EC316 Summary (2):

Topics in Macroeconomics With Time Series Econometrics

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EC316: Topics in Macroeconomics With Time Series Econometrics

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EC316 Supplementary Notes

Lecture 9: The Euro

- Adopting a common currency – fixes ERs
- Giving up Flexible ERs:
    - Giving up ability to adjust both *i* and ER

1: ER Volatility Concern

1) Degree of Openness
    - European economies are very open
    - Int. trade important for domestic *Y*
    - High reliability of X and IM
    - Demand/*Y* is more exposed to fluctuations in ER
2) Wide ER Fluctuations
    - **Real Depreciation** can improve trade balance (X – IM)
    - Higher inflation and collapse of free trade
    - Require more coordinated institutions and common monetary system
3) Common Agricultural Market
    - Common Agricultural Policy (CAP)
    - Single ECU (weighted avg. prices in different currencies) price for agricultural products
    - Devaluation of one currency meant relative price change cross-country – exposes prices again to fluctuations in ER

1.1: Fixing Currency – Bretton Woods Agreement

- Keep volatility in check
- Currencies follow the US$
- Deviations kept {+/- 0.75%}
- *1970s Collapse – Incompatibility between German and US policy goals*
- **US Monetary Expansion** to fund Vietnam War – inflation
- High inflation in US, lose competitiveness due to high prices (IM > X)
- **Germany Monetary Contraction** raised *i* to make German bonds and currency more attractive than US
- *Fed didn't change i so policy option was to devalue*
- *Europeans clashed with ineffectiveness of ER policy – inf. UK & Italy: 20%, Fra. 15%*

1.2: Monetary System Fluctuation Options

1) Raise *i*
2) Ask for realignment
- Slide 13 for Formulae Example
- In EMS: in highest margins – raise *i* or change central parity of devaluation band
- *Higher i rates make currency more attractive*

2: Forming Monetary Union

- Maastricht Treaty – February 1992
    - Single currency decision
    - Convergence of countries aspiring to join – inflation, ER, L-R *i*, pub. def.
    - Creation of ECB
- Single Currency impossible for countries to devalue
- European Council 1998 agrees on members which met criteria

2.1: EMU Admission Criteria

- **Inflation Rate**
    - Previous yr. can't be > 1.5pp above that of three best performers
- **Previous Deficits & Debts**
    - Ratio of Gov. Def. to GDP can't be > 3%
    - Ration of Gov. Debt to GDP can't be > 60%
- **ER**
    - For at least 2 years, fluctuations within band
- **L-Term *i***
    - One year prior to examination, avg. l-term rate can't exceed more than 2pp of the three best performers (using l-term gov. bonds)

2.2: Europe – Optimal Currency Area (OCA)?

- *"To what extent are European economies likely to face **Asymmetric Shocks**?"*
- Two Conditions for OCA
    1) Countries face similar shocks
    2) High labour mobility

2. Can the Euro make business cycles more synchronised?
    - Trade intensity
    - Industry specialisation
    - Labour mobility across countries
- *Some studies find sync. among countries but not all – labour mobility historically low – still possibility of **asymmetric shock** – req. different stabilisation processes*

Lecture 10.1: Univariate Root Testes Cont. (Econometrics)

1: Alternative AR(1) Characterisations

1.1: Stationary Processes

- Where $|\rho| < 1, u =$ White Noise Errror with Mean 0 and Variance σ^2
  - $Y_t = \rho Y_{t-1} + u_t$
    - Y_t is stationary process
    - 0 Mean
    - Constant Variance
  - $Y_t = \alpha + \rho Y_{t-1} + u_t$
    - Y_t is stationary process w/ **drift**,
    - Constant Mean
    - Constant Variance
  - $Y_t = \alpha + \rho Y_{t-1} + \delta t + u_t$
    - Y_t is **trend** stationery process and will be stationary w/
    - Constant Mean (if Detrended - $(Y_t - \delta t)$)
    - Constant Variance (if Detrended $(Y_t - \delta t)$)

1.2: Non-Stationary Processes

- Where $u =$ White Noise Errror with Mean 0 and Variance σ^2
  - $Y_t = Y_{t-1} + u_t \rightarrow \Delta Y_t = u_t$
    - Y_t follows a random walk
    - ΔY_t has 0 Mean & Constant Variance
  - $Y_t = \alpha + Y_{t-1} + u_t \rightarrow \Delta Y_t = \alpha + u_t$
    - Y_t follows a random walk w/ **drift**
    - ΔY_t has Mean α and Variance σ^2
  - $Y_t = \alpha + Y_{t-1} + \delta t + u_t \rightarrow \Delta Y_t = \alpha + \delta t + u_t$
    - Y_t follows a random walk w/ **trend** then **drift**
    - ΔY_t has Mean α and Variance σ^2 (if Detrended $(\Delta Y_t - \delta t)$)

2: Testing for Unit Roots

- **Dickie Fuller**: $Y_t = \alpha + \rho Y_{t-1} + u_t$ has <u>Unit-Root</u> if $\rho = 1$
  - **Testing Regression**: $\Delta Y_t = \alpha + \phi Y_{t-1} + u_t$
  - **Null Hypothesis**: H_0: $\phi = 0$
    - Null Hypothesis: H_0: $\rho = 1$ {As $\phi = (\rho - 1)$}
  - **Test Statistic**: as t-ratio on ϕ called τ on non-std. distribution of test-stat
  - **Decision Rule** (p-value):
    - Y Stationary: {< 0.05} Reject H_0
    - Y Non-Stationary: {> 0.05} Fail-To-Reject H_0

- **Augmented Dickie Fuller**: Adding further lagged Δ terms and trend t to test
  - **Testing Regression**: $\Delta Y_t = \alpha + \phi Y_{t-1} + \gamma_1 \Delta Y_{t-1} + \cdots + \gamma_p \Delta Y_{t-p} + \delta t + u_t$
  - **Null Hypothesis**: H_0: $\phi = 0 \rightarrow H_0$: $\rho = 1$
  - **Test Statistic**: as t-ratio on ϕ called τ on non-std. distribution of test-stat
  - **Decision Rule**:
    - Y Stationary: $\{< 0.05\}$ Reject H_0
      - "Y Stationary about trend if $\delta \neq 0$"
    - Y Non-Stationary: $\{> 0.05\}$ Fail-To-Reject H_0
      - "Y Non-Stationary about trend if $\delta \neq 0$"

