

Theory, Applications and Computations for Panel Data Models

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ADVANCED ECONOMIC THEORY 2007
Week 5

Feb 26, 2007

Models for Analysis of Panel Data

Theory of Panel Data Estimation

Pooling: SUR

Between and Within Effects

Fixed and Random Effect Models

Dynamic Panel

Panel Unit Root and Panel Cointegration

Panel Data Model for Limited Dependent Variables

Lessons from Static and Dynamic Panel data Models

Economic Growth of Countries around the World:

Unemployment-inflation Trade-offs in OECD Countries:

Advantages of Panel Data

- Large number of observations over individuals and time make estimates more efficient and asymptotically consistent
- Possible to check individual and time effects in a regression
- Very inclusive and comprehensive, state and space dimensions
- Can use vast amount of information from census, household surveys, firm or country wise statistics
- Background for testing economic theories at micro as well as macro level

Structure of Panel Date

There are N individuals, $i = 1 \dots N$ living T number of times $t = 1 \dots T$.

There are variables such as earnings of individuals $y_{i,t}$ related with K number of explanatory variables $x_{i,t}$ that may include age, education, training, health status, industry or regional backgrounds.

Panel data model usually formulated like in the following equation aims to find out both individual specific effects that affect such relation, α_i and common elements $\beta_{i,t}$ which is often generalised by β .

$$y_{i,t} = \alpha_i + \beta_{i,t} X_{i,t-1} + e_{i,t} \quad i = 1 \dots N \quad \text{and} \quad t = 1 \dots T \quad (1)$$

$$y_{i,t} = \alpha_i + \beta X_{i,t-1} + e_{i,t}$$

Observations across N individuals over T time periods are stacked implicitly assuming that all observations are drawn from the uniform universe.

Pooled estimates can be obtained by applying the OLS to stacked data set.

$$\begin{bmatrix} y_{1,1} & x_{1,1} & e_{1,1} \\ \cdot & \cdot & \cdot \\ y_{1,T} & x_{1,T} & e_{1,T} \\ y_{2,1} & x_{2,1} & e_{2,1} \\ \cdot & \cdot & \cdot \\ y_{2,T} & x_{2,T} & e_{2,T} \\ \cdot & \cdot & \cdot \\ y_{N,1} & x_{N,1} & e_{N,1} \\ \cdot & \cdot & \cdot \\ y_{N,T} & x_{N,T} & e_{N,T} \end{bmatrix}$$

Sole Literature on Panel Estimation Methods

Arulampalam and Booth(1998), Blanchard and Quah (1989) Blundell and Smith (1989),Chesher (1984) , Dickey and Fuller (1979), Engle and Granger (1987) Hansen (1982), Hausman (1978), Heckman (1979), Im, Pesaran and Shin (2003), Imbens and Lancaster (1994), Keifer (1988), Hendry (1997) , Kao (1999), Kwaitkowski, Phillips, Schmidt and Shin (1992), Larsson, Lyhagen and Lothgren (2001) Levin, Lin and Chu (2002), Pedroni (1999), Pesaran and Smith (1995) Phillips (1987), McCoskey and Kao (1999), Johansen Soren (1988), Johansen Soren (1988) Staigler Stock (1997), Lancaster (1979) Lancaster and Chesher (1983) Zellner A. (1985). Similarly there are number of excellent texts Baltagi, B.H. (1995), Davidson J. (2002), Davidson R and MacKinnon J. G. (2004) ,Greene W. (2000) Hamilton (1994) ,Hsiao Cheng (1993) Lancaster (1990) Ruud P. A. (2000) Verbeek (2004) Wooldridge (2002)

A Glimpse of Panel Method: Total, Within and Between Effects

Total Effect (in deviation form):

$$\beta_{1,OLS} = \frac{\sum_i \sum_t (X_{i,t} - \bar{X})(Y_{i,t} - \bar{Y})}{\sum_i \sum_t (X_{i,t} - \bar{X})^2} = \frac{t_{xy}}{t_{xx}}$$

(2)

$$\begin{aligned} t_{xy} &= \sum_i \sum_t (X_{i,t} - \bar{X})(Y_{i,t} - \bar{Y}) \\ &= \sum_i \sum_t (X_{i,t} - \bar{X}_i + \bar{X}_i - \bar{X})(Y_{i,t} - \bar{Y}_i + \bar{Y}_i - \bar{Y}) \\ &= \sum_i \sum_t ((X_{i,t} - \bar{X}_i)(Y_{i,t} - \bar{Y}_i)) + T \sum_i (\bar{X}_i - \bar{X})(\bar{Y}_i - \bar{Y}) = \end{aligned}$$

$$W_{xy} + b_{xy}$$

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(3)

A Glimpse of Panel Method

Between group effect

$$\hat{\beta}_b = \frac{\sum_t (X_{i,t} - \bar{X})(Y_{i,t} - \bar{Y})}{\sum_t (X_{i,t} - \bar{X})^2} = \frac{b_{xy}}{b_{xx}} \quad (4)$$

Within group effect

$$\hat{\beta}_W = \frac{\sum_i (X_{i,t} - \bar{X}_t)(Y_{i,t} - \bar{Y}_t)}{\sum_i (X_{i,t} - \bar{X}_t)^2} = \frac{W_{xy}}{W_{xx}} \quad (5)$$

$$\begin{aligned} t_{xx} \beta_{OLS} &= t_{xy} = W_{xy} + b_{xy} \\ &= \hat{\beta}_W \frac{W_{xx}}{W_{xx} + b_{xx}} + \hat{\beta}_b \frac{b_{xx}}{W_{xx} + b_{xx}} \end{aligned} \quad (6)$$

SURE: Stacking Models

Individual regression

$$Y_1 = X_1\beta + \varepsilon_1$$

$$Y_2 = X_2\beta + \varepsilon_2$$

$$Y_m = X_m\beta + \varepsilon_m \quad (12)$$

There are \mathbf{m} equations and \mathbf{T} observations in the SURE system (in growth rate example we have 151 countries and 31 observations).

They can be stacked into one large equation system as following.

In matrix notation

$$\begin{bmatrix} Y_1 \\ Y_1 \\ \cdot \\ \cdot \\ Y_m \end{bmatrix} = \begin{bmatrix} X_1 & 0 & \cdot & \cdot & 0 \\ 0 & X_2 & 0 & \cdot & 0 \\ 0 & 0 & X_3 & \cdot & 0 \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ 0 & 0 & \cdot & \cdot & X_m \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \\ \cdot \\ \cdot \\ \beta_m \end{bmatrix} + \begin{bmatrix} e_1 \\ e_2 \\ \cdot \\ \cdot \\ e_m \end{bmatrix} \quad (13)$$

Each Y_m and e_m has a dimension of T by 1 and X_m has T by K

dimension and each β_m has K by 1 dimension. The covariance matrix of

errors has TM by TM dimension.

Assumption of the Sure Model

- Mean of $e_{1,t}$ is zero for every value of $\pi_{1,t}$, $E[e_{1,t}] = 0$
- Mean of $e_{2,t}$ is zero for every value of $\pi_{2,t}$, $E[e_{2,t}] = 0$
- variance of $e_{1,t}$ is constant $\text{var}[e_{1,t}] = \sigma_1^2$ for every i th observation
- variance of $e_{2,t}$ is constant $\text{var}[e_{2,t}] = \sigma_2^2$ for every i th observation
- $\text{cov}(e_{1,t}, e_{1,t}) = 0$ for all $t \neq s$; this also means there is no autocorrelation
- $\text{cov}(e_{2,t}, e_{2,s}) = 0$ for all $t \neq s$; this also means there is no autocorrelation

All of the above assumptions are standard to the OLS assumptions.

The major difference lies on assumption of contemporaneous correlation across the disturbance terms in above two models.

$$\text{cov}(e_{1,t}, e_{2,s}) = \sigma_{1,2}^2 \quad (11)$$

Model

$$ee' = \begin{bmatrix} e_1 \\ e_2 \\ \cdot \\ \cdot \\ e_m \end{bmatrix} [e_1 \quad e_2 \quad \cdot \quad \cdot \quad e_m] = \begin{bmatrix} e_1^2 & e_1 e_2 & \cdot & \cdot & e_1 e_m \\ e_2 e_1 & e_2^2 & e_2 e_3 & \cdot & e_2 e_m \\ \cdot & e_3 e_2 & e_3^2 & \cdot & e_3 e_m \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ e_m e_1 & e_m e_2 & \cdot & \cdot & e_m^2 \end{bmatrix} \quad (14)$$

$$E[ee'] = \begin{bmatrix} \text{var}(e_1) & \text{cov}(e_1 e_2) & \text{cov}(e_1 e_3) & \cdot & \text{cov}(e_1 e_m) \\ \text{cov}(e_2 e_1) & \text{var}(e_2) & \text{cov}(e_2 e_3) & \cdot & \text{cov}(e_2 e_m) \\ \text{cov}(e_3 e_1) & \text{cov}(e_3 e_2) & \text{var}(e_3) & \cdot & \text{cov}(e_3 e_m) \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \text{cov}(e_m e_1) & \text{cov}(e_m e_2) & \text{cov}(e_m e_3) & \cdot & \text{var}(e_m) \end{bmatrix} \quad (15)$$

$$E[ee'] = \begin{bmatrix} \sigma_{11} & \sigma_{12} & \sigma_{13} & \cdot & \sigma_{1m} \\ \sigma_{21} & \sigma_{22} & \sigma_{23} & \cdot & \sigma_{2m} \\ \cdot & \sigma_{32} & \sigma_{33} & \cdot & \sigma_{3m} \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \sigma_{m1} & \sigma_{m2} & \sigma_{m3} & \cdot & \sigma_{mm} \end{bmatrix} = V = \sum \otimes I \quad (16)$$

Variance-Covariance Structure of Errors in a Sure Model

Dimension of each of the $\sigma_{i,j}$, like that of the identity matrix I , is T by T , and reflects the variance covariance matrix of the stacked regression.

The Kronecker product $\sum \otimes I$ is a short way of writing this covariance matrix.

\sum is the variance covariance matrix

\otimes is the symbol for the Kronecker product

I is Identity Matrix with $T \times M$ by $T \times M$ dimension.

SUR Estimation

Application of the OLS technique individually on (2) and (3) generates inconsistent results. Sure method aims to correct this problem by estimating both equations simultaneously.

$$V^{-1} = \sum^{-1} \otimes I$$

The SURE method is essentially a generalised least square estimator:

$$\hat{\beta} = [X'V^{-1}X]^{-1}X'V^{-1}Y = [X'(\sum^{-1} \otimes I)X]^{-1}X'(\sum^{-1} \otimes I)Y \quad (17)$$

$$\hat{\beta} = \begin{bmatrix} \sigma_{11}X_1'X_1 & \sigma_{12}X_1'X_2 & \sigma_{13}X_1'X_3 & \cdot & \sigma_{1m}X_1'X_m \\ \sigma_{21}X_2'X_1 & \sigma_{22}X_2'X_2 & \sigma_{23}X_2'X_3 & \cdot & \sigma_{2m}X_2'X_m \\ \cdot & \sigma_{32}X_3'X_2 & \sigma_{33}X_3'X_3 & \cdot & \sigma_{3m}X_3'X_m \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \sigma_{m1}X_m'X_1 & \sigma_{m2}X_m'X_2 & \sigma_{m3}X_m'X_3 & \cdot & \sigma_{mm}X_m'X_m \end{bmatrix}^{-1} \begin{bmatrix} \sum_m \sigma_{1m}X_1'Y_m \\ \sum_m \sigma_{2m}X_2'Y_m \\ \cdot \\ \cdot \\ \sum_m \sigma_{1m}X_m'Y_m \end{bmatrix}$$

Steps for Sure estimation

- Estimate each equation separately using the least square technique.
- Use the least square residuals from step 1 to estimate the error term.
- Use the estimates from the second step to estimate two equations jointly within a generalised least square framework. If $m=2$ the variance covariance matrix will be as given below.

GLS Example in SURE

$$\Omega = \begin{bmatrix} \sigma_{1,1} & \sigma_{1,2} \\ \sigma_{2,1} & \sigma_{2,2} \end{bmatrix} \quad (19)$$

Using a theorem in matrix algebra W can be decomposed into two parts as

$$P'P = \Omega^{-1} \quad (20)$$

Use this partition of W to transform the original model as

$$PY = PX\beta + Pe \quad (21)$$

$$Y^* = X^*\beta + e^* \quad (22)$$

$$\begin{aligned} \beta_{GLS} &= (X^{*'}X^*)^{-1}X^{*'}Y^* = \\ &= (X'P'PX)X'P'PY \Rightarrow \\ \beta_{GLS} &= (X^{*'}\Omega^{-1}X^*)^{-1}X^{*'}\Omega^{-1}Y^* \end{aligned}$$

The GLS estimates are best, linear and unbiased estimators of the coefficients in the SURE system.

Error component Method

Each cross section unit (country) had its own intercept parameter in the pooled dummy variable model.

The error component method decomposes these errors into a common intercept and the random part.

Thus the model will take the following form:

$$g_{i,t} = \alpha_{0,i} + \alpha_{1,i} \pi_{i,t-1} + e_{i,t}$$
$$\alpha_{0,i} = \bar{\alpha}_1 + \mu_i \quad \text{where } i = 1.., N \quad (23)$$

$\bar{\alpha}_1$ represents the population mean intercept and

μ_i are independent of each error $e_{i,t}$. It has a constant mean and constant variance.

$$E(\mu_i) = 0 \quad \text{and} \quad \text{var}(\mu_i) = \sigma_{\mu}^2$$

$$g_{i,t} = (\bar{\alpha}_1 + \mu_i) + \alpha_{1,i} \pi_{i,t-1} + e_{i,t}$$

$$g_{i,t} = \bar{\alpha}_1 + \alpha_{1,i} \pi_{i,t-1} + (e_{i,t} + \mu_i) = \bar{\alpha}_1 + \alpha_{1,i} \pi_{i,t-1} + v_{i,t}$$

Error component Method-2

The error component include overall error $e_{i,t}$ and individual specific error μ_i , $v_{i,t} = (e_{i,t} + \mu_i)$: common and individual specific errors.

$E(v_{it}) = 0$ the compound error term $v_{i,t}$ has mean zero

$\text{var}(v_{it}) = \sigma_{\mu}^2 + \sigma_e^2$; $v_{i,t}$ is homoskedastic

$\text{cov}(v_{it}, v_{is}) = \sigma_{\mu}^2$ error from the same country in different periods are correlated

$\text{cov}(v_{it}, v_{js}) = 0$ for $i \neq j$ errors from different countries are always uncorrelated.

Like in the SURE method the generalised least square estimator, with transformed method produces the most efficient estimators or error component model.

Need For Pooling Time Series and Cross Section data

- Many economic issues require cause effect analyses of cross-sections of individuals, households or countries over time.
- The major issue that economists like to know remains whether coefficients vary

across observations in the same time period or

whether variables have any systematic pattern over time.

Need For Pooling Time Series and Cross Section data

- For instance macroeconomist are interested to know

What makes growth rates differ across countries at a particular year and of the same country over time.

In other words they want to find out whether there are any country specific and time specific effects on economic growth?

Panel studies of growth studies are carried out to know the determinants of growth of an individual country or a group of countries over time.

How much of fluctuations in economic activities is explained by country specific or time specific factors?

- Microeconomic studies aim to investigate whether profits vary systematically by firms and by production periods.

Two Methods of combining Time Series and Cross Section: Panel Model and Pooling Regression

- When confronted with these questions an appropriate econometric method requires using all observations across individuals for each time period under investigation.

Fixed effects, random effects and dynamic panels

- In Panel data models, major emphasis lies on decomposing total variation within a group and between the groups.

$$y_{i,t} = \beta_{0,i} + \beta_{1,i} X_{i,t-1} + e_{i,t} \quad (1)$$

$$y_{i,t} = \beta_{0,t} + \beta_{1,t} X_{i,t-1} + e_{i,t}$$

Subscript i , t refer to individual and time period respectively.

