feature complicates the analysis of multivariate high frequency data because the multiple processes are irregularly spaced in time with different arrival rate. In this paper we focus on the bivariate process between price and volume duration. According to the mixture of distribution hypothesis, there exists a latent factor, which captures the information flow that cannot be observed directly, but influences the activity on a financial market. Therefore, we employ a latent factor intensity model to describe the joint process of price and volume durations since it is reasonable to assume that the trading intensity is also driven by the latent factor if it exists. The latent factor model captures the time-varying covariates through a direct parametrization of the intensity in a continuous-time framework.