- **Example(s)**:

```
with constant and trend
model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff. for e: 0.001
lagged differences: F(3, 233) = 5.286 [0.0015]
estimated value of (a - 1): -0.0382769
test statistic: tau_ct(1) = -2.5207
asymptotic p-value 0.318
```

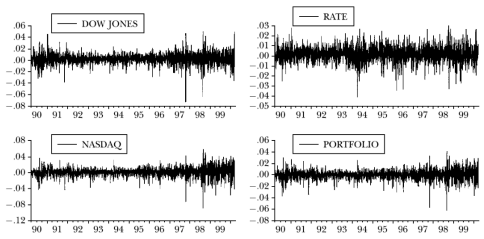
  - **Decision**: p-value on τ-test is $\{> 0.05\} \rightarrow$ Fail-To-Reject $H_0 \rightarrow$ l_GDP Non-St. & Unit-Root

```
test with constant
model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff. for e: 0.006
lagged differences: F(2, 235) = 5.873 [0.0032]
estimated value of (a - 1): -0.664499
test statistic: tau_c(1) = -6.67146
asymptotic p-value 2.469e-009
```

  - Decision: p-value on τ-test is $\{< 0.05\} \rightarrow$ Reject $H_0 \rightarrow$ d_l_GDP Non-St. & Unit-Root

Lecture 10.2: Garch Models of Volatility (Econometrics)

- Where σ^2 is more important than the variables themselves
  - E.g. risk in share price
  - E.g. derivatives (options etc. derived from assets)
  - E.g. – how it looks:

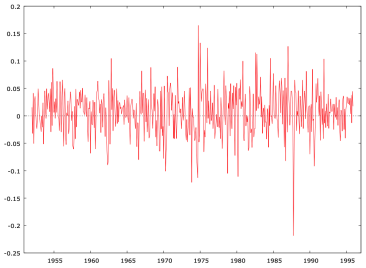


- Volatility Clustering:
  - Riskiness isn't randomly scattered across data, some periods more risky
  - Periods of high volatility followed by periods of tranquillity – **autocorr.**

1: Stock Prices & Returns

- $Y_t = \alpha + Y_{t-1} + \varepsilon_t$
  - *"Stock prices **rise** by average of α ea. period, but are unpredictable"*
- Rearrange: $\Delta Y_t = \alpha + \varepsilon_t$
  - *"Stock prices **are** on average α, but are unpredictable"*

- **Example**:



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```
Augmented Dickey-Fuller test for Return
including 4 lags of (1-L)Return (max was 12)
sample size 523
unit-root null hypothesis: a = 1

   test with constant
   model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
   1st-order autocorrelation coeff. for e: 0.006
   lagged differences: F(4, 517) = 1.425 [0.2244]
   estimated value of (a - 1): -0.869121
   test statistic: tau_c(1) = -9.07561
   asymptotic p-value 2.782e-016
```

→

```
Augmented Dickey-Fuller regression
OLS, using observations 1952:06-1995:12 (T = 523)
Dependent variable: d_Return