Three different methods of pooling observations with time series and cross section dimension

- a. A dummy variable method
- b. The SURE (systematically unrelated regression equations) method
- c. Error component method

Dummy Variable Method

Take a pooled model for growth rate as a function of inflation of i -different countries over t periods.

$$g_{i,t} = \alpha_{0,i} + \alpha_{1,i} \pi_{i,t-1} + e_{i,t} \quad (7)$$

where $g_{i,t}$ is the growth rate in country i , $\pi_{i,t}$ is the inflation rate in country i , and $e_{i,t}$ is the independently and identically distributed random error term.

Error term is normally distributed with mean zero, $e_{i,t} \sim N\left(0, \sigma_i^2\right)$, but the variance may be different from one country to another.

Introducing a dummy variable is the simplest method of isolating individual or time specific effect in a regression model.

$$g_{i,t} = \alpha_{1,1} D_{1,i} + \alpha_{1,2} D_{2,i} + \dots + \alpha_{1,m} D_{m,i} + \alpha_{1,i} \pi_{i,t-1} + e_{i,t} \quad (8)$$

$$\text{Where } D_{1,i} = \begin{cases} 1 & \text{if observation } i=1 \\ 0 & \text{otherwise} \end{cases}$$

The individual effects are picked up by the dummy variable $D_{m,i}$.

SURE. An Example from Economic Growth across countries

In an interdependent world the growth rate in one country is affected by the growth rate in another country. In two country case

$$g_{1,t} = \alpha_{0,1} + \alpha_{1,1}\pi_{1,t-1} + e_{1,t} \quad (9)$$

$$g_{2,t} = \alpha_{0,2} + \alpha_{1,2}\pi_{2,t-1} + e_{2,t} \quad (10)$$

Since international economic situation affects the demand for products at home country, any shock occurring in country 2,

$e_{2,t}$, affects growth prospects in country 1 $g_{1,t}$.

Similarly negative or positive shocks in country 1, $e_{1,t}$, affect the growth in country 2.

There is **contemporaneous correlation** between error terms. In this sense though growth may depend on internal factors but the external factors influence growth rate of each economy.

Pooled Regression of Food Expenditure on Income across UK regions
(Results from SURE estimation)

Regions	COEFFICIENT	ST.ERROR	T-RATIO	R-square	D-wstat
North	0.0764	0.0000	1359700	0.9784	1.9653
Yorkshire and Humberside	0.0688	0.0000	281400	0.9330	1.4732
East Midlands	0.0921	0.0000	524200	0.9370	1.3004
East Anglia	0.0819	0.0000	649310	0.9290	1.6209
Greater London	0.0196	0.0000	1011000	0.8703	1.8434
Rest of the South East	0.0233	0.0000	371290	0.9559	0.8215
South West	0.0459	0.0000	889180	0.9228	1.458
West Midland	0.0406	0.0000	831840	0.9347	1.4549
North West	0.0420	0.0000	204740	0.8308	2.1859
Wales	0.0592	0.0000	725720	0.9784	2.2108
Scotland	0.0516	0.0000	523600	0.9195	1.7456
Northern Ireland	0.0758	0.0000	1281000	0.8592	1.5565
UK	0.0453	0.0000	1043000	0.9608	1.3867

Shazam Syntax

par 15000

```
read y1 y2 y3 y4 y5 y6 y7 y8 y9 y10 y11 y12 y13 y14 y15 y16 y17  
y18 y19 y20 y21 y22 y23 y24 y25 y26 y27 y28 y29 y30 y31
```

```
read p1 p2 p3 p4 p5 p6 p7 p8 p9 p10 p11 p12 p13 p14 p15 p16  
p17 p18 p19 p20 p21 p22 p23 p24 p25 p26 p27 p28  
p29 p30 p31
```

system 2 /

```
ols y8 y1 y2 y3 y4 y5 y6 y7 p2 p3 p4 p5 p6 p7  
ols p8 p1 p2 p3 p4 p5 p6 p7 y2 y3 y4 y5 y6 y7 /DN  
end
```

*pooling cross section and time series

matrix

```
infl=(p1'|p2'|p3'|p4'|p5'|p6'|p7'|p8'|p9'|p10'|p11'|p12'|p13'|p14'|p15'|p16'|p17'|p18'|p19'|p20'|p  
21'|p22'|p23'| &  
p24'|p25'|p26'|p27'|p28'|p29'|p30'|p31')'
```

```
matrix rgg=(y1'|y2'|y3'|y4'|y5'|y6'|y7'|y8'|y9'|y10'|&  
y11'|y12'|y13'|y14'|y15'|y16'|y17'|y18'|y19'|y20'| &  
y21'|y22'|y23'|y24'|y25'|y26'|y27'|y28'|y29'|y30'|y31')'
```

sample 1 4681

ols rgg infl

pool rgg infl /NCROSS=151 DN

genr tindex=sum(seas(151))

genr csindex=time(0)-151*(tindex-1)

*print tindex csindex

pool rgg infl /NCROSS=151 COEF=ACT: 2007:KB:HUBS

One Result on Pooling Model

R-SQUARE = 0.0043 R-SQUARE ADJUSTED = -0.0021
 VARIANCE OF THE ESTIMATE-SIGMA**2 = 55.671
 STANDARD ERROR OF THE ESTIMATE-SIGMA = 7.4613
 SUM OF SQUARED ERRORS-SSE= 0.25887E+06
 MEAN OF DEPENDENT VARIABLE = 3.7790
 LOG OF THE LIKELIHOOD FUNCTION = -16034.0
 RAW MOMENT R-SQUARE = 0.2079

ANALYSIS OF VARIANCE - FROM ZERO				
	SS	DF	MS	F
REGRESSION	67964.	31.	2192.4	39.381
ERROR	0.25887E+06	4650.	55.671	P-VALUE
TOTAL	0.32683E+06	4681.	69.821	0.000

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO	PARTIAL P-VALUE	STANDARDIZED CORR.	ELASTICITY AT MEANS
INFL	-0.87005E-03	0.2204E-03	-3.948	0.000	-0.058	-0.0093
T2	5.4945	0.6072	9.049	0.000	0.132	0.0469
T3	5.0154	0.6072	8.260	0.000	0.120	0.0428
T4	5.2188	0.6072	8.595	0.000	0.125	0.0445
T5	4.8993	0.6072	8.068	0.000	0.118	0.0418
T6	2.4485	0.6072	4.032	0.000	0.059	0.0209
T7	5.9081	0.6072	9.730	0.000	0.141	0.0504
T8	4.3478	0.6072	7.160	0.000	0.104	0.0371
T9	4.4664	0.6072	7.356	0.000	0.107	0.0381
T10	4.1043	0.6072	6.759	0.000	0.099	0.0350
T11	2.8885	0.6072	4.757	0.000	0.070	0.0247
T12	2.2897	0.6072	3.771	0.000	0.055	0.0195
T13	1.1199	0.6072	1.844	0.065	0.027	0.0096
T14	3.1440	0.6072	5.178	0.000	0.076	0.0268
T15	3.7295	0.6072	6.142	0.000	0.090	0.0318
T16	4.7003	0.6076	7.736	0.000	0.113	0.0401
T17	3.4980	0.6072	5.761	0.000	0.084	0.0299
T18	3.4993	0.6072	5.763	0.000	0.084	0.0299
T19	3.9309	0.6078	6.468	0.000	0.094	0.0336
T20	3.5159	0.6076	5.787	0.000	0.085	0.0300
T21	3.3853	0.6077	5.571	0.000	0.081	0.0289
T22	2.2109	0.6075	3.639	0.000	0.053	0.0189
T23	2.9452	0.6073	4.850	0.000	0.071	0.0251
T24	2.9669	0.6073	4.886	0.000	0.071	0.0253
T25	3.4106	0.6087	5.603	0.000	0.082	0.0291
T26	4.2862	0.6072	7.058	0.000	0.103	0.0366
T27	4.2761	0.6073	7.042	0.000	0.103	0.0365
T28	4.3304	0.6072	7.142	0.000	0.103	0.0370
T29	3.0099	0.6072	4.957	0.000	0.073	0.0257
T30	3.2318	0.6072	5.322	0.000	0.078	0.0276

Fixed Effect Models for Analysis of Panel Data

Each individual i has T observations and there are $i = 1, \dots, N$ individuals.

$$y_{i,t} = \alpha_i + \mathbf{x}_{i,t}\beta + \varepsilon_{i,t} \quad \varepsilon_{i,t} \sim IID(0, \sigma_{\varepsilon}^2)$$

Parameter α_i picks up the difference among individuals. It can be estimated by OLS when N is small but not when that is large. The model is transformed to the least square dummy variable method when N is too large.

$$\bar{y}_i = \alpha_i + \bar{\mathbf{x}}_i\beta + \varepsilon_i$$

$$\text{where } \bar{y}_i = T^{-1} \sum_i y_{i,t}$$

$$y_{i,t} - \bar{y}_i = (\mathbf{x}_{i,t} - \bar{\mathbf{x}}_i)\beta + (\varepsilon_{i,t} - \varepsilon_i)$$

fixed effect least square dummy variable estimator of β is

$$\beta_{FE} = \left(\sum_t \sum_i (\mathbf{x}_{i,t} - \bar{\mathbf{x}}_i)(\mathbf{x}_{i,t} - \bar{\mathbf{x}}_i)' \right)^{-1} \sum_t \sum_i (\mathbf{x}_{i,t} - \bar{\mathbf{x}}_i)(y_{i,t} - \bar{y}_i)$$

Fixed Effect Models for Analysis of Panel Data

$$\alpha_i = \bar{y}_i - \bar{x}_i \beta_{FE}$$

These estimators are unbiased, consistent and efficient.

$$\text{cov}(\beta_{FE}) = \sigma_\varepsilon^2 \left(\sum_t \sum_i (x_{i,t} - \bar{x}_i)(x_{i,t} - \bar{x}_i)' \right)^{-1}$$

$$\sigma_\varepsilon^2 = \frac{1}{N(T-1)} \sum_i \sum_t (y_{i,t} - \alpha_i - x_{i,t} \beta_{FE})^2$$

The fixed effect concentrates on differences among individuals.

Fixed effect model in matrix notation

$$y_i = i\alpha_i + X_i\beta + \varepsilon_i$$

$$\begin{bmatrix} Y_1 \\ Y_1 \\ \cdot \\ \cdot \\ Y_n \end{bmatrix} = \begin{bmatrix} I & 0 & \cdot & \cdot & 0 \\ 0 & I & 0 & \cdot & 0 \\ 0 & 0 & I & \cdot & 0 \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ 0 & 0 & \cdot & \cdot & I \end{bmatrix} \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \cdot \\ \cdot \\ \alpha_n \end{bmatrix} + \begin{bmatrix} X_1 \\ X_2 \\ \cdot \\ \cdot \\ X_n \end{bmatrix} \beta + \begin{bmatrix} e_1 \\ e_2 \\ \cdot \\ \cdot \\ e_n \end{bmatrix}$$

$$Y = [d_1 \quad d_2 \quad \cdot \quad \cdot \quad d_n \quad X] \begin{bmatrix} \alpha \\ \beta \end{bmatrix} + \varepsilon$$

Fixed Effect Models for Analysis of Panel Data

$$Y = D\alpha + X\beta + \varepsilon$$

This can be easily estimated by the OLS when the number of cross section units are small. Many panel data studies have much larger observations. It results in over parameterisation and loss of degree of freedom. For this the model is transformed by a projection matrix

$$M_d = I - D(D'D)D'$$

$$M_d Y = M_d D\alpha + M_d X\beta + M_d \varepsilon$$

$$b = [X' M_d X]^{-1} [X' M_d Y]$$

$$M_d = \begin{bmatrix} M^0 & 0 & 0 & \dots & 0 \\ 0 & M^0 & \dots & \dots & \dots \\ 0 & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots \\ 0 & 0 & 0 & \dots & M^0 \end{bmatrix} \quad \text{where } M^0 = I_T - \frac{1}{T} i i'$$

Multiplying any variable by M^0 is equivalent taking deviation from the mean ie $M^0 X_i = X_i - \bar{X}i$

$$Y = D\alpha + X\beta + \varepsilon$$

$$a = (D'D)^{-1} D(Y - Xb)$$

$$\text{var}(b) = s^2 [X' M_d X]^{-1} \quad \text{and} \quad s^2 = \frac{\sum_t \sum_i (y_{it} - a_i - x_{i,t} b)}{nT - n - k}$$

Determinants of Economic growth in the US, UK, Germany, France and Japan: Fixed Effect Panel
Data Model (1960-2000)

	Coefficient	Std.Error	t-value	t-prob
Investment ratio (I/Y)	0.0007	0.0003	2.1500	0.0330
Real interest rate	0.0003	0.0006	0.4510	0.6530
Population growth rate	1.0218	0.0025	405.0000	0.0000
Saving ratio (S/Y)	0.0001	0.0006	0.0973	0.9230
Per-capita income	1.0069	0.0017	594.0000	0.0000
Trade balance ratio (X-M)/Y)	-0.0001	0.0002	-0.7370	0.4630
Constant	-0.0221	0.0090	-2.4400	0.0160
UK	-0.0014	0.0072	-0.1970	0.8440
US	-0.0039	0.0054	-0.7180	0.4740
Germany	-0.0029	0.0039	-0.7280	0.4680
France	-0.0107	0.0105	-1.0200	0.3070

sigma 0.009673186 sigma^2 9.357053e-005
R^2 0.9999804; RSS 0.012538450674 TSS 639.4401902
no. of observations 145 no. of parameters 11; individual: 4
number of individuals 5 (derived from year); longest time series 31 [1970 - 2000]
shortest time series 23 (unbalanced panel)

Determinants of Economic growth in the US, UK, Germany, France and Japan: Within Group Panel Data Model (1960-2000)

	Coefficient	Std.Error	t-value	t-prob
Investment ratio (I/Y)	0.0007	0.0003	2.1500	0.0330
Real interest rate	0.0003	0.0006	0.4510	0.6530
Population growth rate	1.0218	0.0025	405.0000	0.0000
Saving ratio (S/Y)	0.0001	0.0006	0.0973	0.9230
Per-capita income	1.0069	0.0017	594.0000	0.0000
Trade balance ratio (X-M)/Y)	-0.0001	0.0002	-0.7370	0.4630

sigma 0.009673186 sigma^2 9.357053e-005 R^2 0.9999789
 RSS 0.012538450674 TSS 594.73136048 no. of observations 145
 no. of parameters 11; number of individuals 5 (derived from year);
 longest time series 31 [1970 - 2000]; shortest time series 23 (unbalanced panel)

Random Effect Models for Panel Data Analysis

$y_{i,t} = \mu + \mathbf{x}_{i,t}\beta + \alpha_i + \varepsilon_{i,t}$; $\alpha_i, \sim IID(0, \sigma_\alpha^2)$ are individual specific random errors and $\varepsilon_{i,t} \sim IID(0, \sigma_\varepsilon^2)$ are remaining random errors.

$$\alpha_i \mathbf{l}_T + \varepsilon_i \quad \mathbf{l}_T = (1, 1, \dots, 1)'$$

$$Var(\alpha_i \mathbf{l}_T + \varepsilon_i) = \Omega = \sigma_\alpha^2 \mathbf{l}_T \mathbf{l}_T' + \sigma_\varepsilon^2 I_T$$

