Advanced Programming in Quantitative Economics

Introduction, structure, and advanced programming techniques

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Tutorial Day 5 - Morning

10.30P Selected exercises. Choice of

- Reading HF data
- Implement HF Autoregressive Duration Model
- Using graphing package
- AR(p) estimation with/without ARFIMA package

12.00 Lunch

IBM Tick data

High frequency data displays strange characteristics.
As an exercise, investigate the fraction of trades which show small price changes.
Take the data file `ibm0908tick.csv` (Source: WRDS) with the prices , and see if you can recreate the following table:

Price differences

ΔP	-0.04	-0.03	-0.02	-0.01	0.00	0.01	0.02	0.03	0.04
n	17697	32244	57774	127748	637664	127676	58104	32223	17801
%	1.50	2.73	4.90	10.82	54.03	10.82	4.92	2.73	1.51

Also get me a plot of the prices during the first 45 minutes of trading on the first day of the sample.

AR Conditional Duration models

The file mmm9912-adur.txt contains 1680 adjusted intraday trading durations of 3M stock in December 1999. There are 39 10-minute intervals in a trading day. The URL for the data file:
`http://gsbwww.uchicago.edu/fac/ruey.tsay/teaching/fts2/`

(a). Build a duration model for the adjusted series using an Exponential duration model.

(b). Check your duration model implementation using simulated data

Autoregressive Conditional Duration ACD(1,1) model:

$$x_i = \psi_i \varepsilon_i$$
$$\mathrm{E}(\varepsilon_i) \equiv 1, \qquad \mathrm{E}(x_i) = \psi_i$$
$$\psi_i = \omega_0 + \gamma_1 x_{i-1} + \omega_1 \psi_{i-1} \varepsilon \sim \mathrm{Exp}(1)$$

ACD models, deriving moments, likelihood and tests

unconditional expectation:

$$E(x_i) = \frac{\omega_0}{1-(\gamma_1+\omega_1)}$$

Log likelihood: (Jacobian term, Heij et al. §1.2, (1.10), (1.19))

$$x = \psi\varepsilon, \qquad f(x) = f(\varepsilon)\left|\frac{d\varepsilon}{dx}\right| = f\left(\frac{x}{\psi}\right)\left|\frac{1}{\psi}\right|$$

Parameter restrictions:
For specific distributions of ε: Derive unconditional variance of $x_i \Rightarrow$ interpret/restrict parameters during estimation/simulation, e.g. use $\omega_0 > 0$, $0 < \gamma_1 + \omega_1 < 1$.

Diagnostic checks:
"normalized innovations" $\widehat{\varepsilon}_i = x_i/\widehat{\psi}_i$. QQ-plot, no correlation in $\hat{\varepsilon}_i$, SACF, Ljung Box statistic.

ACD hints

See also Tsay (2005), Analysis of Financial Time Series.

- What is θ, your vector of parameters?
- Notice the recursion you will need in the likelihood function?
- Can you generate data from the model?
- Think of the parameter restrictions
- Check whether your $\widehat{\varepsilon}_i$ are indeed uncorrelated, and distributed like an exponential.

Exercise: Selecting and Plotting

- Study the file `fxukjpdm.mat` using `OxEdit`, such that you understand what is in it
- Define a matrix

```
mD= <1991, 5, 15;
     2003, 7, 12>;
```

- Write an Ox program with a routine that takes as input a string with the filename and the above matrix, and returns both a vector of dates and the matrix with exchange rates, between the dates in `mD`.
- Try out different options for selecting the data with combinations of the commands `dayofcalendar()`, `selectifr()`, `vecrindex()`
- Add a function taking the exchange rate returns, printing mean and standard deviation of the returns.
- Can you also select only those days within this period where the DEM/USD exchange rate is increasing by more than 1%?

Constant variances?

One can wonder if the variance of the FX returns over time are constant. To find out, compute the variance $s_i^2(k)$ over k returns $r_{i-k+1}, ..., r_i; i = k - 1, .., T - 1$.

One way to check this could be to compute

$$C_i = \sum_{j=0}^{i} r_j^2 \qquad\qquad s_i^2(k) = \frac{1}{k}(C_i - C_{i-k})$$

Search functions to cumulate things by yourself: You do not need *any* loop for this exercise.

As output, plot $s_i^2(k)$ against a time index, using $k = 22$ lags.

Note: Above formula assumes that the mean return is zero. What would you have to change if the mean return is not zero?

Plotting

Create a plotting function, taking as input the exchange rates and an array with the names of the exchanges rates, which

- makes four plots in one window, containing
  1. The exchange rates against a time-index (simple) or against time (more difficult)
  2. A density plot of the returns on the UK exchange rate, with a normal approximation
  3. A crossplots of the returns of the UK vs JP
  4. A QQ-plot of the UK returns against the Student-t density with 4 degrees of freedom (The variance of the student-t density is $\nu/(\nu - 2)$).
- saves the graph as an EPS file, and shows the graph on screen.

NB: As always: Try one plot at a time...