              coefficient   std. error   t-ratio    p-value
  ---------------------------------------------------------
  const        0.00603858   0.00189116    3.193    0.0015    ***
  Return_1    -0.869121     0.0957645    -9.076    2.78e-016 ***
  d_Return_1  -0.0867612    0.0860734    -1.008    0.3139
  d_Return_2  -0.125928     0.0744505    -1.691    0.0914    *
  d_Return_3  -0.115434     0.0604937    -1.908    0.0569    *
  d_Return_4  -0.0923983    0.0436894    -2.115    0.0349    **
```

2: Stock Price Volatility

- $\Delta y_t = \Delta Y_t - \Delta \overline{Y}$ $\{\Delta Y_t = \alpha + \varepsilon_t\}$; $\left\{\Delta \overline{Y} = \frac{\sum \Delta Y_t}{T} = \alpha\right\}$
  - $\Delta y_t = \alpha + \varepsilon_t - \alpha$
  - $\Delta y_t = \varepsilon_t$
- $\therefore \sigma^2_{\Delta y_t} = \Delta y_t^2$
  - *Difference in stock price, deviations from mean, square them*

2.1: AR(1) Model of Volatility

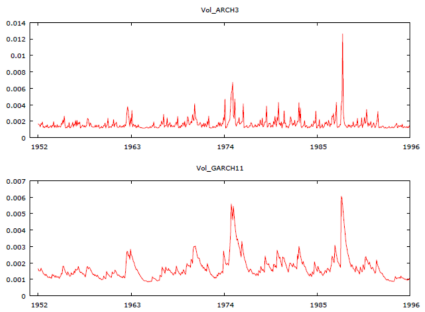
- Vol. depends on vol. in previous period
- Usually $\rho > 0$: if high vol. last period, there will likely be again, same /w low
    - "**Volatility Clustering**"
    - Error u_t means there can be exceptions
    - Provided R's are stationary: OLS estimates, t-stats, p-values can be interpreted the standard way

3: Autoregressive Conditional Heteroscedasticity (ARCH) Models

- Financial time-series
- Involves equations for Y_t and σ_t^2

- GARCH Model:
    - Adds lags of σ_t^2 instead of just squared terms

- ARCH vs. GARCH
    -



4: Conclusion

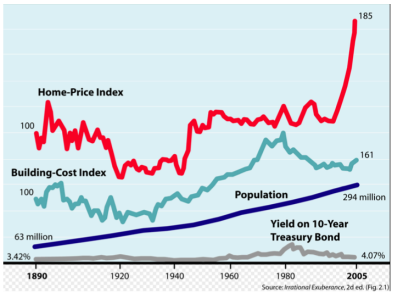
- Many t-series variables, such as asset prices, seem to exhibit random walk behaviour – hard to predict future movement
- However, volatility is more accurately predictable – used as dependant variable

Lecture 11: The Great Recession

- How does macroeconomic theory explain 2007-2010 crisis?
- House problem to financial crisis → financial to macroecon. → policy → recovery

1: Housing Problem to Financial Crisis

- **Economic Bubble**: prices of assets > their fundamental value
  - Once they burst, asset prices collapse
- **Sub-Prime**: intended for borrowers w/ low probability of repayment
  - Amplification led to system collapse



1.1: The Bubble

- Rapid house price demand post-2000
  - Long period low i – incentive to borrow to buy (expanded financial sector)
  - No need to raise i as π was low (house price change doesn't enter π)
  - Expectation of house prices continuing to rise (irrational exuberance)
    - People think it's an easy way to make money
  - Borrowing easier as banks made mortgage approvals less strict
  - Low probability repayment households were approved (sub-prime)
  - Banks didn't care about this risk as they repackaged the mortgages and sold them as ranks of Mortgage Backed Securities

1.2: Initial Trigger

- Summer 2007
  - Started in the sub-prime mortgage market
  - House prices stopped increasing and people increasingly defaulted
  - Underlying properties are foreclosed and transferred to banks
    - Current value of house < initial loan

1.3: Bubble Popped into Financial Crisis

- Banks are intermediaries between borrowers and lenders
- **Solvency Problem**: if asset value < liabilities: bank becomes insolvent

- **Liquidity Problem**: banks now cant repay their lenders
- **Leverage** plays a part in amplifying this – everything is blown up
    - Leverage Ratio = {Assets/Capital}
    - Capital Ratio = {Capital/Assets}
    - Incentive existed due to (1) underestimated risk, (2) high bonus incentive
    - There was a regulation on min{Capital Ratio} – new ways to avoid

- **Complexity**:
    - Movement away from balance sheet operations
- **Securitization**:
    - *Creation of securities based on bundling assets (e.g. mortgages)*
    - **Mortgage Backed Security**: a title to returns from bundle of mortgages
        - Bundled assets shouldn't be correlated but sub-prime's were, high
    - **Collateralised Debt Obligations**: high risk, high return assets on default

- **Structured Investment Vehicles (SIVs)**:
    - Off balance sheet operations independent from banks
    - **Liability** side: borrows from investors (short-term debt)
    - **Asset** side: holds various forms of securities
    - *Asset relies on bank as lender of last resort*

- Shadow Banking & American International Group**

- House Prices Decreased
    - Assets became **Toxic Assets** very high risk and no one wanted to hold
    - Fire Sales
    - Assets attached to the mortgages declined in value also

2: Financial Problem to Macroeconomic Problem

3: Policy Response

4: Slow Recovery

Lecture 12: High Debt

"Why do economists worry when governments accumulate debt quickly?"

1) Budget Constraint of Government