Errors are correlated, therefore this requires estimation by the GLS estimator

Transform the model by pre-multiplying by Ω^{-1} where

$$\Omega^{-1} = \sigma_\varepsilon^2 \left[I_T - \frac{\sigma_\alpha^2}{\sigma_\varepsilon^2 + T\sigma_\alpha^2} \mathbf{l}_T \mathbf{l}_T' \right]$$

$$\beta_{GLS} = \left(\sum_t \sum_i (\mathbf{x}_{i,t} - \bar{\mathbf{x}}_i)(\mathbf{x}_{i,t} - \bar{\mathbf{x}}_i)' + \psi T \sum_i (\bar{\mathbf{x}}_i - \bar{\mathbf{x}})(\bar{\mathbf{x}}_i - \bar{\mathbf{x}})' \right)^{-1}$$

$$\left(\sum_t \sum_i (\mathbf{x}_{i,t} - \bar{\mathbf{x}}_i)(y_{i,t} - \bar{y}_i) + \psi T \sum_i (\bar{\mathbf{x}}_i - \bar{\mathbf{x}})(\bar{y}_i - \bar{y})' \right)$$

Random Effect Models for Panel Data Analysis

$$\Omega = \begin{bmatrix} \sigma_\alpha^2 + \sigma_\varepsilon^2 & \sigma_\alpha^2 & \sigma_\alpha^2 & \cdot & \cdot & \sigma_\alpha^2 \\ 0 & \sigma_\alpha^2 + \sigma_\varepsilon^2 & \cdot & \cdot & \cdot & \cdot \\ 0 & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \sigma_\alpha^2 & \sigma_\alpha^2 & \sigma_\alpha^2 & \cdot & \cdot & \sigma_\alpha^2 + \sigma_\varepsilon^2 \end{bmatrix}$$

$$\Omega^{-\frac{1}{2}} = \frac{1}{\sigma_\varepsilon} \left[I_T - 1 - \frac{\sigma_\varepsilon}{\sqrt{T\sigma_\alpha^2 + \sigma_\varepsilon^2}} \right]$$

$$\beta_{GLS} = \sum_i (X' \Omega^{-1} X)^{-1} \sum_i (X' \Omega^{-1} Y)$$

Dynamic Panel data models

$$y_{i,t} = \mathcal{W}_{i,t}\beta + \alpha_i + \varepsilon_{i,t} \quad \text{with } \gamma < 1$$

$$\gamma_{FE} = \frac{\sum_t \sum_i (y_{i,t} - \bar{y}_i)(y_{i,t} - \bar{y}_{i,t-1})}{\sum_t \sum_i (y_{i,t-1} - \bar{y}_{i,-1})} \quad ; \quad \bar{y}_i = T^{-1} \sum_i y_{i,t} \quad \text{and} \quad \bar{y}_{i,-1} = T^{-1} \sum_i y_{i,t-1}$$

This is not asymptotically unbiased estimator:

$$\gamma_{FE} = \gamma + \frac{(1/NT) \sum_t \sum_i (\varepsilon_{i,t} - \bar{\varepsilon}_i)(y_{i,t} - \bar{y}_{i,t-1})}{(1/NT) \sum_t \sum_i (y_{i,t-1} - \bar{y}_{i,-1})^2}$$

$$P \lim_{N \rightarrow \infty} (1/NT) \sum_t \sum_i (\varepsilon_{i,t} - \bar{\varepsilon}_i)(y_{i,t} - \bar{y}_{i,t-1}) = -\frac{\sigma_\varepsilon^2}{T^2} \frac{(T-1) - T\gamma + \gamma^T}{(1-\gamma)^2} \neq 0$$

Dynamic Panel data models

Instrumental variable methods have been suggested to solve this inconsistency

$$\hat{\gamma}_{IV} = \frac{\sum_t \sum_i y_{i,t-2} (y_{i,t-1} - \bar{y}_{i,t-2})}{\sum_t \sum_i y_{i,t-2} (y_{i,t-1} - y_{i,t-2})} \quad \text{and}$$

where y_{i-2} is used as instrument of $(y_{i,t-1} - y_{i-2})$

It is asymptotically

$$P \lim_{N \rightarrow \infty} (1/NT) \sum_t \sum_i (\varepsilon_{i,t} - \bar{\varepsilon}_i) y_{i,t-2} = 0$$

Moment conditions with vector of transformed error terms

$$\Delta \varepsilon_i = \begin{pmatrix} \varepsilon_{i,2} - \varepsilon_{i,1} \\ \varepsilon_{i,3} - \varepsilon_{i,2} \\ \cdot \\ - \\ \varepsilon_{i,T} - \varepsilon_{i,T-1} \end{pmatrix}$$

Dynamic Panel data models

$$Z_i = \begin{bmatrix} [y_{i0}] & 0 & 0 & \dots & 0 \\ 0 & [y_{i0}, y_{i1}] & \cdot & \cdot & \cdot \\ 0 & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ 0 & 0 & 0 & \dots & [y_{i0}, y_{i,T-2}] \end{bmatrix}$$

$$E\{Z_i' \Delta \varepsilon_i\} = 0$$

Or for moment estimator write the transformed errors as

$$E\{Z_i' (\Delta y_{i,t} - \gamma \Delta y_{i,t-1})\} = 0$$

$$\min_{\gamma} \left(\frac{1}{N} \sum_{i=1}^N Z_i' (\Delta y_{i,t} - \gamma \Delta y_{i,t-1}) \right)' W_N \left(\sum_{i=1}^N Z_i' (\Delta y_{i,t} - \gamma \Delta y_{i,t-1}) \right)$$

GMM method includes the most efficient instrument

$$\hat{\gamma}_{GMM} = \left(\left(\sum_{i=1}^N \Delta y_{i,t-1}' Z_i \right) W_N \left(\sum_{i=1}^N Z_i' \Delta y_{i,t-1} \right) \right)^{-1} \times \left(\sum_{i=1}^N \Delta y_{i,t-1}' Z_i \right) W_N \left(\sum_{i=1}^N Z_i' \Delta y_{i,t} \right)$$

The optimal weighting matrix W_N can guarantee the most efficient estimator, this should be inversely proportional to transformed covariance matrix.

$$\hat{W}_N^{opt} = \left(\frac{1}{N} \sum_{i=1}^N Z_i' \Delta \varepsilon_i \Delta \varepsilon_i' Z_i \right)^{-1}$$

Computer Demonstration: Generating Panel data in Excel, Growth batch, Unemployment batch,

Panel Data Estimation Example from the BHPS

Stata Analysis

```
. xtreg stsrc duration, fe
```

```
Fixed-effects (within) regression      Number of obs   =   35016  
Group variable (i): pid                Number of groups =   8995
```

```
R-sq:  within = 0.0045                Obs per group:  min =    1  
        between = 0.1948                avg =    3.9  
        overall = 0.0285                max =    37
```

```
corr(u_i, Xb) = -0.3383                F(1,26020)      =  118.35  
                                                Prob > F        =  0.0000
```

```
-----+-----  
stsrc |   Coef.  Std. Err.   t  P>|t|  [95% Conf. Interval]  
-----+-----  
duration | .0000141  1.29e-06  10.88  0.000  .0000115  .0000166  
_cons | 22.03168  .0001639    .  0.000  22.03136  22.032  
-----+-----  
sigma_u | .01359554  
sigma_e | .02161173
```

Panel Data Models with Limited Dependent Variables

$$y_{i,t}^* = x_{i,t}'\beta + \alpha_i + \varepsilon_{i,t}$$

$y_{i,t} = 1$ if $y_{i,t}^* > 0$ where $y_{i,t}^*$ is a latent variable; $y_{i,t} = 0$ otherwise.

Alternative names: dichotomous dependent variables, discrete dependent random variable, binary variable, either or choice variables

$$Y_i = \begin{cases} \beta_0 + \beta_1 X_t + u_t & \text{if event occurs} \\ 0 & \text{otherwise} \end{cases}$$

- the labour force participation (1 if a person participates in the labour force, 0 otherwise)
- yes or no vote in particular issue
- to marry or not to marry
- to study further or to start a job
- to buy or not to buy a particular stock
- choice of transportation mode to work (1 if a person drives to work, 0 otherwise)
- Union membership (1 if one is a member of the union, 0 otherwise)
- Owning a house (1 if one owns 0 otherwise)
- Multinomial choices: work as a teacher, or as a clerk, or as a self employed or professional or as a factory worker
- Multinomial ordered choices: strongly agree, agree, neutral, disagree

Probit and Logit: Introduction

$$\Pr(Y_i = 1) = \Pr(Z_i^* \leq Z_i) = F(Z_i) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{Z_i} e^{-\frac{t^2}{2}} dt = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\beta_1 + \beta_2 X} e^{-\frac{t^2}{2}} dt \quad (13)$$

Here t is standardised normal variable, $t \sim N(0,1)$

Steps for a probit model

probability depends upon unobserved utility index Z_i which depends upon observable variables such as income. There is a thresh-hold of this index when after which family starts owning a house, $Z_i \geq Z_i^*$.

Logit model

variable Y_i which takes value 1 ($Y_i = 1$) if a student gets a first class mark, value 0 ($Y_i = 0$) otherwise. Probability of getting a first class mark in an exam is a function of student effort index denoted by Z_i . $P_i = \frac{1}{1 + e^{-Z_i}}$; where

$$Z_i = \beta_1 + \beta_2 X_i + u_i$$

An example of a logit model: what determines that a student gets the first class degree?

$$Z_i = \beta_1 + \beta_2 H + \beta_3 E + \beta_4 A + \beta_5 P + e_i$$

H = hours of study, E= exercises, A = attendance in lectures and classes; P = papers written for assignment.

Ratio of odds: $\left[\frac{P_i}{1 - P_i} = \frac{1 + e^{Z_i}}{1 + e^{-Z_i}} = e^{Z_i} \right]$; taking log of the odds $\ln\left(\frac{P_i}{1 - P_i}\right) = Z_i$

Features of a logit model

- a. probability goes from 0 to 1 as the index variable Z_i goes from $-\infty$ to $+\infty$.
Probability lies between 0 and 1.
- b. Log of the odds is linear in x, characteristic variables but probabilities themselves are not linear but non linear function of the parameters. Probabilities are estimated using the maximum likelihood method.
- c. Any explanatory variable that determines the value of Z_i , measures how the log of odds of an event (i.e. owning a house) changes as a result of change in explanatory variable such as income.
- d. We can calculate P_i for given estimates of $\hat{\beta}_1$ and $\hat{\beta}_2$ or all other $\hat{\beta}_i$.
- e. Limiting case when $P_i=1$; $\ln\left(\frac{P_i}{1-P_i}\right)$ or when $P_i=0$ $\ln\left(\frac{0}{1-P_i}\right)$; OLS cannot be applied in such case but the maximum likelihood method may be used to estimate the parameters.

Tobit Model

It is an extension of the probit model, named after Tobin.

We observe variables if the event occurs: ie if some one buys a house.

We do not observe explanatory variables for people who have not bought a house.

The observed sample is censored, contains observations for only those who buy the house.

$$Y_i = \begin{cases} \beta_0 + \beta_1 X_t + u_t & \text{if event occurs} \\ 0 & \text{otherwise} \end{cases}$$

Y_t is equal to $\beta_0 + \beta_1 X_t + u_t$ if the event is observed equal to zero if the event is not observed.

It is unscientific to estimate probability only with observed sample without worrying about the remaining observations in the truncated distribution.

The Tobit model tries to correct this bias

The effect of observed variables on probability

$$\frac{\partial P_i}{\partial x_{i,j}} = \begin{cases} \beta_j & \text{for the linear probability model} \\ \beta_j P_j (1 - P_j) & \text{for the logit probability model} \\ \beta_j \phi(Z_i) & \text{for the probit probability model} \end{cases}$$

where $Z_i = \beta_0 + \sum_{i=1}^k \beta_i x_{i,j}$ **and** $\phi(\cdot)$ **is the standard normal density**

Panel models of limited dependent variables

$$y_{i,t}^* = x'_{i,t} \beta + \alpha_i + \varepsilon_{i,t}$$

$y_{i,t} = 1$ if $y_{i,t}^* > 0$ where $y_{i,t}^*$ is a latent variable; $y_{i,t} = 0$ otherwise.

$$\text{Log}L(\beta, \alpha_1, \dots, \alpha_N) = \sum_{i,t} y_{i,t} \log F(\alpha_i + x'_{i,t} \beta) + \sum_{i,t} (1 - y_{i,t}) (1 - \log F(\alpha_i + x'_{i,t} \beta))$$

Random Effect Probit model

$$y_{i,t}^* = x'_{i,t} \beta + \alpha_i + \varepsilon_{i,t}$$

$$y_{i,t} = 1 \text{ if } y_{i,t}^* > 0$$

$$y_{i,t} = 0 \text{ if } y_{i,t}^* \leq 0$$

$$\begin{aligned} f(y_{i,t}, \dots, y_{i,T} / x_{i,t}, \dots, x_{i,T}, \beta) &= \int_{-\infty}^{\infty} f(y_{i,t}, \dots, y_{i,T} / x_{i,t}, \dots, x_{i,T}, \beta) f(\alpha_i) d\alpha_i \\ &= \int_{-\infty}^{\infty} \left[\prod_i f(y_{i,t} / x_{i,t}, \beta) \right] f(\alpha_i) d\alpha_i \end{aligned}$$

$$f(y_{i,t} / x_{i,t}, \beta) = \Phi \left(\frac{x'_{i,t} \beta + \alpha_i}{\sqrt{1 - \sigma_u^2}} \right) \text{ if } y_{i,t} = 1$$

$$\dots = 1 - \Phi \left(\frac{x'_{i,t} \beta + \alpha_i}{\sqrt{1 - \sigma_u^2}} \right) \text{ if } y_{i,t} = 0$$

Tobit Panel model

$$y_{i,t}^* = x'_{i,t} \beta + \alpha_i + \varepsilon_{i,t}$$

$$y_{i,t} = 1 \text{ if } y_{i,t}^* > 0$$

$$y_{i,t} = 0 \text{ if } y_{i,t}^* \leq 0$$

$$f(y_{i,t}, \dots, y_{i,T} / x_{i,t}, \dots, x_{i,T}, \beta) = \int_{-\infty}^{\infty} f(y_{i,t}, \dots, y_{i,T} / x_{i,t}, \dots, x_{i,T}, \beta) f(\alpha_i) d\alpha_i$$

$$f(y_{i,t} / x_{i,t}, \beta) = \frac{1}{\sqrt{2\pi\sigma_\varepsilon^2}} \exp\left(-\frac{1}{2} \frac{(y_{i,t}^* = x'_{i,t} \beta + \alpha_i + \varepsilon_{i,t})^2}{\sigma_\varepsilon^2}\right) \text{ if } y_{i,t} = 1$$

$$\dots = 1 - \Phi\left(\frac{x'_{i,t} \beta + \alpha_i}{\sigma_\varepsilon}\right) \text{ if } y_{i,t} = 0$$

Dynamics and initial conditions

$$y_{i,t}^* = x'_{i,t}\beta + \gamma y_{i,t-1} + \alpha_i + \varepsilon_{i,t}$$

$$\begin{aligned} f(y_{i,t}, \dots, y_{i,T} / x_{i,t}, \dots, x_{i,T}, \beta) &= \int_{-\infty}^{\infty} f(y_{i,t}, \dots, y_{i,T} / x_{i,t}, \dots, x_{i,T}, \beta) f(\alpha_i) d\alpha_i \\ &= \int_{-\infty}^{\infty} \left[\prod_i f(y_{i,t} / y_{i,t-1}, \alpha_i, \beta) \right] f(y_{i,t} / x_{i,t}, \alpha_i, \beta) f(\alpha_i) d\alpha_i \end{aligned}$$

$$f(y_{i,t}, \dots, y_{i,T} / x_{i,t}, \dots, x_{i,T}, \beta) = \int_{-\infty}^{\infty} f(y_{i,t}, \dots, y_{i,T} / x_{i,t}, \dots, x_{i,T}, \beta) f(\alpha_i) d\alpha_i$$

$$f(y_{i,t} / y_{i,t-1}, \alpha_i, \beta) = \Phi \left(\frac{(x'_{i,t}\beta + \gamma y'_{i,t-1} + \alpha_i)}{\sqrt{1 - \sigma_\alpha^2}} \right) \quad \text{if } y_{i,t} = 1$$

$$\dots \dots \dots = 1 - \Phi \left(\frac{(x'_{i,t}\beta + \gamma y'_{i,t-1} + \alpha_i)}{\sqrt{1 - \sigma_\alpha^2}} \right) \quad \text{if } y_{i,t} = 0$$

