Econ 195S.62

Time Series for Financial Analysis, Spring 2010

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Description: Students will learn some theoretical and empirical tools and techniques developed in financial econometric to model the conditional distribution in discrete time. The topics to be considered include modeling the conditional expectation through the ARMA models, modeling the conditional variance through the GARCH models, exploring alternative (to the normal) distributions to capture conditional asymmetry and Fat-tail. All these models will be applied to Finance, mainly to measure the value-at-risk of a portfolio, to price European option and finaly to forecast the term structure of interest rate. The primary objective of the course is for each student to produce a research project that contributes new insights into the overall understanding of conditional density modeling and testing. Students start with a defined research project that entails GARCH estimation in observed data and some applications in derivative or fixed-income market. Students whose research goes substantively beyond the starting project will be encouraged to proceed to an honors thesis in their senior year.

Content:

1. Stylized facts of financial data
2. Conditional expectation modeling: ARMA and VARMA
3. Conditional variance modeling: univariate and multivariate GARCH
4. Conditional third and fourth moments modeling: Alternatives to Normal density
5. Multi period-ahead forecasting: Monte Carlo simulation vs closed-form (Introduction to Discrete time affine models)
6. Risk calculations: VaR and Es, Introduction to density evaluation
7. Option Pricing
8. Term structure of interest rate

Theme: The goal is to implement and evaluate several conditional distribution models on different type of financial data, with an emphasis on applications in Finance (i.e derivatives pricing, risk evaluation and fixed income analysis).

Procedures: This course combines lecturing, theoretical and empirical homework exercises, seminar course that requires substantial student involvement with the material and the data analysis. It is not a traditional lecture/exam type course. Some presentations on the progress of on-going research (which are related to the evolution of the course) are required. After a date is determined for a student's presentation, that date cannot be changed and the student is expected to deliver a presentation on progress to date on the assigned date.

Prerequisites: econometrics ECON 139 (may be taken concurrently), at least one 100-level finance. Additional advanced work in mathematics, statistics, probability and finance, along with experience in computer programming would be very helpful. A knowledge of either Matlab or Gauss is strongly recommanded, although some ARMA and GARCH models are already available in some statistical softwares like STATA and E-VIEWS.

Registration is by permission only, which is obtained via e-mail to the instructor.

Eligibility: The course is available to junior undergraduate economics majors contemplating an honors thesis in their senior year.

Expectations: The task of producing original research is both serious and demanding. Students are expected to maintain steady progress on their projects, to give thoughtful and detailed presentations of work in progress, and to participate actively during the course.

Attendance: Attendance to the course is mandatory. An attendance record will be maintained. Unexcused absences will be grounds for dismissal with a withdrawal (W) or failing (F) grade.

Grading: Some students are strongly encourage to download and clean their own data set with well defined indications of the initial topics to investigate, however I can provide some returns, options and yields data upon request. The evaluation will consist on 30% on theoretical and empirical homework assignments and 70% on the student's personal research project.

Detailed description with references

1. **Part 1:** Stylized facts of financial data
This part provides a motivation of all the theoretical models that we will further introduce. We will present some descriptive statistics of several financial time series, including bonds and stocks. For instance, one of the well-known characteristic of daily stocks returns are the absence of autocorrelation in the returns, but significant autocorrelation of squared returns: This leads to the introduction of GARCH models. A very good reference for this part is the first chapter of Tsay (2002) **(*Analysis of Financial Time Series*.).**

2. **Part 2**: Conditional expectation modeling: ARMA and VARMA
The final goal of this course is to model the conditional distribution of financial time series in general. We can decompose this task into three parts: the mean, the variance, and the shape of the distribution (known as skewness and kurtosis). This part is about modeling the conditional mean. All the discussion here will be done around the well known ARMA and VARMA process; these models are designed to capture the autocorrelation structure of a given time series. A comprehensive reference here is the

chapter 3 of Hamilton (1994) (***Time series analysis***). This part covers the properties of ARMA processes, the estimation, the forecasting and the specification tests.

3. **Part 3**: Conditional variance modeling: univariate and multivariate GARCH

This part introduces the conditional variance modeling through the GARCH models. The GARCH models provide a very simple framework to capture the autocorrelation of squared returns. A very naïve intuition is to view this as ARMA on squared returns. But in fact the GARCH modeling encompasses this, and handles some stylized fact such as the leverage effect which is very important to price derivative. Two surveys can be found in Engle (1995) (***ARCH selected readings***) and Rossi (1996) (***Modelling stock market volatility***). This part will cover some properties of GARCH processes, their estimation, their evaluation and some specification tests.

4. **Part 4:** Conditional third and fourth moments modeling: Alternatives to Normal density.

When modeling the first two conditional moments, it is often assume that the conditional distribution is normal. But using some tools like the QQ plots on standardized residuals clearly indicates that the conditional distribution of some financial time series has some asymmetry and fat-tail. Here we introduce some alternatives; a readable book to view distributions and their characteristics is Johnson, N.-L., S. Kotz, and N. Balakrishnan, (***Continuous univariate distributions***).

5. **Part 5:** Multi period-ahead forecasting: Monte Carlo simulation vs closed-form (Introduction to Discrete time affine models)

All the materials discussed above concern modelling the on-step ahead conditional distribution. In many financial applications the multi-step ahead distribution is needed, for instance to price option with maturity greater than 1. The part discusses several techniques to derive the multi-step distribution, in most of these models we cannot derived the multi-step ahead distribution in closed form, and we need some simulation: a good reference is Christoffersen (2003), (***Elements of financial risk-management***). However there exist a well know class of conditional distribution for which the multistep-ahead distribution exist: This class of model is well known as the affine models. This course will focus only on two affine processes: The Heston-Nandi GARCH (Heston and Nandi (RFS, 2000)) and the IG-GARCH (Christoffersen, Heston and Jacobs (JE, 2006)).

6. **Part 6:** Risk calculations: VaR and Es, Introduction to density evaluation

A direct application of conditional density modeling is the Value at Risk and the Expected Short-fall evaluation. We will discuss the computation of these two quantities, and more importantly we will introduce the Backtesting. For a good reference, see Christoffersen (JIE, 1998).

7. **Part 7**: Option Pricing

A good specification of the conditional density has some implication in term of derivative pricing. We will show how to compute European call options in the

GARCH set-up, and evaluate different specifications in terms of through their pricing errors. Christoffersen (2003), (***Elements of financial risk-management***)

8. Part 8: Term structure of interest rate.

This part provides an application to the bond market. For a given model (the VARMA for instance) and a given maturity, we will show how to derive bond price. A good reference is the chapter 12 of the ***handbook of financial econometrics*** edited by Yacine Ait-Sahalia and Lars Peter Hansen (2010).