2) Analysing Debt-to-GDP Ratio
3) Political Theory of Debt

- **Primary Deficit**: (G – T) *"gov. spending (-) taxes (collected)"*
  - G (can be) > T: with borrowing
- **Cyclically Adjusted Deficit**: what the deficit would be if Y was at natural level
- **Inflation-Adjusted Deficit**: deficit measured in real terms (adjusted for π)

1: Government Budget Constraint

- Create a budget deficit to stimulate economy, people to spend
- How can you repay this?

$$Deficit_t = B_{t-1}(r) + (G_t - T_t)$$

B_{t-1} = Bonds & Bills Issued (Government Debt)
r = Real Interest Rate
$(G_t - T_t)$ = Primary Deficit

- Assume **Deficit Financing** (sell *B* to investors; as opposed to T > G):

$$B_t - B_{t-1} = Deficit_t$$

- Hence Budget Constraint:

$$B_t - B_{t-1} = B_{t-1}(r) + (G_t - T_t)$$

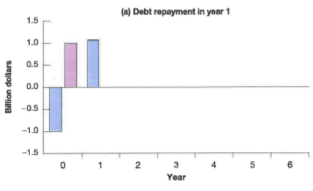
$$\boxed{B_t = B_{t-1}(1+r) + (G_t - T_t)}$$

$$Debt\ Year\ t = Debt\ Year\ t-1(1+r) + Primary\ Deficit$$

1.1: Repaying Debt

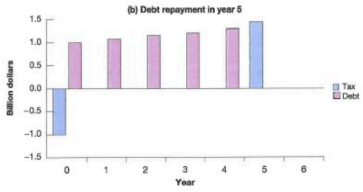
- **Case 1 Example**:
  - *Repays in year 1 so* {$B_0 = 1$; $B_1 = 0$}
  - Hence (sub to above):

$$(T_1 - G_1) = (1+r)$$



  - Gov. creates **Primary Surplus** in year 1 (=) (1+*r*)
  - An increase in T of initial T cut plus *i* rate on debt

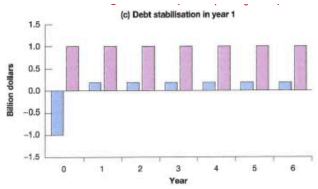
- **Case 2 Example**:
  - *Repay after t years so no payment previously*
  - Hence:



$$(T_1 - G_1) = (1 + r)^t$$

  - Gov. creates **Primary Surplus** (=) $(1+r)^t$
  - \\ If G unchanged, reduction of T today must be offset by increase in T_t
  - \\ Delaying T increase or higher *i* means T increase must be **larger**

- **Case 3 Example**:
  - *Stabilise at a higher level* $\{B_0 = B_1 = 1\}$
  - Government doesn't need to repay
  - Hence:



$$(T_1 - G_1) = (1 + r) - 1$$
$$(T_1 - G_1) = r$$

  - To stabilise debt, gov must achieve **Primary Surplus** (=) real interest rate and this must hold for every subsequent year

2: Analysing Debt-to-GDP Ratio

- Normalise above by the real output Y

$$\frac{B_t}{Y_t} = \frac{B_{t-1}}{Y_t}(1 + r) + \frac{(G_t - T_t)}{Y_t}$$

$$\rightarrow \frac{B_t}{Y_t} = \frac{B_{t-1}}{Y_{t-1}}\frac{Y_{t-1}}{Y_t}(1 + r) + \frac{(G_t - T_t)}{Y_t}$$

$$\text{As: } \frac{Y_{t-1}}{Y_t} = \frac{1}{(1+g)}; \text{Approximate: } \frac{(1+r)}{(1+g)} \approx (1 + r - g)$$

$$\rightarrow \frac{B_t}{Y_t} - \frac{B_{t-1}}{Y_{t-1}} = \frac{B_{t-1}}{Y_{t-1}}(r - g) + \frac{(G_t - T_t)}{Y_t}$$

- *"Change in debt ratio is (=) to sum of":*
  - Difference between real interest and rate of GDP, multiplied by end-of-period debt ratio
  - The ratio of **Primary Deficit** to GDP

- First Equation: debt level evolves with real interest
- Second Equation: debt-to-GDP ratio evolves with real interest and growth

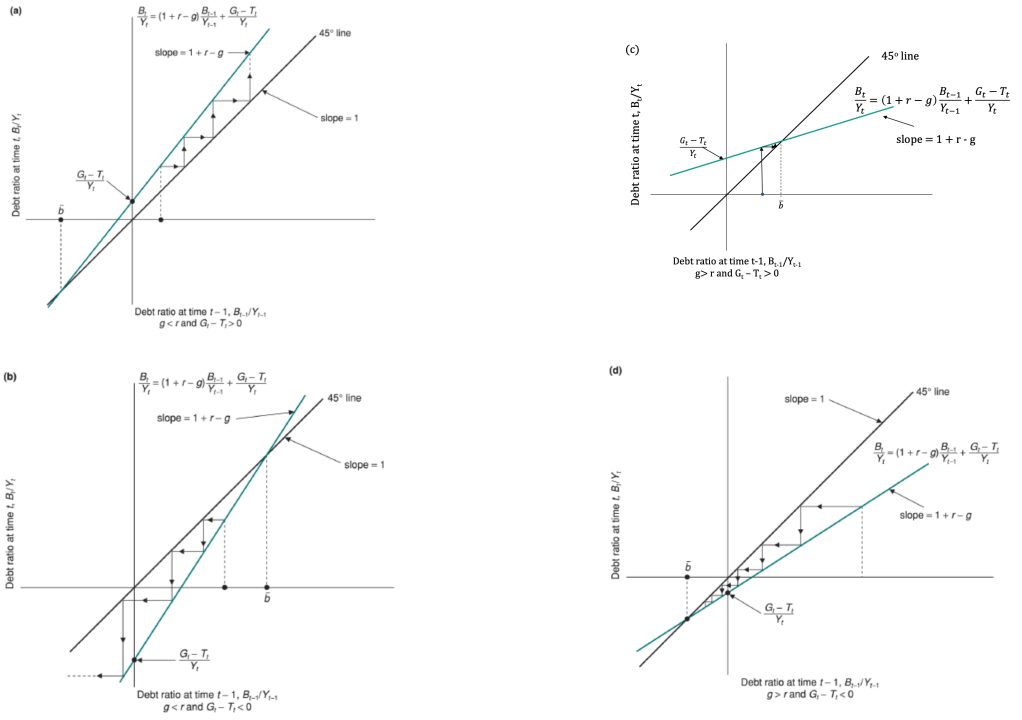
2.1: What Will Happen to Debt-GDP in L-R?

- Effected by {Deficit/Debt Position A/Interest Rate r/Growth Rate g}
- Treating in year t as **Exogenous** (a given)
- Hence:

$$y_t = \beta y_{t-1} + A$$

- Parameter $\beta = (1 + (r - g))$
- $A =$ Primary Deficit
- $y_t =$ General Varibale for Debt Ratio
- Is Debt-GDP **sustainable** or **unstable** (keeps growing)?
    - Is it converging or diverging to 45° line

	$g > r$	$g < r$
Primary Deficit ($G_t - T_t > 0$)	Figure (a)	Figure (c)
Primary Deficit ($G_t - T_t < 0$)	Figure (b)	Figure (d)



- (a) & (b): if ($g < r$), with (+) Debt and Primary Deficits, debt ratio increases
    - **Diverge** from Equilibrium
    - Prevent exponential increase in debt ratio: run **Primary Surplus**: (G < T)
- (c) & (d): if ($g > r$), debt-GDP ratio will **Converge** to steady state in L-R
    - Even with **Primary Deficits**, convergence occurs
    - Governments don't need to stabilise debt-to-GDP ratio

3: Political Theory of Debt

- 1960's: strong growth w/ average growth exceeding r almost everywhere ($g > r$)
    - Falling debt ratios w/o needing surpluses
- 1970's: lower growth and lower interest rates
- 1980's: growth rates slowed, interest increased
    - To avoid increase in Debt-GDP, countries should have created large surpluses
    - However, period leading to 2007 saw sharp increase in Debt-GDP ratios

3.1: Dangers of Very High Public Debt

Usually around 200%

1) Increase **Primary Surplus**, government raises taxes but they're unpopular
2) Political uncertainty increases → increases risk premium → increases interest rate
3) Fiscal tightening induced by first increase in r then generates deeper recession → reduces rate of growth
4) Increase in r and lower g result in higher ($r - g$) → more difficult to stabilise debt-GDP ratio

3.2: Return from High Debt

- If debt-GDP is very high, can escalate and lead to debt crisis
    - Impossible to issue new debt, except at extraordinary rates