Table 3. The wage model estimatesDependent variable - log gross hourly earnings (*derived variable*)

Number of observations - 5108

Variable	Coefficient	t-stat.	Mean
Intercept	0.042865	0.2773	
Years of schooling (<i>derived variable</i>)	0.041662	14.2672	12.136
Age at Date of Interview	0.059554	21.3142	36.662
Age squared	-0.000650	-18.3420	1492.846
Vocational qualifications	0.042175	3.3939	0.389
Sex	0.223546	18.1097	0.500
English 2 nd language	-0.222350	-2.7740	0.025
<i>RG Social Class: most recent job</i>			
Professional occupation	0.162362	0.7498	0.073
Managerial and technical	0.073698	0.3422	0.304
Skilled non-manual	-0.210799	-0.9770	0.288
Skilled manual	-0.264472	-1.2254	0.205
Partly skilled occupation	-0.360438	-1.6732	0.177
Unskilled occupation	-0.424298	-1.9709	0.069
Armed forces	0.113362	0.4318	0.020
<i>Region / Metropolitan Area Dummies</i>			
Inner London	0.289657	3.4308	0.048
Outer London	0.252697	3.1381	0.080
R. of South East	0.155620	1.9941	0.219
South West	0.083689	1.0566	0.112
East Anglia	0.046243	0.5614	0.058
East Midlands	0.013843	0.1746	0.110
West Midlands Conurb.	0.061383	0.7387	0.054
R. of West Midlands	0.045400	0.5634	0.078
Greater Manchester	0.151121	1.8403	0.060
Merseyside	0.153563	1.7593	0.039
R. of North West	0.090306	1.1025	0.062
South Yorkshire	0.070065	0.8220	0.044
West Yorkshire	0.050060	0.5990	0.051
R. of Yorks & Humber	0.032916	0.3931	0.050
Tyne & Wear	0.051728	0.6001	0.042
R. of North	0.035033	0.4255	0.059
Wales	0.051493	0.6336	0.068
Scotland	0.106978	1.3404	0.094
Northern Ireland	0.024426	0.2779	0.038
R ² = 0.92273928 Adjusted R ² = 0.92225211			

Note: Mean of dependent variable is 1.8226.

The BHPS

The British Household Panel Survey (BHPS) is a longitudinal data set. It started in 1991 with approximately 5500 households and more than 10,300 individuals drawn from 250 different areas of Great Britain.

There have been eight waves of BHPS until so far. It includes variables describing the economic, social and regional background of individuals and their labour market status and earnings over years.

The BHPS compares to the PSID data set in the United States, which started much earlier in 1968 with 4800 families and about 31,000 individuals.

The British Household Panel Survey is a multi-purpose study whose unique value resides in the fact that (1) it follows the same representative sample of individuals - the panel - over a period of years; (2) it is household-based, interviewing every adult member of sampled households; (3) it contains sufficient cases for meaningful analysis of certain groups such as the elderly or one parent families; (4) it allows for linkage of data both from other surveys and from local area statistics. The Wave 1 panel consists of some 5,500 households and 10,300 individuals drawn from 250 different areas of Great Britain. Continuing representativeness of the survey is ensured (and loss of panel members minimised) through (a) following panel members wherever they move in the UK; (b) including in the panel the new members of households formed by original panel members; (c) efficient fieldwork practices; (d) training videos for the interviewers; and by (e) regular contact with panel members through special reports and letters.” Source: <http://www.iser.essex.ac.uk/bhps/index.php#topcent>

Table 1

Descriptive Statistics

	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
WAGE	.40	64.67	7.3291	3.9415	2.421	.024	14.977	.047
Real wage	.38	64.67	6.8506	3.6330	2.470	.024	16.450	.047
AGE	16.00	72.00	38.8614	10.0534	.133	.024	-.580	.047
Schooling	.00	17.00	12.4292	3.7152	-1.324	.024	1.117	.047
<9	.00	1.00	.1357	.3425	2.127	.024	2.526	.047
>500	.00	1.00	.1887	.3913	1.592	.024	.534	.047
PRO	.00	1.00	5.514E-02	.2283	3.898	.024	13.199	.047
MAN	.00	1.00	.3019	.4591	.863	.024	-1.255	.047
SNM	.00	1.00	.2485	.4322	1.164	.024	-.645	.047
SM	.00	1.00	.1831	.3868	1.639	.024	.686	.047
PSO	.00	1.00	.1267	.3326	2.245	.024	3.042	.047
UO	.00	1.00	4.053E-02	.1972	4.661	.024	19.728	.047
ARMY	.00	1.00	1.925E-02	.1374	7.000	.024	47.003	.047

Table 2

Social Group	Average real wage rate
Managers and Professionals	8.697048
Skilled non-manual workers	5.853007
Skilled manual and partly skilled workers	5.634582
Unskilled workers	5.077317

Determinants of log real wages in the BHPS

	Wave specific Model		Time trend Model		Simple Model	
	Coefficients	t-stat	Coefficients	t-stat	Coefficients	t-stat
(Constant)	-0.14747	-2.59251	-0.06943	-1.21463	0.077762	1.398395
Schooling	0.02773	24.69335	0.024771	22.89871	0.02236	20.63917
AGE	0.061577	25.59521	0.061922	25.59911	0.064557	26.37733
AGE SQ	-0.00071	-23.6162	-0.00072	-23.7254	-0.00073	-23.9861
REGION	0.108861	13.76351	0.110162	13.85307	0.108349	13.43424
SEX	0.289535	38.1348	0.290434	38.0495	0.291724	37.68031
<9	-0.22086	-20.5803	-0.21948	-20.3914	-0.21897	-20.0628
>500	0.09911	9.982215	0.093538	9.430559	0.094012	9.346495
PRO	0.27677	8.92049	0.22158	7.804683	0.180633	6.313034
MAN	0.242631	8.659276	0.185404	7.434985	0.143636	5.730343
SNM	0.011577	0.409853	-0.04718	-1.85722	-0.09587	-3.7605
SM	-0.07086	-2.49312	-0.13256	-5.14719	-0.18186	-7.0363
PSO	-0.13489	-4.67352	-0.19871	-7.53563	-0.24978	-9.44191
UO	-0.15041	-4.77689	-0.20085	-6.64589	-0.24771	-8.12958
ARMY	-0.0054	-0.15241	-0.01209	-0.33963	-0.01323	-0.36642
W2	0.129078	8.836155	-	-	-	-
W3	0.016599	1.164677	-	-	-	-
W4	0.133982	9.182063	-	-	-	-
W5	0.150253	10.28989	-	-	-	-
W6	0.234902	14.26546	-	-	-	-
W7	0.188706	12.92747	-	-	-	-
W8	0.22254	15.22138	-	-	-	-
TIME	-	-	0.039577	5.361771	-	-
TIME SQ	-	-	-0.00119	-1.50042	-	-
R squared	0.417		0.416		0.399	

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Variation in real wages by the size of the company

	Big companies		Small Business	
	Coefficients	t-stat	Coefficients	t-stat
(Constant)	0.29994	1.099604	-0.0457	-0.33149
Schooling	0.022003	8.608514	0.024922	7.732276
AGE	0.060397	9.556513	0.05835	9.261173
AGE SQ	-0.00072	-8.85622	-0.00069	-8.9733
REGION	0.129167	7.660593	0.134833	5.584151
SEX	0.255387	15.62679	0.308492	12.72529
PRO	0.120275	0.491738	-0.08024	-1.61605
MAN	0.03926	0.16106	-	-
SNM	-0.20562	-0.84153	-0.21833	-7.06839
SM	-0.22536	-0.92101	-0.38824	-10.9582
PSO	-0.28734	-1.17199	-0.36387	-8.91642
UO	-0.58074	-2.32851	-0.42895	-7.62572
W2	0.125986	3.872638	0.220977	5.109043
W3	0.029339	0.940177	0.100242	2.295374
W4	0.129666	4.149246	0.187425	4.15907
W5	0.130334	4.161889	0.242116	5.341385
W6	0.026827	0.109107	0.09715	2.083886
W7	0.145871	4.711325	0.274512	6.472693
W8	0.201444	6.403804	0.300538	6.962366

R squared

0.401

0.369

Table 5 Variation in wages across professional classes

Managers and Professionals		Skilled non-manual		Skilled manual and partly skilled		Unskilled Occupation	
Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat
-0.24238	-2.30467	-0.279	-3.21818	0.079343	0.997643	0.265824	1.2131
0.033991	14.63375	0.025129	9.700202	0.020295	12.37499	0.01783	4.236874
0.07674	15.00896	0.072049	17.12924	0.045051	11.8383	0.03088	2.958091
-0.00089	-14.2944	-0.00085	-15.8118	-0.0005	-10.5144	-0.00032	-2.54643
0.155313	12.07284	0.08104	5.171669	0.074779	5.100802	0.106354	3.106725
0.205673	16.6282	0.359635	22.84687	0.368248	28.36602	0.275157	8.168141
-0.19619	-9.80429	-0.15601	-7.43583	-0.19338	-10.01	-0.06789	-1.47323
0.081668	5.47145	0.083755	4.03365	0.159345	8.910793	0.016583	0.314742
0.131612	5.324048	0.115727	4.170396	0.107282	4.412229	0.1093	1.578589
0.02364	0.981268	-0.00268	-0.09843	0.028341	1.212702	0.027789	0.42512
0.122919	5.054341	0.117295	4.189873	0.138125	5.634414	0.097687	1.419719
0.135043	5.596049	0.154982	5.445144	0.143342	5.879854	0.127856	1.803636
0.034108	0.930621	0.113121	3.3613	0.350556	13.56767	0.58311	10.77931
0.186893	7.839752	0.181157	6.241838	0.179	7.3533	0.064058	0.869105
0.2438	10.16457	0.195785	6.728269	0.209928	8.637929	0.09961	1.43655
		0.302		0.307		0.331	
						0.565	

Regional variation in log real wages

	South East		Rest of the UK	
	Coefficients	t-stat	Coefficients	t-stat
(Constant)	0.070817	0.628037	-0.18588	-2.83481
Schooling	0.03283	14.53105	0.025668	19.87559
AGE	0.055873	12.01928	0.063831	22.75449
AGE SQ	-0.00064	-11.1071	-0.00074	-20.9837
SEX	0.253966	17.23961	0.300643	33.8597
<9	-0.19384	-9.2052	-0.22896	-18.4183
>500	0.100411	5.300475	0.09737	8.371546
PRO	0.289589	4.955016	0.261049	7.092697
MAN	0.228659	4.190061	0.246252	7.573783
SNM	-0.05313	-0.9588	0.035501	1.08647
SM	-0.12119	-2.14751	-0.05636	-1.71977
PSO	-0.19596	-3.39382	-0.1169	-3.52365
UO	-0.17541	-2.82167	-0.13962	-3.84105
ARMY	-0.03561	-0.51443	0.003636	0.088666
W2	0.127825	4.512517	0.128312	7.55933
W3	-0.01947	-0.70262	0.031207	1.887415
W4	0.10896	3.848974	0.142439	8.401605
W5	0.133526	4.699018	0.155435	9.172799
W6	0.244195	7.584801	0.230597	12.08414
W7	0.163457	5.720786	0.196882	11.64921
W8	0.206867	7.245746	0.227713	13.44049

R squared

0.43

0.401

Using Stata PcGive, Limdep, Excel for Panel Data Analysis

Create a Panel id and time variable along with dependent and independent variables. Save your data in the CSV format; import of STATA; do preliminary statistics; Use data editor to check nature of data; select statistics/multivariate linear models/fixed effect random effect models, choose dependent and independent variables and study the results.

Estimating Panel data model in pcGive: Select panel data package, open data file, data need to be in the stacked format, determine dependent and independent variables, give time variables, estimate dynamic and static panels. Alternatively write batch programmes in PcGive as given in the next pages and do all calculations at one time.

Limdep is very good for Panel data model, particularly for limited dependent variable models; It has its own commands and routines which are not necessarily that difficult. In Shazam Pale can be computed as a system or SUR method.

Increasingly recent studies have looked into nonstationarity and heterogeneity issues in panel data model. Levin and Lin (1992)

$$\Delta y_{i,t} = a_i = \rho y_{i,t-1} + \sum_{k=1}^n \phi_k \Delta y_{i,t-k} + \delta_i t + \theta_t + u_{i,t}$$

$$H_0 : \rho = 0 \text{ against } H_A : \rho < 0$$

Levin, A., C. Lin and C. Chu (2002): “Unit Root Tests in Panel Data: Asymptotic and finite sample properties”, Journal of Econometrics, 108, p.12-24.

IM, Pesharan and Shin (1997)

Im, K.S., M. Pesaran and Y. Shin (2003): “Testing for Unit Roots in Heterogeneous Panels”, Journal of Econometrics, 115, p.53-74.

$$\Delta y_{i,t} = a_i = \rho y_{i,t-1} + \sum_{k=1}^n \phi_k \Delta y_{i,t-k} + \delta_i t + \theta_t + u_{i,t}$$

$$\text{Heterogeneity in unit roots: } H_0 : \rho_i = 0 \text{ against } H_A : \rho_i < 0$$

Maddala and Wu (1999) tests for unbalanced panel

Maddala, G.S. and S. Wu (1999): “A comparative study of unit root test with panel data and a new simple test”, Oxford Bulletin of Economics and Statistics, 61, p.631-652.

$$\Pi = -2 \sum_{i=1}^N \ln \pi_i \text{ with } \chi^2 \text{ distribution}$$

where π_i is the probability limit of ADF test

Panel Unit Root Test

Increasingly recent studies have looked into nonstationarity and heterogeneity issues in panel data model. Levin and Lin (1992)

$$\Delta y_{i,t} = a_i = \rho y_{i,t-1} + \sum_{k=1}^n \phi_k \Delta y_{i,t-k} + \delta_i t + \theta_t + u_{i,t}$$

$$H_0 : \rho = 0 \text{ against } H_A : \rho < 0$$

Levin, A., C. Lin and C. Chu (2002): “Unit Root Tests in Panel Data: Asymptotic and finite sample properties”, Journal of Econometrics, 108, p.12-24.

IM, Pesharan and Shin (1997)

Im, K.S., M. Pesaran and Y. Shin (2003): “Testing for Unit Roots in Heterogeneous Panels”, Journal of Econometrics, 115, p.53-74.

$$\Delta y_{i,t} = a_i = \rho y_{i,t-1} + \sum_{k=1}^n \phi_k \Delta y_{i,t-k} + \delta_i t + \theta_t + u_{i,t}$$

Heterogeneity in unit roots: $H_0 : \rho_i = 0$ against $H_A : \rho_i < 0$

Panel Unit Root Test

Maddala and Wu (1999) tests for unbalanced panel

Maddala, G.S. and S. Wu (1999): “A comparative study of unit root test with panel data and a new simple test”, Oxford Bulletin of Economics and Statistics, 61, p.631-652.

$$\Pi = -2 \sum_{i=1}^N \ln \pi_i \text{ with } \chi^2 \text{ distribution}$$

where π_i is the probability limit of ADF test

KSSS test

$$KPSS = \sum_{t=1}^T S_t^2 / \hat{\sigma}^2 \text{ where } S_t = \sum_{s=1}^t e_s \text{ is the partial sum of errors in a regression of Y}$$

on an intercept and time trend. In contrast to the unit root test this test assumes that Y series are stationary and alternative hypothesis is nonstationarity.

