ECONOMIC STATISTICS

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Course Material Developed by Department of Economics,

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Week 13

Time series analysis, further topics

Summary

End of semester essay – remarks

- Results contrary to expectations are also informative!
- Results are often not unambiguous – e.g. sensitive to specification

Summary

1st part: cross sectional data

- Descriptive statisitcs, correlation, OLS

2nd part: time series analysis

- Distributed lag models – total effect, lag length selection
- Univariate time series analysis – autocorrelation, testing unit root, trend, seasonality
- Time series regressions– ADL(p,q) model, cointegration, ECM

Most important points

- Descriptive statistics:
  - Median, deciles, histogram
  - Correlation and its square
- OLS:
  - Interpretation of coefficients (ceteris paribus)
  - Hypothesis testing
- Time series analysis:
  - Importance of stationarity

Outlook

- Statistics, probability calculus
  - E.g. standard deviation, probability distributions, hypothesis testing
- Introduction to econometrics
  - E.g. precise properties of OLS estimation
- Microeconometrics
- Macrostatistics

Asset prices

- Volatility (variability) – why is it of importance?
- Examples:

  Stock prices, stock market indices, foreign exchange rates

Random walk

- Random walk:

$$\Delta Y_t = e_t$$

- Random walk with drift:

$$\Delta Y_t = \alpha + e_t$$

- Market efficiency – no arbitrage
- Exchange rate cannot be forecasted
- Question: can volatility be modeled?

Measuring volatility

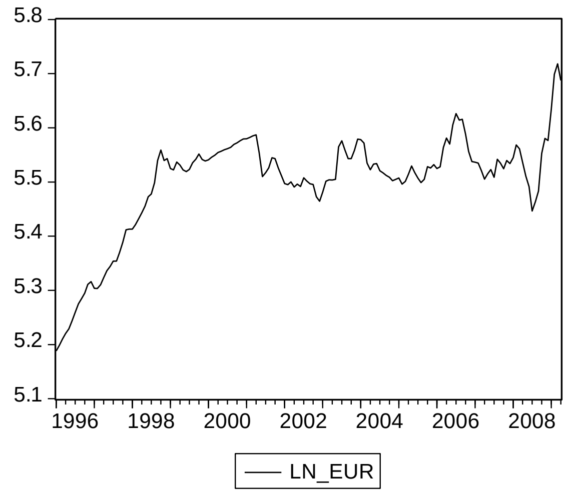
- Assumption: random walk holds
- Volatility measure: $(\Delta y_t)^2$
  - Positive
  - Bigger change – bigger volatility
  - Different at every time point
  - = variance at a given time point
- Modeling: e.g. AR(1)

$$\Delta y_t^{\ 2} = \alpha + \phi \Delta y_{t-1}^{\ 2} + e_t$$

ARCH: modeling the residual of an AR(p) model

Example

Forint/Euro (ECU) monthly central exchange rate, 1996–2009

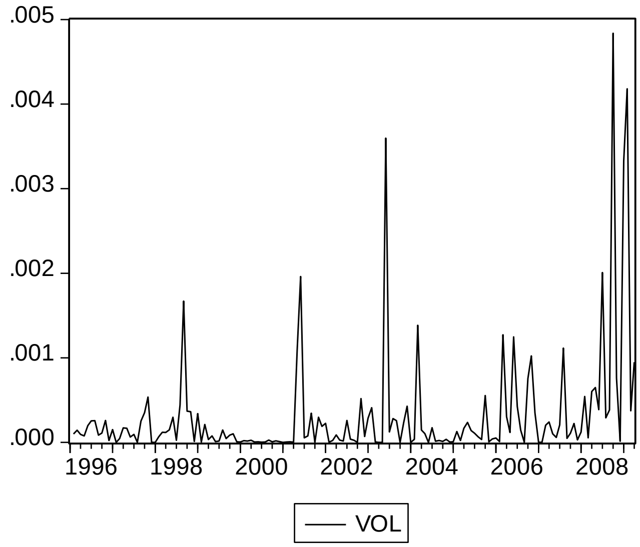


Example, cont.

Volatility:

ADF-test: unit root process

- Volatility is persistent



Causal relationships

- Correlation: no causality
- Regression: economic considerations about causality – dependent vs. explanatory variables
- Time series data: past data can cause present data, other way round not possible

Granger-causality

- X Granger-causes Y if past values of X can help forecasting Y
- Not necessarily true causality!
- Assumption here: stationary variables

ADL(1,1) model:

$$Y_t = \alpha + \phi Y_{t-1} + \beta X_{t-1} + e_t$$
$$\text{Testing lack of Granger causality} : \mathrm{H}_0 : \ \beta = 0$$

ADL(p,q) model

$$Y_t = \alpha + \delta t + \phi_1 Y_{t-1} + \ldots + \phi_p Y_{t-p} + \beta_1 X_{t-1} + \ldots + \beta_q X_{t-q} + e_t$$
$$H_0 : \beta_1 = \beta_2 = \ldots = \beta_q = 0$$
$$H_1 : \text{any } \beta_j \neq 0 \quad j = 1,\ldots,q$$

Good approximation: if any β significant – X Granger-causes Y

Correct: joint test of several coefficients

EViews: View/Coefficient tests/Wald test

F-statistic – small P-value: H_0 rejected

Example: exchange rate and export

- 1996–2009 monthly MNB data
- Log difference, export: seasonally adjusted
- Estimation of ADL(3,6) model – does the exchange rate Granger-cause the export?