- Wait rather than immediately introducing adequate measures as:
    - Debt crises unpredictable, short-sighted gov.'s reluctant to admit crisis
    - Fiscal policy/correction would impact differently on societal groups

3.3: Reduce High Debt

Where ($r > g$), three way to achieve reduction:

1) Generate **Primary Surpluses**
2) **Monetary Financing by CB**: Print money by purchasing gov. bonds
    - Raises inflation, like a form of taxation – reduces real value of debt and cash
3) **Repudiate the Debt**
    a. Pros: reduces distortions of high debt
    b. Cons: erodes trust between investors and government – gov.'s perhaps unable to run deficits in case of unexpected high expenditure

3.4: Political Theory of Debt

- Reduce Debt → Redistribute Wealth (debt reduction, raised tax, higher inflation)
    - Rentiers: earn from securities
    - Entrepreneurs: earning from owning physical capital
    - Workers: earning from owning human capital

Lecture 13 & 14: Time Series Correlation, Cointegration & Error Correlations

1) ADL Model
2) T-Series Regression w/ X & Y Stationary
3) T-Series Regression w/ X & Y Non-Stationary (Unit-Roots)
    - Spurious regression
    - Cointegration
    - Estimation/Testing w/ Cointegrated Variables
    - T-Series Regression w/ X & Y Cointegrated (Error Correction Model)

1: Recall Stationarity & Non-Stationarity

- **Stationarity**: Constant Mean, Constant Variance, No Seasonality
- Y_t is Stationary (does not have a Unit-Root) if:
    - $E(Y_t)$ is (=) @ all *t* values
    - $\sigma^2_{Y_t}$ is (=) @ all *t* values
    - $cov_{Y_t,Y_{t-s}}$ depends only on *s*, not on *t*
- Y_t is Non-Stationary (has a Unit-Root) if:
    - $\phi = 0;\ \rho = 1$
    - $\sigma^2_{Y_t} \to \infty$ $\left\{\text{Where } \sigma^2_{Y_t} = \frac{\sigma^2}{1-\rho^2}\right\}$

2: Autoregressive Distributed Lag $ADL(p, q)$

$$Y_t = \alpha + \delta t + (\rho_1 Y_{t-1} + \cdots + \rho_p Y_{t-p}) + (\beta_0 X_{t-0} + \beta_1 X_{t-1} \ldots + \beta_q X_{t-q}) + \varepsilon_t$$

- Y_t is dependent upon:
    - p lags of Y_t
    - X
    - q lags of X
- *Y & X must hold the same stationarity properties (both stationary or non-')*

3: Testing ADL for Non-Stationarity

- Stationary → OLS Regression → t-test → F-test
- Rewrite for change in Y_t:

$$\Delta Y_t = \alpha + \delta t + \left(\phi Y_{t-1} + \gamma_1 \Delta Y_{t-1} + \cdots + \gamma_{p-1} \Delta Y_{t-(p+1)}\right) + \left(\theta X_t + \omega_1 \Delta X_{t-1} + \cdots + \omega_{t-1} \Delta X_{t-(q+1)}\right) + \varepsilon_t$$

- **Long-Run Multiplier**: Y & X are in equilibrium → X increases by 1 in perpetuity → Y changes accordingly → L-RM (=) difference between equilibrium Y and this effect of X on Y

3.1: Spurious Regression w/ Non-Stationarity

- Recall (**Example**): $Y_t = \alpha + \beta X_t + \varepsilon_t$
  - t-tests will show values which indicate $\beta \neq 0$ when it may be (recall)
  - This is called "Spurious Regression"

3.2: Cointegration w/ Non-Stationarity

- Cointegration: in **equilibrium**, errors **stationary**, no **Unit-Root**,
- No Cointegration: no **equilibrium**, errors **non-stationary**, **Unit-Root**
  - ** Cointegration if: Unit-Root in Variables → No Unit-Root in ε_t **
  - Error Estimation: $\varepsilon_t = Y_t - \alpha - \beta X_t$
  - Equilibrium ε_t stays small
  - The gap between each line of Y and X is relatively **constant**
    - https://www.youtube.com/watch?v=q5wbOSjbVW4

- If both of these have Unit-Roots, ε_t also is expected to have a Unit-Root
  - If ε_t holds Unit-Root: Spurious Regression
  - Possible that Unit-Roots of Y and X "cancel ea. other out"
  - *"If Y and X have Unit-Roots but a linear combination of them is Stationary, Y and X are Cointegrated"*

3.3: Regression w/ Cointegration

- Cointegration of Y and X: no Spurious Regression
- Regression of Y and X: 'cointegrated regression'
- Regression coefficient: Long-Run Multiplier
- *Engle-Granger Test, Johansen Test*

3.3.1: Regression w/ Cointegration in Gretl

- Same as Unit-Root but:
  - H_0: "**Unit-Root** exists, **non-stationary**, **no cointegration** between X & Y"
  - H_A: "**No Unit-Root** exists, **stationary**, **cointegration** between X & Y"

4: Issues w/ Cointegration Testing (Engel-Granger Test)

- Previously focused only on Y and X but we can use up to K variables
- The Engel-Granger Test would only find whether there is Cointegration or not – not how many Cointegrating relationships there are
- Therefore, (1) use the Johansen Test which is VAR-based, (2) do multiple Engel-Granger Tests for combinations of ln values (e.g. ln(Y) & ln(C), ln(C) & ln(I))

4.1: Example – Cointegration Between C, I, Y

- If ln(Y), ln(C), ln(I) contain Unit-Roots, possible **two** Cointegrating relationships
- **Johansen Test**:

```
Estimation period: 1951:2 - 2002:2 (T = 205)
Case 3: Unrestricted constant

Log-likelihood = 2630.62 (including constant term: 2048.85)

Rank Eigenvalue Trace test  p-value  Lmax test  p-value
   0    0.13754     37.265 [0.0051]    30.334 [0.0012]
   1   0.028769     6.9313 [0.5916]    5.9840 [0.6212]
   2  0.0046103    0.94729 [0.3304]   0.94729 [0.3304]

Corrected for sample size (df = 201)
Rank Trace test p-value
   0     37.265 [0.0054]
   1     6.9313 [0.5958]
   2    0.94729 [0.3335]
```

  - $H_{Rank\ 0}$: Null that there is 0 Cointegrating relationships
  - $H_{Rank\ 1}$: Null that there is 1 Cointegrating relationships
  - $H_{Rank\ 2}$: Null that there is 2 Cointegrating relationships
  - If | Critical Value | < | trace-stat |: Reject Null Hypothesis
  - If p-value < 0.05: Reject Null Hypothesis
  - *This Example:*
    - Reject $H_{Rank\ 0}$
    - Fail to Reject $H_{Rank\ 1}$
    - Fail to Reject $H_{Rank\ 2}$

- **Engel-Granger Test (Form of DF Test)**:
  - Step 1: test for Unit-Root in C (Model of Y & C)
  - Step 2: test for Unit-Root in Y (Model of Y & C)
  - Step 3: Cointegration Regression
  - Step 4: test for Unit-Root in Error ε_t
  - *Cointegrated if: Unit-Root in Y & C, no Unit-Root in* ε_t

5: Error Correction Model (ECM)

- *Moving forward, assuming variables are Cointegrated*
- If X and Y are Cointegrated, their relationship can be shown as ECM

$$\Delta Y_t = \varphi + \lambda \varepsilon_{t-1} + \omega_0 \Delta X_t + e_t$$

- Error from Y and X regression: $\varepsilon_{t-1} = Y_{t-1} - \alpha - \beta X_{t-1}$
- ECM Error: e_t
- EMC has: $\lambda < 0$:
  - If we knew ε_{t-1}, ECM would be similar to ADL
  - ECM says ΔY depends on ΔX, also same idea as ADL
  - New: ΔY depends on ε_{t-1} (equilibrium error)
  - New: (for now) assume $\{\Delta X_t = 0\}$; $\{e_t = 0\}$ to observe ε_{t-1}

5.1: ECM Intuition

- If $\varepsilon_{t-1} > 0$: Y_{t-1} is **too high** to be in equilibrium
- As $\lambda < 0$: $\lambda\varepsilon_{t-1}$ $(-)$ thus so too ΔY_t $(-)$
- *"If Y_{t-1} is above equilibrium, it will start falling in the next period so the equilibrium error will be 'corrected'"*
- If $\varepsilon_{t-1} > 0$: **Opposite of Above** (If $\lambda > 0$, errors magnified rather than corrected)

5.2: ECM Testing

- Don't worry about Spurious Regression
- Assumed Y and X have Unit-Roots
- Assumed Y and X are Cointegrated, thus ε_{t-1} is Stationary
- Assumed ΔY and ΔX are Stationary
- Hence, dependent and all explanatories are Stationary
- Thus, OLS regressions and t-tests etc. work as standard
- New issue: ε_{t-1} is explanatory, errors not directly observed, replace w/ residuals

- **Two-Step Estimation**:
  - Step 1: Run regression of Y and X and save residuals (uhat)
  - Step 2: Run regression of ΔY on intercept and ΔX w/ residuals from Step 1, lagged by one period

$$\Delta Y_t = \varphi + \delta t + \lambda\varepsilon_{t-1} + \left(\gamma_1\Delta Y_{t-1} + \cdots + \gamma_{p-1}\Delta Y_{t-p}\right) + \left(\omega_0 X_t + \cdots + \omega_q\Delta X_{t-q}\right) + e_t$$

- Same 'correction of equilibrium error' interpretation

- **Example**:

Table 8.3: Two-step Estimation of the Simple Error Correction Model

Variable	OLS Estimate	t-statistic	P-value
Intercept	-0.023	-0.068	0.946
$\hat{\varepsilon}_{t-1}$	-1.085	-14.458	8.7×10^{-32}
ΔX_t	1.044	5.737	4.1×10^{-8}

  - Error coefficient says "equilibrium error of 1cent causes Y to fall by 1.085cents in the next period, all else remaining constant"

6: Summary

- We can now model under **three** circumstances
  - When all variables are Stationary
  - When all variables have Uni-Roots and are Cointegrated
  - When all variables have Unit-Roots and are not Cointegrated

Lecture 15: Policy & Policy Makers

- *"Given uncertainty about policy, would we be better w/o it?"*
- *"Can we trust policymakers to use correct policy?"*
- Policy Uncertainty → Policy Expectations → Policy Politics

1: Policy Uncertainty

- **Example**: CB want decreased Unemployment w/ Monetary Expansion
    - ME is increase in M → lower i → higher I → higher demand → lower u
    1) Is unemployment at the natural level?
    2) How much will i change?
    3) How will stock prices change? (lower i → lower disc. rate → higher PV)
    4) How will ER change? (How will this effect (X – IM))

- Uncertainty can be modelled
- Economic agents → financial markets → firms and households
- *"Normal g of GDP, G is reduced by 1%, expected consequences on GDP"*
    - The Area-Wide Model of European CB
    - MULTIMOD Mark II
    - NiGEM
    - The Quest Model of the European Commission
- **Example**:
    - Brexit inflation modelling will produce a range of outcomes with varying likelihoods due to uncertainty

- Should uncertainty mean Policy Makers do less?
    - **Yes**, policy should be aimed at avoiding prolonged recessions → slow booms and avoid inflation pressure
    - Higher u, or higher π, more active policies should be
    - Should stop well short of trying to achieve constant u or g

2: Policy Expectations

- What people do: depends on expectations of policy
- What policy makers do: depends on the state of the economy

2.1: Inflation Unemployment Trade-Off

- Recall:

$$\pi = \pi^e - \alpha(u - u_n)$$

  - (1) CB state policy → (2) W-Setters & HHs negotiate wages → (3) CB acts
  - *CB sets π target → wage setters and households negotiate W → CB implements these in order to achieve π taget*
  - Increase in u over natural: lower π
  - Decrease in u under natural: higher π

- Suppose 0-inflation Mon. Pol.

$$\pi = -\alpha(u - u_n)\ \{\pi^e = 0\}$$

  - To achieve 0-inflation, $u = u_n$
  - **Time Inconsistency**: incentive to deviate from announced policy once other player has made a move (W-Setters in this case)
  - **Example:**
    - If: $\alpha = 1$, accept 1% π, CB can achieve u of 1% below natural
    - In response: W-Setters expect $\pi^e = 1$ → economy returns to u_n w/ higher π

2.2: Credibility