Kwaitkowski, D. P.C. Phillips, P. Schmidt and Y. Shin (1992): “Testing the null hypothesis of Stationarity against the alternative of a unit root”, Journal of Econometrics, 54, p.159-178.

Panel Cointegration Test

See also Asteriou (2006) Applied Econometrics, Palgrave and Verbeek (2004) A guide to Modern Econometrics, Wiley.

Kao test

Kao, C. (1999): “Spurious Regression and residual-based Tests for Cointegration in Panel Data”, Journal of Econometrics, 90, p.1-44.

Start with $Y_{i,t} = a_i + \beta X_{i,t} + e_{i,t}$

Residual based cointegration $\hat{e}_{i,t} = \rho \hat{e}_{i,t-1} + v_{i,t}$

Estimate

$$\hat{\rho} = \frac{\sum_t \sum_i \hat{e}_{i,t}^2 \hat{e}_{i,t-1}^2}{\sum_t \sum_i \hat{e}_{i,t}^2} \text{ and}$$

related t statistics

$$t_p = \frac{(\hat{\rho} - 1) \sqrt{\sum_t \sum_i \hat{e}_{i,t}^2}}{1/(NT) \left(\sum_t \sum_i (\hat{e}_{i,t}^2 - \hat{\rho} \hat{e}_{i,t-1}^2)^2 \right)}$$

Panel Cointegration Test of Pedroni

$$Y_{i,t} = a_i + \delta_t + \sum_{m=1}^M \beta_{mi} X_{mi,t} + e_{i,t}$$

Within group tests

$$\text{Panel } v \text{ statistic } T^2 N^3 Z_{vNT} = \frac{T^2 N^{3/2}}{\left(\sum_t \sum_i L_{11}^{-2} e_{i,t}^2 \right)}$$

$$\text{Panel } \rho \text{ statistic } T\sqrt{N} Z_{\rho NT} = \frac{T\sqrt{N} \left(\sum_t \sum_i L_{11}^{-2} \hat{e}_{i,t-1}^2 \Delta \hat{e}_{i,t-1}^2 - \hat{\lambda}_i \right)}{\left(\sum_t \sum_i L_{11}^{-2} e_{i,t}^2 \right)}$$

$$\text{Panel } t \text{ statistic } Z_{tNT} = \sqrt{\sigma_{NT}^2 \left(\sum_t \sum_i L_{11}^{-2} e_{i,t-1}^2 \right)} \left(\sum_t \sum_i L_{11}^{-2} \hat{e}_{i,t-1}^2 \Delta \hat{e}_{i,t-1}^2 - \hat{\lambda}_i \right)$$

$$\text{Panel } t \text{ statistic (parametric) } Z_{tNT} = \sqrt{\sigma_{NT}^2 \left(\sum_t \sum_i L_{11}^{-2} e_{i,t-1}^2 \right)} \left(\sum_t \sum_i L_{11}^{-2} \hat{e}_{i,t-1}^2 \Delta \hat{e}_{i,t-1}^2 - \hat{\lambda}_i \right)$$

Between group tests

$$\text{Group } \rho \text{ statistic } T\sqrt{N} Z_{\rho NT} = T\sqrt{N} \frac{\sum_t \left(\hat{e}_{i,t-1}^2 \Delta \hat{e}_{i,t-1}^2 - \hat{\lambda}_i \right)}{\left(\sum_t \sum_i e_{i,t}^2 \right)}$$

$$\text{Group } t \text{ statistic } \sqrt{N} Z_{tNT-1} = \sqrt{N} \sum_{i=1}^N \sqrt{\sigma_i^2 \sum_t e_{it}^2} \left(\sum_t \left(\hat{e}_{i,t-1}^2 \Delta \hat{e}_{i,t-1}^2 - \hat{\lambda}_i \right) \right)$$

$$\text{Group } t \text{ statistic (parametric) } \sqrt{N} Z_{tNT-1} = \sqrt{N} \sum_{i=1}^N \sqrt{\sigma_i^2 \sum_t e_{it}^2} \left(\sum_t \left(\hat{e}_{i,t-1}^2 \Delta \hat{e}_{i,t-1}^2 - \hat{\lambda}_i \right) \right)$$

Panel Max and Trace Statistics

Larsson test

Based their test on Johannes' maximum likelihood procedure.

$$\Delta Y_{i,t} = \Pi_i y_{i,t-1} + \sum_{k=1}^n \Gamma_k \Delta Y_{i,t-k} + u_{i,t}$$

$$H_0 : \text{rank}(\Pi_i) = r_i \leq r \quad \text{for all } i \text{ from } 1 \text{ to } N.$$

$$H_A : \text{rank}(\Pi_i) = p \quad \text{for all } i \text{ from } 1 \text{ to } N.$$

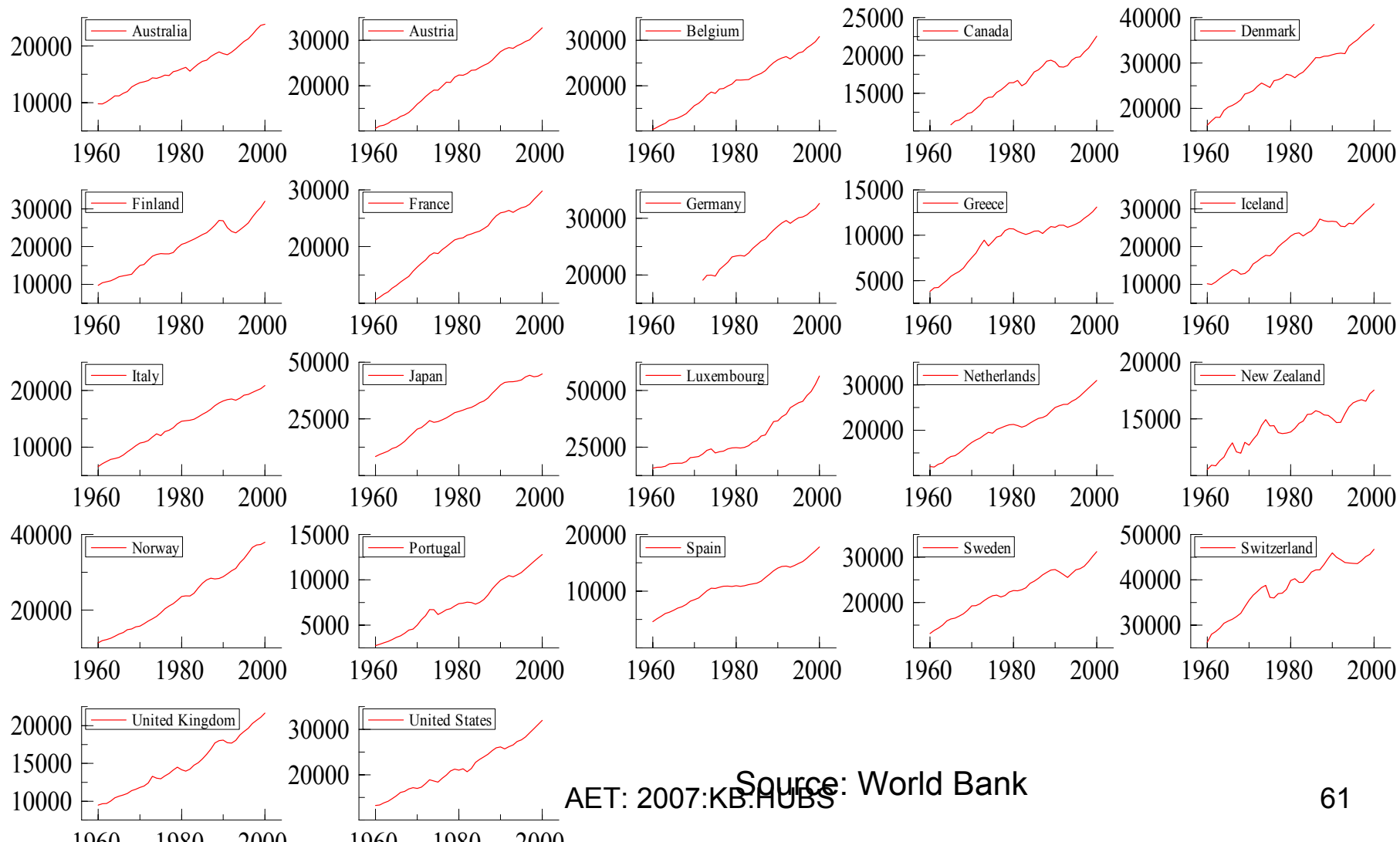
The standard rank test statistics is defined in terms of average of the trace statistic for each cross section unit and mean and variance of trace statistics.

$$LR = \frac{\sqrt{N}(LR_{Nt} - E(Z_k))}{\sqrt{\text{Var}(Z_t)}}$$

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Evidence on Economic Growth-1

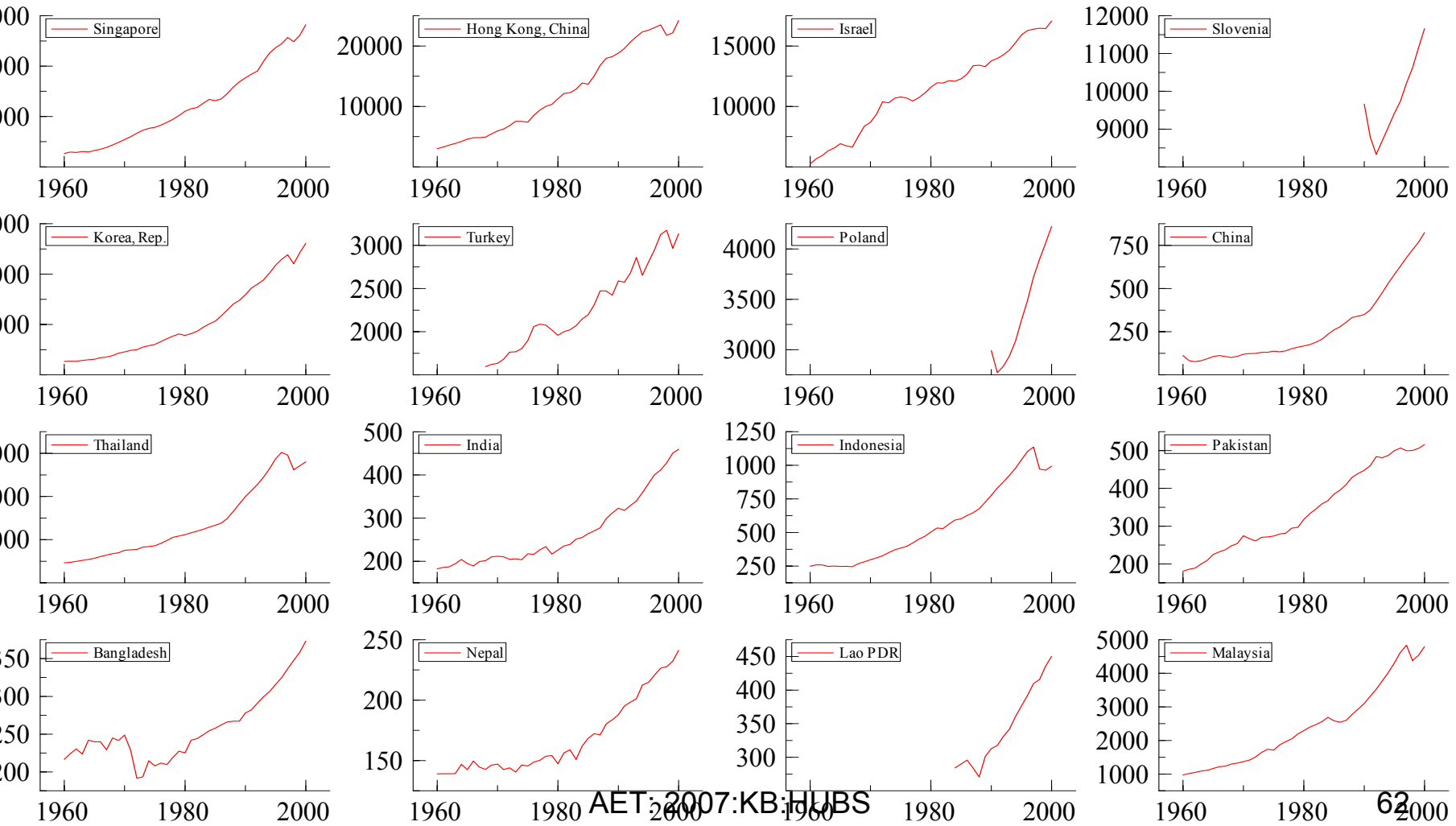
Per Capita GDP in OECD Economies (1960-2000)



