Advanced Programming in Quantitative Economics

Introduction, structure, and advanced programming techniques

Charles S. Bos

VU University Amsterdam

c.s.bos@vu.nl

20 – 24 August 2012, Aarhus, Denmark

Tutorial Day 5 - Morning

10.30P Selected exercises. Choice of

- Reading HF data
- Implement HF Autoregressive Duration Model
- Using graphing package
- ARFIMA estimation with 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:

$$x_i = \psi_i \varepsilon_i$$

$$E(\varepsilon_i) \equiv 1, \qquad E(x_i) = \psi_i$$

$$\psi_i = \omega_0 + \gamma_1 x_{i-1} + \omega_1 \psi_{i-1} \varepsilon \sim \text{Exp}(1)$$

ACD models, deriving moments, likelihood and tests

unconditional expectation:

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

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...

Long memory and Level shifts

See article

> *Long Memory and Level Shifts: Re-analyzing Inflation Rates*
>
> *C.S. Bos, P.H. Franses and M.Ooms*

What is stronger? Long memory correlation in series, or the shift in level?

$$(1-\Phi(L))(1-L)^d z_t = \Theta(L)\epsilon_t \qquad \epsilon_t \sim \mathcal{N}(0, \sigma_z^2)$$

$$z_t = y_t - \sum_{r=1}^{k} \mu_r I_{t>\tau_r T} \equiv y_t - x_t'\gamma$$

In article: Use ϕ_1, ϕ_{12}, no MA, and four breaks.
The article reports $\beta_i = \gamma_i/\sigma_z$
Data y_t is the inflation over the period 1958:1–1995:12, adjusted for seasonality

Exercise Arfima: Using objects

1. Start writing a program `loadsa0.ox` which
   - Reads `sa0.mat`
   - Compute inflation $y_t = \Delta log(P_t)$, where P_t is the price index
   - Selects the correct period, throw out the rest
   - Places it in a `Database` object. Use `db.Deterministic(FALSE)` to create seasons, or build them using kronecker products.
   - Regress inflation on 12 seasonal dummies, and store the residuals: Rough way of adapting for seasonality
   - Prepare dummies which take the value 1 after (1973:01, 1976:07, 1979:01, 1982:07)
   - Save the database in `.in7` format.
2. Write a program `estsa0.ox` which takes the prepared database, estimates an ARFIMA(12,d,0) model on the seasonally adjusted inflation, including the dummies as regressors, and gives results.

OxPack: Arfima

Using the database created using `loadsa0.ox`, a combination of OxMetrics/OxPack can be used for getting the same results in a graphical manner.