- *CBs will therefore need to be seen as **Credible** when staying in-line w/ policy*
  - *Commit not to do something that seems desirable to them in the short-run*
  - *Will have bad effects for both parties in the long-run (like Prisoners D.)*

1) Make CB independent
   - Less likely to deviate to achieve s-term goals (e.g. if ties to political party – may deviate pre-election)
2) Encourage CBs to view l-term inflation
   - Reduce incentive for s-term goals (e.g. give CBs l-term in the office)
3) Choose Inflation-Averse CB
   - If inflation is not liked, unlikely to want low unemployment through high inflation

3: Policy Politics

- CB/political goals may not align w/ economic/societal goals
- Short-Sighted Voters: don't care for L-R economy (want politicians to cut taxes)
- **Conservatives**: stimulate the L-Term economy

Lecture 16: Monetary Policy Rules

- Should CB change *i*? Long-Run objectives of CB
- E.g. the Federal Reserve's response to Coronavirus {$i = \sim 0$}
- *What is optimal target for π?*

- **Recall** (Short-Run):
  - Increase on M supply leads to decreased *i* and increased demand/output
- (Medium-Run):
  - Change in M has a neutral effect
  - No effect on growth of economy or unemployment
  - Money change leads to proportional price increases
  - Changes in money growth lead to corr. changes in π

1: Optimal Inflation Rate

- *Most wealthy countries have had low inflation for the last few decades*
- *Very high inflation can disrupt economic activity*
- Target: ~0%-3% p.a. (not too costly)
- Costs: Trade-off between inflation and low unemployment/high output

1) Show Leather Costs
2) Tax Distortions
3) Money Illusion
4) Inflation Variability

1.1: Shoe Leather Costs

- Increased opportunity cost of holding money: higher costs due to going to the bank more often w/ high inflation (could be working instead etc.)

1.2: Tax Distortions

- Tax on capital gains: higher inflation, higher tax (volumetrically)
- **Effective Tax Rate**: ratio of {tax paid-to-price sold}
  - Buy house £50,000; sell house £50,000$(1+\pi)^T$
  - Real value of house unchanged as money will buy you same amount
  - Pay greater tax, but shouldn't pay tax as sold at same relative price
  - cap gains tax = 30% {cap. gain = 0}, effective tax rate:
  - $\frac{50000(1+\pi)^T - 50000}{50000(1+\pi)^T}(0.30)$
    - $\pi = 0: ETR = 0$
    - $\pi = 3\%: ETR = 7.6\%$
- Tax Distortions: tax doesn't increase w/ π (e.g. move to higher income brackets)
  - Same **real** income, different **nominal** income

1.3: Money Illusion

- People make mistakes when assessing **real** vs. **nominal** changes
- E.g. comparing income across time means you need to account for π
- E.g. choosing assets or consuming/saving

1.4: Inflation Variability

- Higher π usually means more variable π
- E.g. buying a bond w/ longer maturity is far riskier w/ higher inflation

2: Benefits of Inflation

1) Seignorage
2) Option of Negative Real i
3) Money Illusion Revisited

2.1: Seignorage

- Money creation: alternative to borrowing form public or raising tax
    - High π trade-off
    - Works well in countries w/ high π

2.2: Negative Real Interest Rates

- Recall: $\{r = i - \pi\}$
- *Economy w/ higher π has more scope to use Monetary Policy to fight recession*
- **Example**:
    - $r_{A,B} = 0.02; \pi_A = 0.03;\ \pi_B = 0.00$
    - $\therefore i_A = 0.05; i_B = 0.02$
    - If $\pi > i$: chance that r is (-)
        - Investors gain from borrowing
        - Higher investment and higher demand

2.3: Money Illusion Revised

- Workers should be indifferent between:
    - $\pi = 0.03; W(\uparrow) = 0.01$
    - $\pi = 0.00; W(\downarrow) = 0.02$
    - Both give 2% decrease in Real Wage however the first case is more likely to be accepted – people happier w/ higher wage and inflation

2.4: Optimal Inflation Rate?

- Some want price stability (zero-inflation)
    - Eliminates Money Illusion and eases decisions
- Others want to keep small inflation
    - E.g. 3% is desirable compared to 1%
    - Costs of 3% are outweighed by benefits compared to 0%
    - **Indexing Tax**: taxes change w/ inflation – prevents some costs

3: Monetary Policy Rules

- Money growth rate
    - Until 90's CBs chose nominal money growth for M-R economy
- Inflation targeting
    - Today, (low) Inflation Targeting is used for M-R – require S-R *i* changes

3.1: Money Growth Rate (1990's)

- CB chose target nominal M growth corresponding to desired π for M-R
- In S-R, CB allowed for deviations of nominal M growth from target
    - E.g. recession: increase nominal M growth → faster decrease in *i*
- CB announce range of nominal M growth which allowed to follow M-R desired π and S-R deviations like above
- *Stopped using this rule over time*
    - Money growth didn't drive π as exp. – more difficult to target M-R π

- S-R: M growth determines output
- M-R: M growth determines π
- *Not a tight relationship due to the shift in money demand*

- **Example**:
    - Monzo introduced – people prefer this to holding money → reduction in real money demand
    - In M-R: also needs to be corresponding reduction in real M stock
    - For money stock (growth) to remain same, must be price increase so (+) π
    - Relationship between money and π breaks down
    - Therefore, abandon Money Growth Rate, adopt Inflation Targeting

3.2: Inflation Targeting (1990's →)

- Recall Phillips Curve:
  - $\pi = \pi_{t-1} - \alpha(u - u_n)$
  - $\pi^* =$ Target Inflation
  - $\pi^* = \pi^* - \alpha(u - u_n)$ {Target Achieved Ea. Pd.}
  - $0 = 0 - \alpha(u - u_n)$
  - $u = u_n$ {Unemployment Always Natural}
  - $\therefore Y = Y_n$
  - *<u>Inflation Targeting</u> leads to CB eliminating deviations from natural level*
    - *Not likely to happen in practice*
    - CBs can't always achieve desired S-R π
    - Phillips Curve doesn't always hold
    - *<u>Inflation Targeting</u> is strong in the M-R and allows Mon. Pol. to stabilise Y around S-R natural*

3.2.1: The Taylor Rule