Source: World Bank
AET: 2007:KB.HUBS

Evidence on Economic Growth -2

Per capita income in growth miracle countries 1960-2000

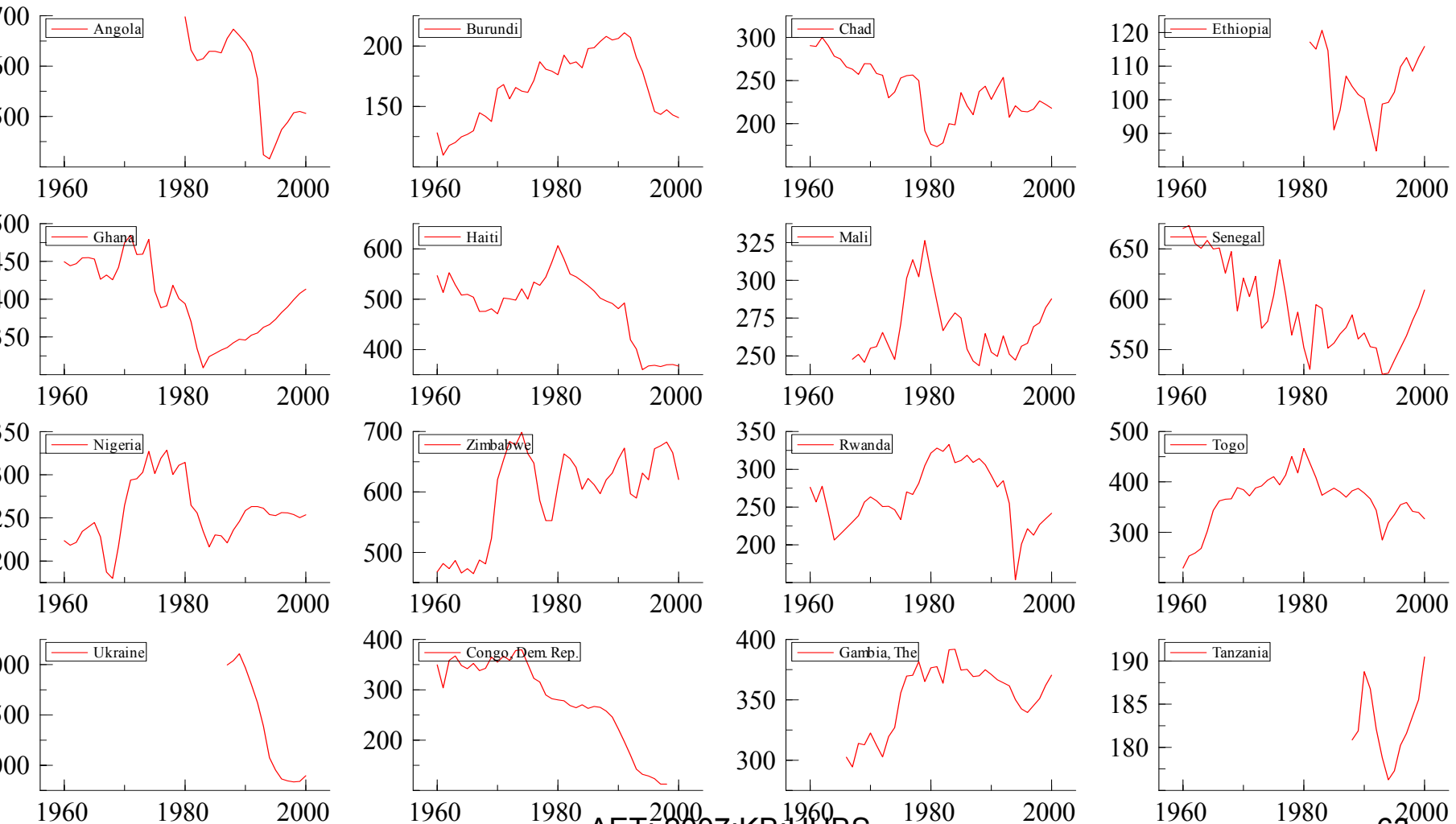


AET, 2007:KB,HUBS

Source: World Bank

Evidence on Economic Growth -3

Per Capita GDP in Growth Disaster Economies 1960-2000

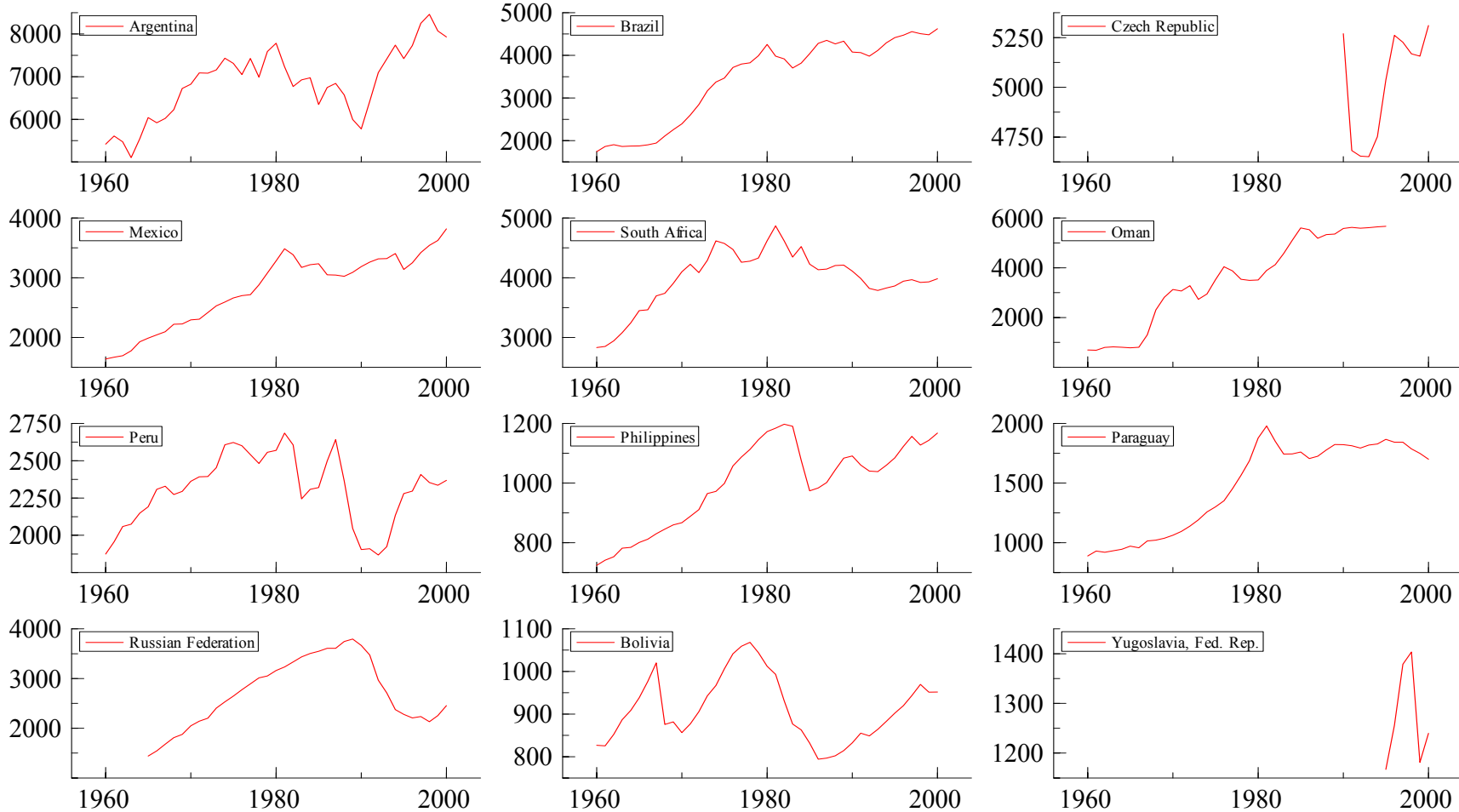


AET: 2007:KB:HUBS

Source: World Bank

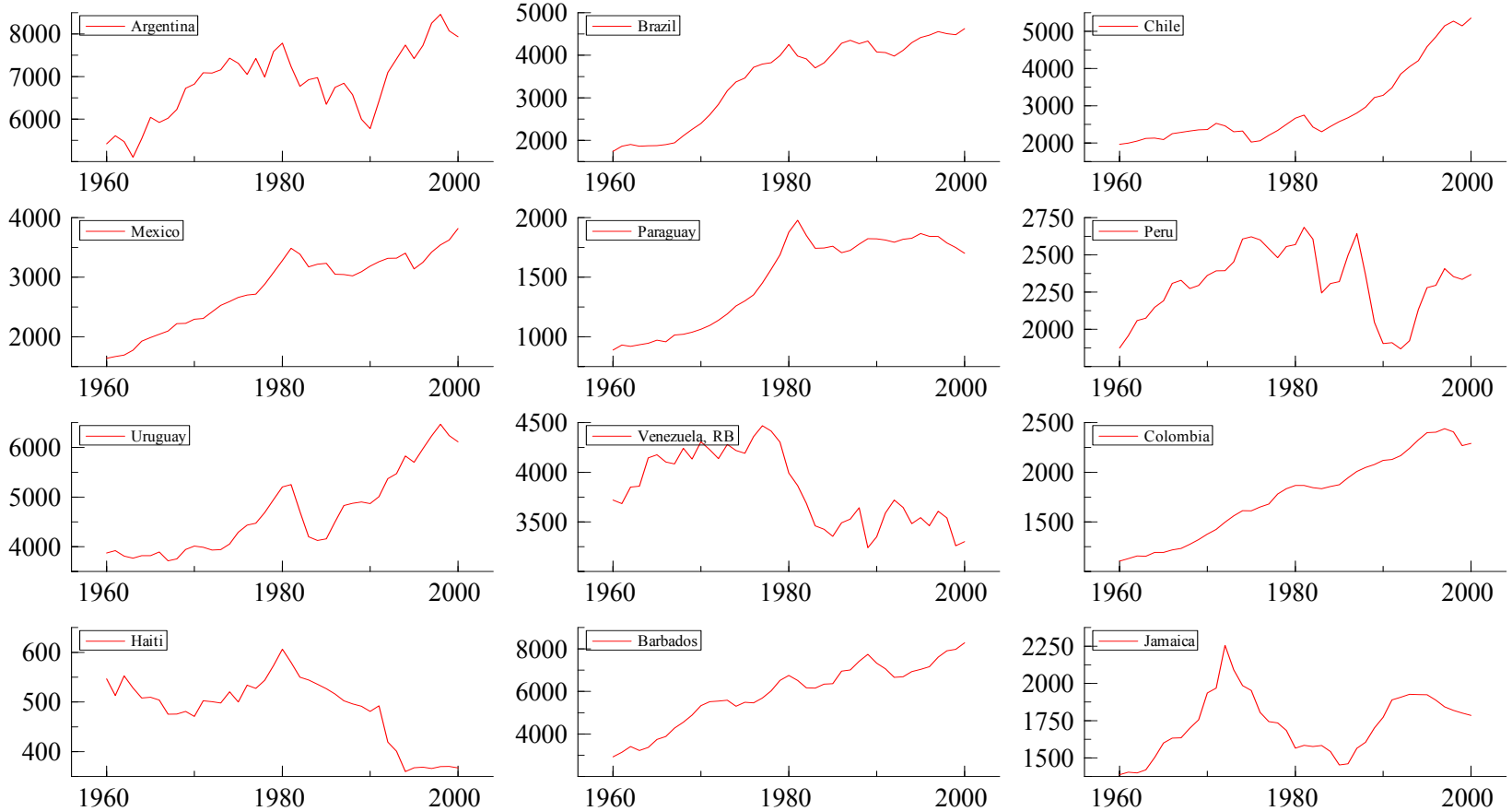
Evidence on Economic Growth -4

Per capita income in Trouble-prone Mid-income countries 1960-2000



Evidence on Economic Growth -5

Per capita income Latin and Central American and Caribbean countries 1960-2000



Source: World Bank
AET: 2007:KB.HUBS

Relevant Literature (there are too many to list!!!)

Growth Theories and Sessions in this conference

One or two sector growth models

Ramsey (1928), Harrod (1939), Domar (1947), Solow (1956), Cass (1965),
Koopman (1965), Uzawa (1962), Lucas (1988), Rebelo (1991)
Romer (1989), Barro (1998) and Barro and Sala-i-Martin(1995), Quah (1997),
Parente and Prescott (1993) Rankin (1992) Dixon H (1987) Jones (1995)
Greenwood and Jovanovic (1990), Turnovsky (1993)

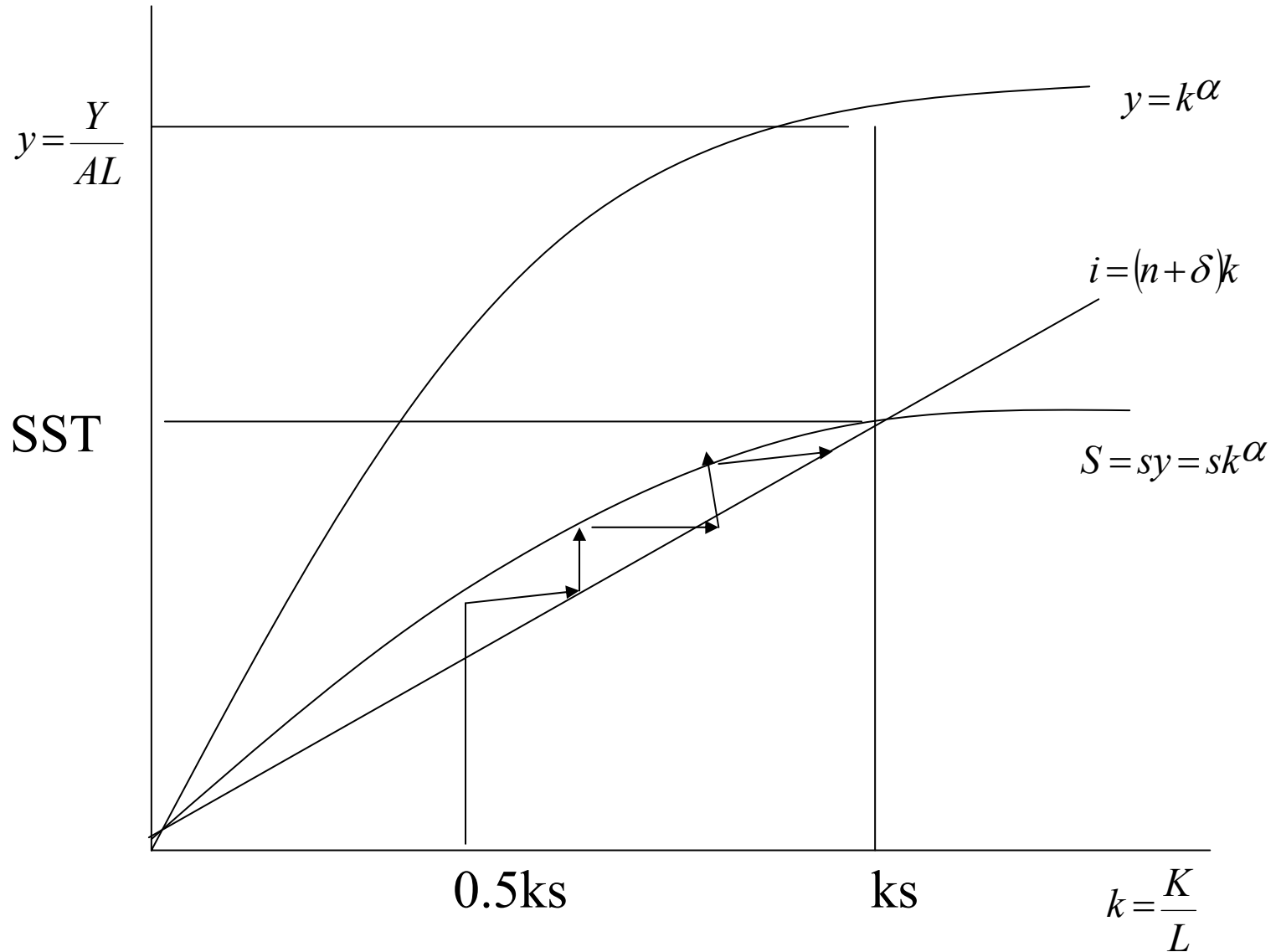
Empirical growth study

Maddison (1991). Nicolas Kaldor (1961) Rodrik (1999) Mankiw et. al. (1992), Hendry D.F.
(1997)
Temple (1999) McMahon G and L. Squire(2003) Holly S and M Weale Eds.(2000)
Perroti (1996) Grossman and Helpman (1991) HM Treasury (2002)

Dynamic General Equilibrium Models and stochastic DGEM

Debreau (1954), Solow (1956), Cass(196), King and Fullerton (1984),
Miller and Spencer (1977), Aurback and Kotlikoff (1987), Ballard, Fullerton, Shoven and
Whalley(1985), Piggott and Whalley (1985), Bhattarai and Whalley (1999),
Hutton and Kenc (1994), Perroni (1995), Rutherford (1995),
Bhattarai (1997,1999) Doornik and Hendry (2001), Cooly (1995)

Per Capita Output and Per Capita Capital Stock in the Steady State



Major Growth issues

- Capital accumulation
- Technology and its adoption
- Openness, trade and growth
- Tax policy
- Human Capital, Education
- Country specific factors
- Political Freedom and Market Economy

Determinants of Growth: Panel Regression Model

$$y_{i,t} = \alpha_i + x_{i,t} \beta_{i,t} + \lambda_t + e_{i,t}$$

$$\begin{bmatrix} y_{i,1} \\ y_{i,2} \\ \cdot \\ \cdot \\ y_{i,T} \end{bmatrix} = \begin{bmatrix} x_{i,1} \beta \\ x_{i,2} \beta \\ \cdot \\ \cdot \\ x_{i,T} \beta \end{bmatrix} + \begin{bmatrix} \alpha_i \\ \alpha_i \\ \cdot \\ \cdot \\ \alpha_i \end{bmatrix} + \begin{bmatrix} \lambda_1 \\ \lambda_2 \\ \cdot \\ \cdot \\ \lambda_T \end{bmatrix} + \begin{bmatrix} e_{1i} \\ e_{2i} \\ \cdot \\ \cdot \\ e_{mi} \end{bmatrix}$$

$$y_i = x_i \beta + \lambda_t + \iota_i \alpha_i + e_i$$

Baltagi (1995), Doornik and Hendry (2001)

Estimator of a Panel Data Model

$$y_i = x_i \beta + D_i \delta + e_i$$

$$y = W\beta + e$$

$$\hat{\beta} = (W'W)^{-1} W' y$$

Dynamic Panel Data Model

$$y_{i,t} = \sum_{s=1}^p a_k y_{i,t-s} + \beta^t(L)x_{i,t} + \lambda_t + \alpha_i + e_{i,t}$$

$$y_i = W_i \delta + \iota_i \alpha_i + e_i$$

GMM Estimator (Baltagi (1995), Doornik and Hendry (2001)):

$$\hat{\delta} = \left[\left(\sum_i W_i^* Z_i \right) A_N \left(\sum_i Z_i' W_i \right) \right]^{-1} \left(\sum_i W_i^* Z_i \right) A_N \left(\sum_i Z_i' y_i^* \right)$$

$$A_N = \left(\frac{1}{N} \sum_i Z_i' H_i Z_i \right)^{-1}$$

Determinants of Economic Growth in Newly Emerging Growth Miracle Economies.