Estimation results

Dependent Variable: DLOG_EXP_SA

Sample(adjusted): 1996:08 2009:04

Variable	Coefficient	Prob.
C	0,0324	0,0013
DLOG_EXP_SA(-1)	-0,6367	0,0000
DLOG_EXP_SA(-2)	-0,1867	0,0478
DLOG_EXP_SA(-3)	0,2420	0,0032
DLOG_EUR(-1)	-0,1133	0,6332
DLOG_EUR(-2)	-0,1918	0,4492
DLOG_EUR(-3)	-0,0600	0,8183
DLOG_EUR(-4)	-0,2586	0,3348
DLOG_EUR(-5)	0,3938	0,1445
DLOG_EUR(-6)	0,5185	0,0465
@TREND	-0,0002	0,0272

R-squared 0,4428

Testing Granger-causality

H_0: exchange rate coefficients jointly = 0

Wald Test:

Test Statistic	Value	df	Prob.
F-statistic	1,971	(6, 142)	0,0736
Chi-square	11,829	6	0,0659

Two-way relationships

- Example: stationary variables (e.g. differenced)
- 2 variables: X, Y – Granger-causality and reverse Granger-causality with ADL(p,q) model:

$$Y_t = \alpha_1 + \delta_1 t + \phi_{11} Y_{t-1} + \ldots + \phi_{1p} Y_{t-p} + \beta_{11} X_{t-1} + \ldots + \beta_{1q} X_{t-q} + e_{1t}$$

$$X_t = \alpha_2 + \delta_2 t + \phi_{21} X_{t-1} + \ldots + \phi_{2p} X_{t-p} + \beta_{21} Y_{t-1} + \ldots + \beta_{2q} Y_{t-q} + e_{2t}$$

- The 2 equations jointly: VAR model

VAR model

- Generalization of AR model for more variables
- More dependent variables – more equations
- Lags of all variables are included in each equation
- Usual approach: same lag length for each variables– VAR(p)
- Deterministic trend can be included

VAR model – why useful?

- Testing Granger-causality
- Uncertain direction of causality
  - Interest rate – foreign exchange rate, inflation – foreign exchange rate
  - Price levels of substitute goods
- ”Atheoretical”
- Good predictive power

Example: RMPY

1947Q1–1992Q4, U.S. data (source: RMPY.xls textbook database)

- Interest rate of 3-month government bond
- Money supply (bn USD)
- GDP-deflator (1987=1)
- Real GDP (bn USD, 1987 price)

Estimation of VAR(1) model

- Stationary variables
- 4 equations separately

Or with EViews:

- Quick/Estimate VAR
- Interpretation of output:
  - Significance, Granger-causality?
  - Sign, size of coefficients?

VAR(1) estimation results

Sample(adjusted): 1947:3 1992:4

t-statistics in [ ]

	DLM	DLP	DLR	DLY
DLM(-1)	0,749455	0,120612	3,390617	0,283097
	[15,1413]	[2,32848]	[2,73419]	[3,36818]
DLP(-1)	0,060612	0,519014	1,778745	-0,116885
	[1,03368]	[8,45814]	[1,21081]	[-1,17390]
DLR(-1)	-0,012993	0,009935	0,221877	0,000381
	[-4,38043]	[3,20071]	[2,98575]	[0,07561]
DLY(-1)	-0,031576	-0,038780	3,224227	0,308554
	[-0,70792]	[-0,83081]	[2,88528]	[4,07383]
C	0,003351	0,001589	-0,035747	0,004986
	[3,23615]	[1,46617]	[-1,37778]	[2,83544]
@TREND	3,41E-06	1,81E-05	-0,000562	-3,13E-05
	[0,39252]	[1,99189]	[-2,57979]	[-2,12328]

Lag length selection in VAR models

One approach:

- Maximal reasonable lag length: p_{max}
- Estimate VAR(p_{max})
- If any of the lags of order p_{max} significant: finished
- Otherwise: decrease lag length by one

Supplementary topics – summary

- Modeling volatility
- Granger-causality: concept, testing
- VAR models – introduction

Time series analysis, further topics

Seminar 13

Modeling volatility

- Assumption: random walk holds $\Delta Y_t = e_t$
- Volatility measure: $(\Delta y_t)^2$
  - Positive
  - Bigger change – bigger volatility
  - Different at every time point
  - = variance at a given time point
- Modeling: e.g. pl. AR(1)

$$\Delta y_t^{\ 2} = \alpha + \phi \Delta y_{t-1}^{\ \ 2} + e_t$$

Example

BUX daily closing level, January–June 2009

Volatility graph?

Is volatility stationary

in this period?

Granger-causality

- X Granger-causes Y if past values of X can help forecasting Y
- Not necessarily true causality!
- Assumption here: stationary variables

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Joint test of several coefficients

EViews: View/Coefficient tests/Wald test

F-statistic – small P-value: H_0 rejected

Example: exchange rate and export

- 1996–2009 monthly MNB data
- Export: seasonally adjusted
- Log(export), log(exchange rate) stationary?
- Log difference stationary?
- Estimate ADL(3,6) model – does the exchange rate Granger-cause the export?

VAR model

- Generalization of AR model for more variables
- More dependent variables – more equations
- Lags of all variables are included in each equation
- Usual approach: same lag length for each variables– VAR(p)
- Deterministic trend can be included

Example: RMPY

RMPY.wf1

1947Q1–1992Q4, U.S. data

- Interest rate of 3-month government bond
- Money supply (bn USD)
- GDP-deflator (1987=1)
- Real GDP (bn USD, in 1987 price)

Logarithm of levels and dlog – Stationarity? Cointegration? (6 equations)

Estimation of VAR(1) model

- Stationary variables

EViews:

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Example: RMPY model?

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