- *"CB should choose i rather than state of M growth"*
- $i = i^* - \alpha(\pi - \pi^*) - \beta(u - u_n)$
  - $i^*, \pi^* =$ Target Interest Rate, Target Inflation
  - Once CB chooses target π, try to achieve through adjusting *i*
  - α, β show relative importance
  - If $\{\pi = \pi^*\}$ & $\{u = u_n\}$: CB gets $\{i = i^*\}$
  - If $\{\pi > \pi^*\}$: CB should increase $\{i > i^*\}$
  - If $\{u > u_n\}$: CB should decrease $\{i < i^*\}$

Lecture 17: Fiscal Policy Rules

- Changes in Government Budget Constraint (G – T)
    - Primary Surplus or Primary Deficit
- **Short-Term**: how to use fiscal policy to finance gov. expenditure
- **Long-Term**: how to manage gov. debt and distribute tax burden
    - Aging populations: imbalances between how much a gov. needs to spend at the top of the distribution vs. how much they raise in tax from lower

- Fiscal Issues
    - Ricardian Equivalence
    - Deficits, output stabilisation, cyclically adjusted deficit
    - Wars and deficits
- Fiscal Restraints
    - Fiscal rules
    - Fiscal rules for countries within monetary union

1: Ricardian Equivalence

- *"Neither deficits nor debts have any effect on economic activity"*
    - E.g. gov. uses debt financing (deficit spending), effects will be neutral

- Government raises government spending
    - Extra can be financed by rising T or raising public debt
    - Does financing method matter in economic activity?

- Optimistic View
    - Perfectly foresighted consumers – rational view of future, expectations taken into account when decision making in the present
    - How we finance extra spending should have **no** effect on behaviour
    - E.g. people won't change C in response to a tax cut as they will expect future tax increase so expected labour income will remain same
    - *Assumes*: consumers understand gov. budget constraint
    - *Assumes*: expect primary surpluses to follow primary deficits

- PV of Tax Liabilities
    - Suggests timing of taxes doesn't matter
    - What matters is PV of tax liabilities
    - **Example**: gov. announces 0-tax income in the S-R, you know they can afford this L-R is increase in future income tax
        - Year 1: higher (Y-T); Year 2: lower; Year 3: lower…
        - Savings increase with current higher Y_D – save for lower Y periods
        - **Overall**: no change

- Evidence shows this holds reasonably but not enough to ignore debts/deficits
    - Tax cuts known, future taxes uncertain
    - People not infinitely lived, or don't optimise over all *t* periods
    - Not all households are the same

2: Output Stabilisation

- Deficits during recessions should be offset by surpluses during booms
    - Times are bad: run deficits
    - Times are good: run surpluses
    - Full employment deficits: deficit which would exist under natural Y
        - OECD Mid-Cycle deficit or cyclically adjusted deficit

- Cyclically Adjusted Deficit
    - S-R fluctuations may be driven by debt financing
    - Once Y returned to Y_n, and still deficit; L-R debt accumulation
    - If {CAD = 0}: debt stabilises

- Fiscal goal not necessarily to have {CAD = 0} always
    - In recession, gov. may want large deficit enough that {CAD > 0}
    - Since debt will accumulate, expect policy change over *t* (tax increase)

- CAD theory simple but difficult in practice
    - Hard to establish how much lower deficit would be if output was higher
        - E.g. Y drops by 1% in recession, increase in deficit of 0.5% of Y
        - If Y 5% < Y_n: deficit-to-Y level 2.5% higher than it would be at Y_n
        - **Automatic Stabiliser**: when Y drops, deficit increases to stabilise
    - Difficult to assess how far output is from Y_n
        - Also hard to assess u_n
        - If u_n is too low, too high an estimate of Y_n
        - Therefore, CAD will be too optimistic

3: Wars & Deficits

- Consumers and firms are effected differently depending on war funding method
- Using deficits is the most common method in war
    - **Distribution**: debt burden of war is passed to future generations
    - **Tax Distortions**: deficit spending helps reduces tax distortions

3.1: Distribution

- Assume Y is fixed at Y_n
- In wars G increases (military equipment, infrastructure, healthcare etc.)
- So **debt** finance or **taxation** finance?
- **Deficit Finance**
    - Sharp ↑ G increases demand for goods
    - *i* must ↑ so I ↓
- **Taxation Finance**
    - ↑ T, significant ↓ C
    - By how much depends on consumers' expectations (e.g. longer the war lasts, longer they'll get higher taxes, more likely ↓ C)
    - ↑ in G will be partly offset by ↓ in C
    - Therefore, ↑ in *i* and I ↓ will be smaller
- *Lower I means lower K so, post-war, lower Y*
- *By ↓ K accumulation, deficits can be passed to future generations*

3.2: Tax Distortions

- G is exceptionally high (e.g. reconstruction post-earthquake)
- T must ↑ drastically
- Distortions: people work less or engage in tax avoidance
- Tax Smoothing: during crises deficits must be very large but, taxes used to compensate for this in future should be reasonably small and spread

4: Politics & Fiscal Restraints

- Politics can lead to L-Term deficits – can rules limit the negatives?
- The USA:
    1) Constitutional budget balance amendment
    2) Impossible to conduct fiscal policy
- The UK
    1) The Golden Rule: gov. will only borrow to invest and not to fund G
    2) Sustainable investment rule: public debt kept at sustainable level
- Why systematically run public deficits?
    - ↑ C before elections in order to increase probability of re-election
    - Gov.'s tend to spend above means and pass burden to future
    - Population ageing in advanced countries so high spending on pensions etc. are not relative to T claimed from working age
- Monetary Union increases importance of fiscal discipline
    1) Correct incentive to pass costs of fiscal expansion
    2) Prevent crisis in one country spreading to all members