2-step estimation using dynamic panel data model				
	Coefficient	Std.Error	t-value	t-prob
Gdpprcap(-1)	0.12036	0.01812	6.64000	0.00000
GDP60	-0.00159	0.00043	-3.73000	0.00000
china	0.00288	0.00137	2.11000	0.03700
Hkong	-0.00171	0.00077	-2.21000	0.02800
Ireland	0.00110	0.00128	0.86300	0.38900
Korea	0.00335	0.00074	4.53000	0.00000
Malta	-0.00197	0.00068	-2.90000	0.00400
Portugal	-0.00061	0.00096	-0.63700	0.52500
Singapore	0.00113	0.00027	4.21000	0.00000
Sratio	0.15583	0.04257	3.66000	0.00000
Irattio	0.18329	0.02995	6.12000	0.00000
Prindex	-0.00510	0.00487	-1.05000	0.29700
rint	-0.02795	0.06357	-0.44000	0.66100
xmratio	-0.00461	0.00097	-4.74000	0.00000
Japan	-0.00056	0.00086	-0.65300	0.51500
sigma	4.914753	sigma^2	24.1548	
RSS	3526.6004	TSS	2240.0576	
no. of observations				
161		no. of parameters	15	

Determinants of Growth across OECD Countries

	Coefficient	Std.Error	t-value	t-prob
Grpercap(-1)	0.180988	0.05395	3.35	0.00
Sy	0.216942	0.03	7.23	0.00
Iy	-0.00045	0.05464	-0.00824	0.99
Xmy	0.0648251	0.01251	5.18	0.00
Popg	-1.88968	0.4329	-4.37	0.00
Govy	-0.203699	0.0558	-3.65	0.00
Txy	-0.132421	0.0445	-2.98	0.00
Australia	0.972477	0.4075	2.39	0.02
Austria	-1.6312	0.3127	-5.22	0.00
Belgium	-1.8475	0.3254	-5.68	0.00
Canada	-0.463298	0.1385	-3.34	0.00
Denmark	-0.170403	0.04258	-4	0.00
Finland	-0.209737	0.05947	-3.53	0.00
France	0.077469	0.07293	1.06	0.29
Germany	-0.362554	0.04693	-7.73	0.00
Greece	-0.585984	0.06581	-8.9	0.00
Iceland	-0.207666	0.05016	-4.14	0.00
Ireland	-0.411256	0.0768	-5.35	0.00
Italy	-0.0800266	0.0598	-1.34	0.18
Japan	-0.398036	0.06241	-6.38	0.00
Luxembourg	-0.718133	0.1419	-5.06	0.00
Netherlands	-0.221358	0.04843	-4.57	0.00
New Zealand	-0.127106	0.04085	-3.11	0.00
Norway	-0.153097	0.03551	-4.31	0.00
Portugal	-0.216048	0.04225	-5.11	0.00
Spain	-0.114415	0.0264	-4.33	0.00
Switzerland	-0.330109	0.04088	-8.07	0.00
United Kingdom	-0.0111015	0.01851	-0.6	0.55
Constant	6.88023	0.9513	7.23	0.00
Sigma 1.645049 ; sigma^2 2.71; R^2 = 0.453642; N =390; K 29				
Wald (joint): Chi^2(28) = 580.8 [0.000] **				
Wald (dummy): Chi^2(1) = 52.31 [0.000] **				
AR(1) test: N(0,1) = 1.691 [0.091] **			AR(1) test: N(0,1) = 1.691 [0.091] **	
AR(2) test: N(0,1) = -0.1074 [0.915]				

Table 5

Determinants of growth in Growth-disaster Countries.

	Coefficient	Std.Error	t-value	t-prob
Sy	0.0536652	0.0578	0.929	0.357
Iy	0.387516	0.03472	11.2	0
Popg	1.58804	0.6546	2.43	0.018
Xmy	-0.0645406	0.04199	-1.54	0.13
Infl	-0.000239639	5.52E-05	-4.34	0
Govy	-0.254936	0.05758	-4.43	0
Rint	-0.0128252	0.001408	-9.11	0
Rexch	-0.00829239	0.0006404	-12.9	0
Central African Rep.	-0.567217	1.896	-0.299	0.766
Ghana	0.764814	0.909	0.841	0.404
Nicaragua	-0.267793	0.1168	-2.29	0.025
Sierra Leone	-0.0683136	0.128	-0.534	0.596
Venezuela, RB	-0.294535	0.1456	-2.02	0.048
Constant	-0.894037	2.785	-0.321	0.749
Sigma	4.263287	Sigma^2	18.17	562
R^2	0.3457624			
RSS	1072.361362	TSS	1639.1007	168
No. of observations	79	no. of parameters		20
Wald (joint):	Chi^2(19)	180.1	[0.000]	
Wald (dummy):	Chi^2(1)	0.103	[0.748]	
AR(1) test:	N(0,1)	0.8735	[0.380]	
AR(2) test:	N(0,1)	-1.269	[0.204]	

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Table 7
Determinants of growth in Latin and Central American countries.
Panel GMM (one Step) Estimation with Individual Effects

	Coefficient	Std.Error	t-value	t-prob
iy	0.1306	0.0522	2.5000	0.0130
xmy	0.0302	0.0209	1.4500	0.1490
infl	-0.0009	0.0002	-4.0000	0.0000
cadef	0.0475	0.0306	1.5500	0.1220
Constant	-4.4425	3.6730	-1.2100	0.2270
Antigua and Barbuda	2.3244	3.0800	0.7550	0.4510
Argentina	0.3609	1.0630	0.3390	0.7340
Bahamas, The	-0.0664	1.2470	-0.0533	0.9580
Barbados	0.9192	1.0350	0.8880	0.3750
Belize	1.4098	2.5280	0.5580	0.5770
Bolivia	2.5282	3.0420	0.8310	0.4060
Brazil	3.9497	2.2790	1.7300	0.0840
Chile	2.1572	2.7650	0.7800	0.4360
Colombia	0.6180	1.8630	0.3320	0.7400
Costa Rica	2.1726	2.1460	1.0100	0.3120
Dominican Republic	0.1568	2.3280	0.0674	0.9460
Ecuador	0.8159	2.3880	0.3420	0.7330
El Salvador	1.1222	1.0850	1.0300	0.3010
Grenada	1.5311	2.6970	0.5680	0.5700
Guatemala	-2.7476	0.4757	-5.7800	0.0000
Guyana	-0.3287	2.7390	-0.1200	0.9050
Haiti	-0.9212	1.9150	-0.4810	0.6310
Honduras	-1.3697	1.3050	-1.0500	0.2940
Jamaica	1.5202	2.5750	0.5900	0.5550
Mexico	-0.1066	2.1300	-0.0500	0.9600
Nicaragua	0.2862	1.8670	0.1530	0.8780
Panama	-0.3209	2.1480	-0.1490	0.8810
Paraguay	1.0235	2.7600	0.3710	0.7110
Peru	1.0299	0.7821	1.3200	0.1880
Puerto Rico	0.9467	0.6354	1.4900	0.1370
St. Kitts and Nevis	0.8115	0.6603	1.2300	0.2200
St. Lucia	0.1886	2.1710	0.0869	0.9310
St. Vincent and the Grenadines	-0.3299	1.7820	-0.1850	0.8530
Suriname	2.5300	2.6500	0.9550	0.3400
Trinidad and Tobago	-0.8258	2.4170	-0.3420	0.7330
sigma	4.494	Observations	617	
sigma^2	20.19	Parameters	35	
R^2	0.194			
Wald (Joint)	$\chi^2(3) = 11.11$		[0.000]	**

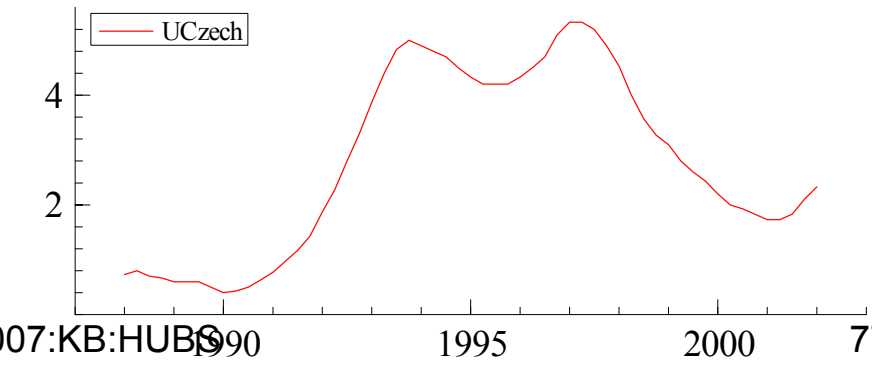
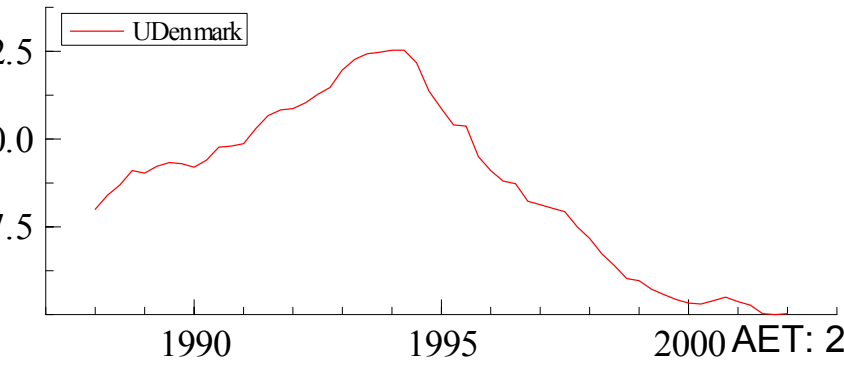
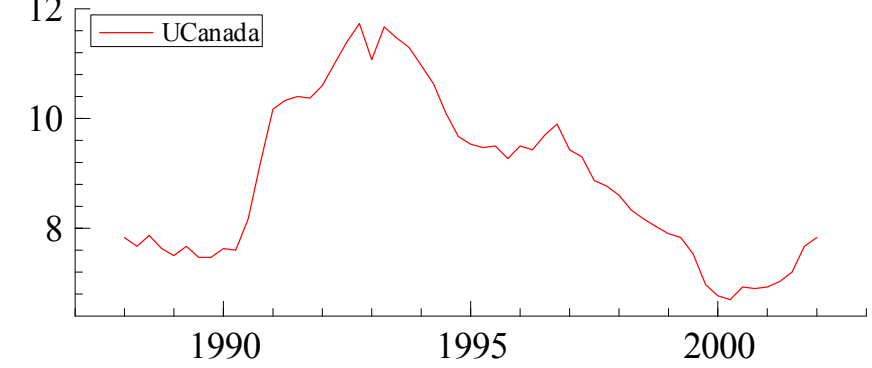
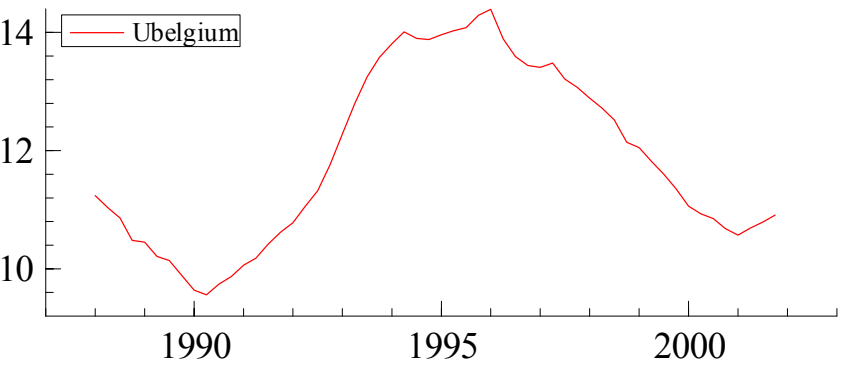
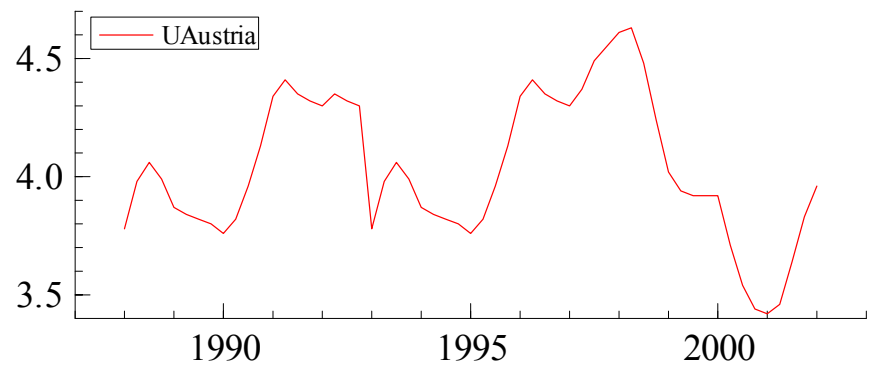
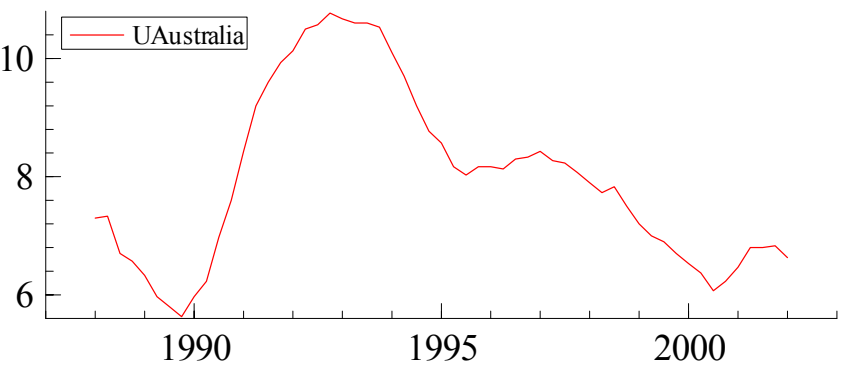
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Wide gap exists in living standards among rich and poor countries.

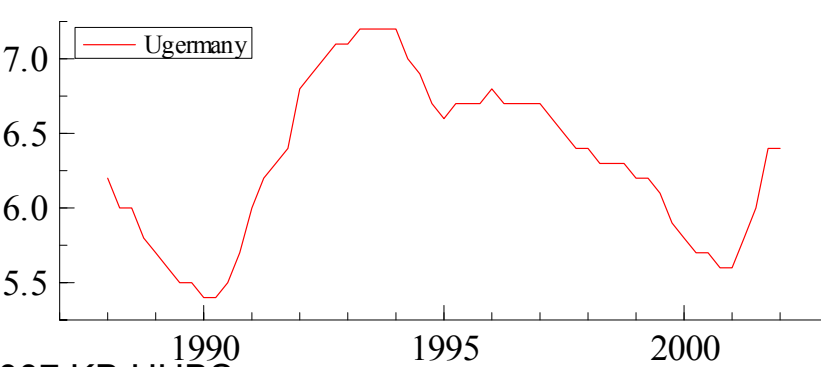
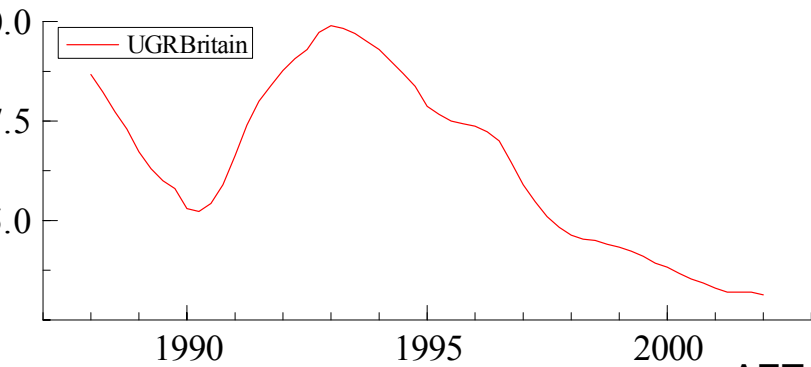
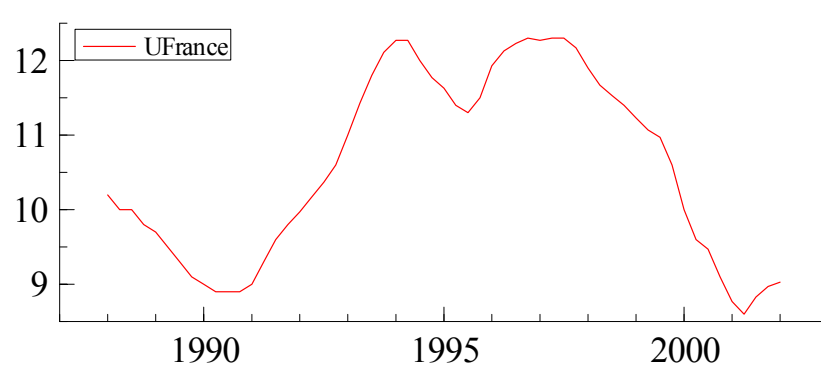
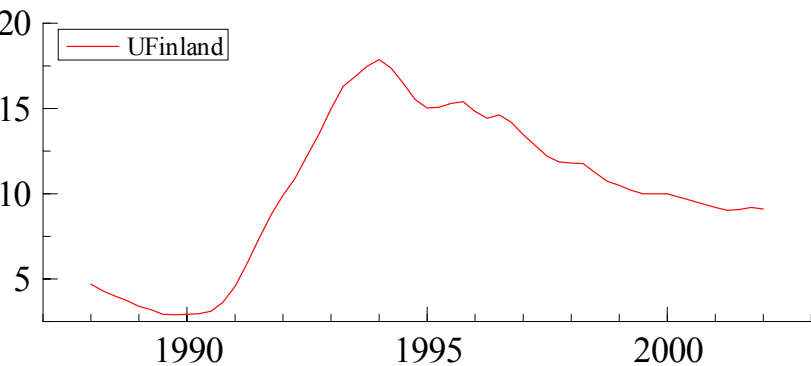
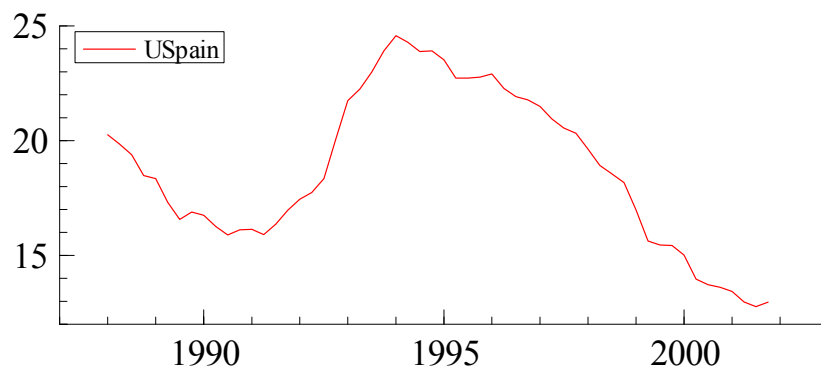
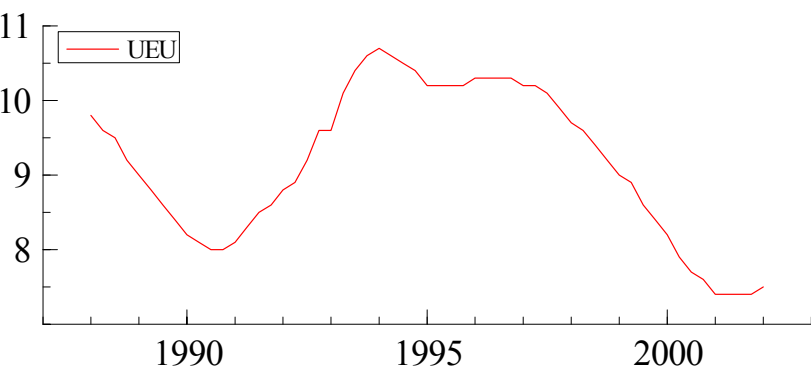
These gaps can be narrowed if the technical idea, capital and labour could flow freely among them.

It is not possible unless growth in the major objective of households, firms and governments.

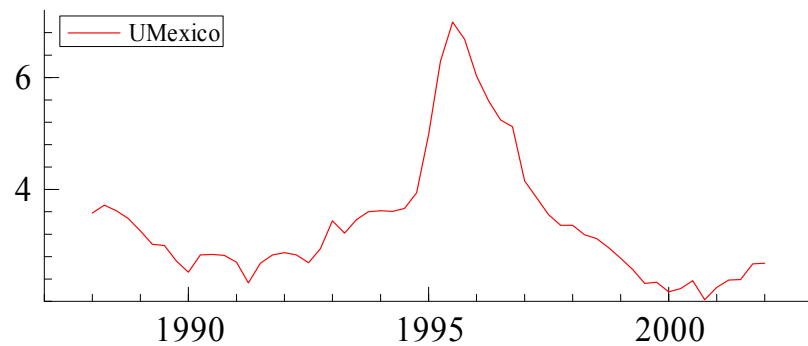
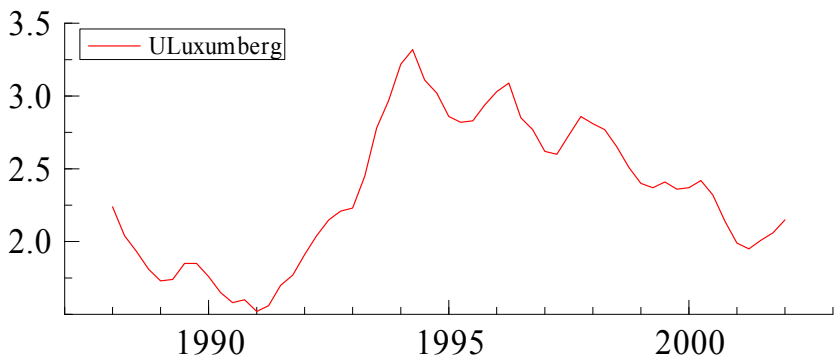
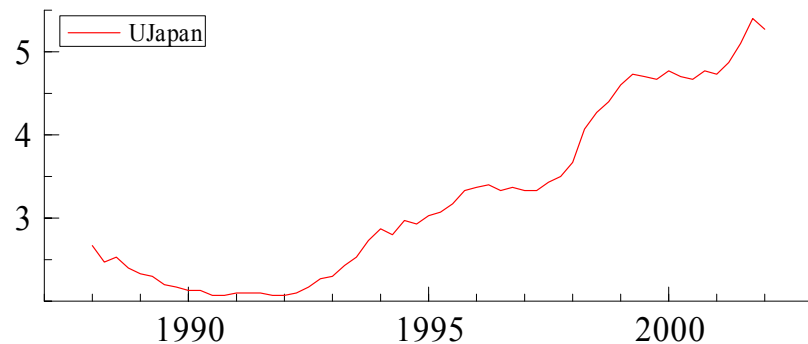
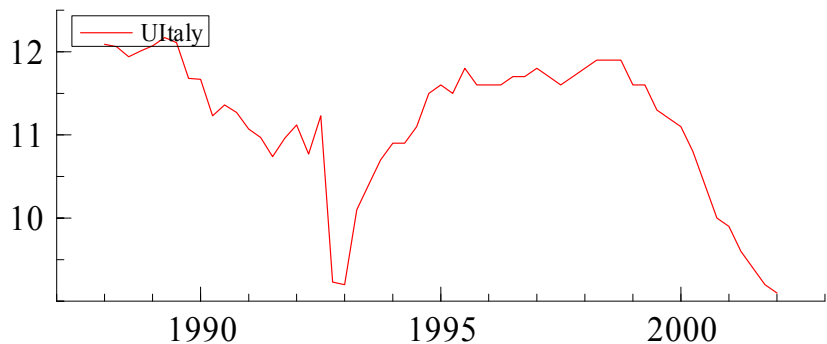
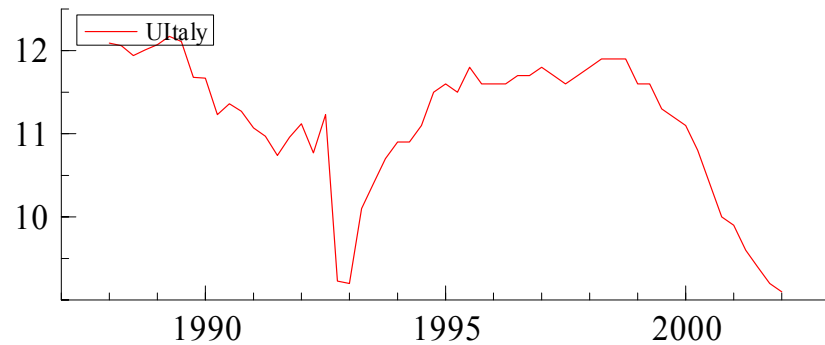
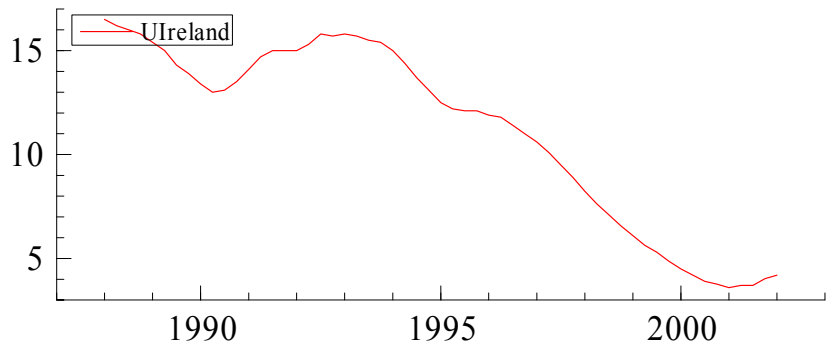
Unemployment Rates in OECD Economies: 1988:1-2002:1



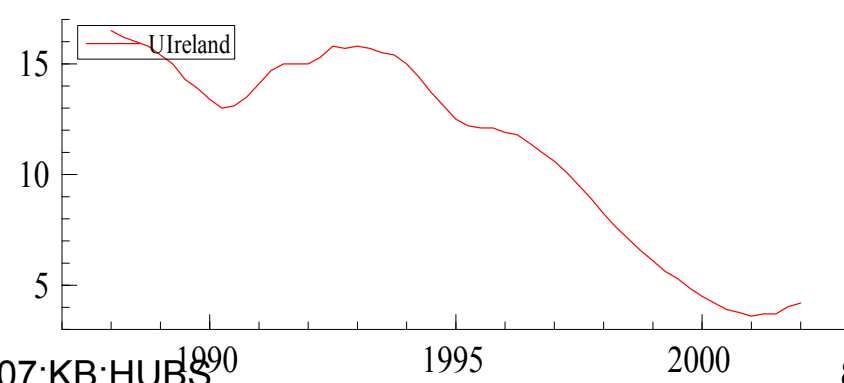
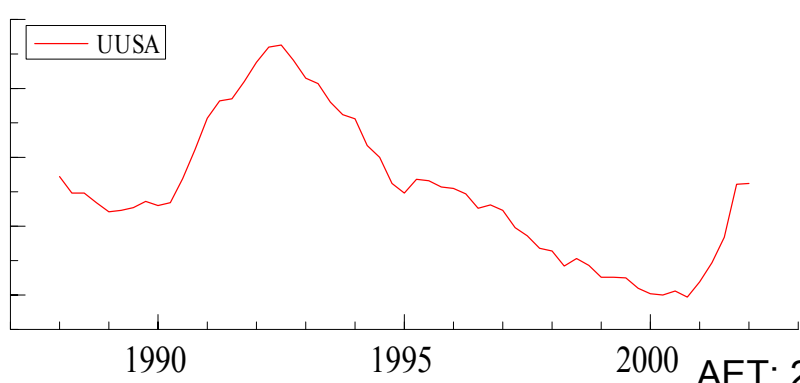
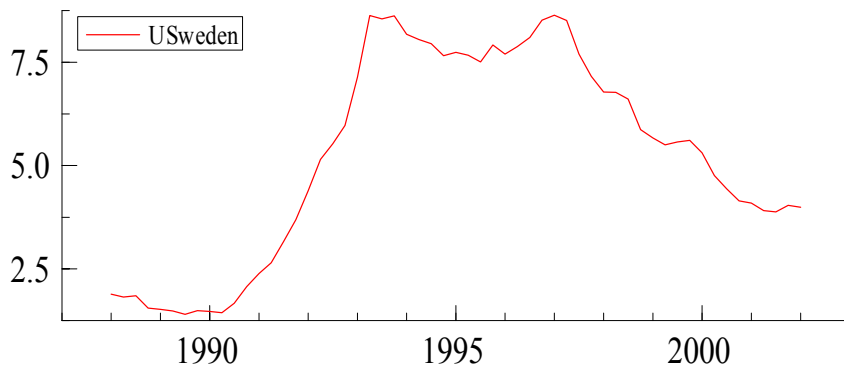
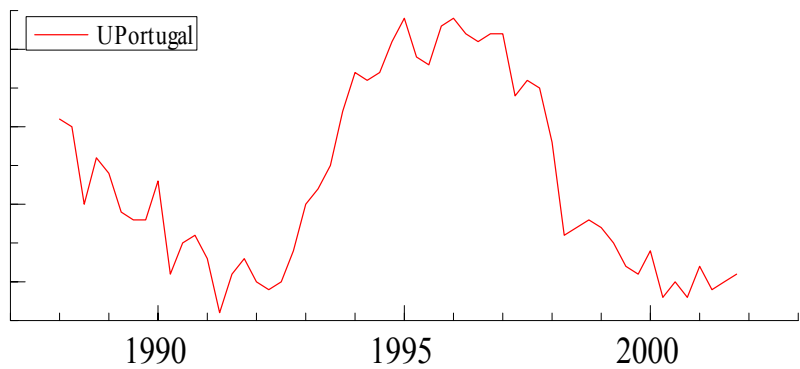
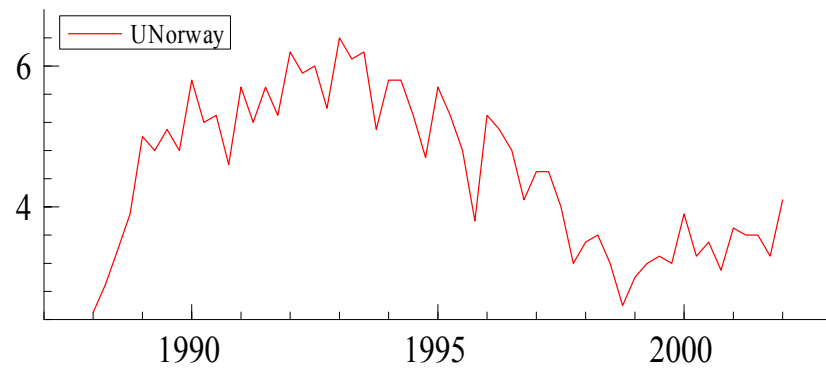
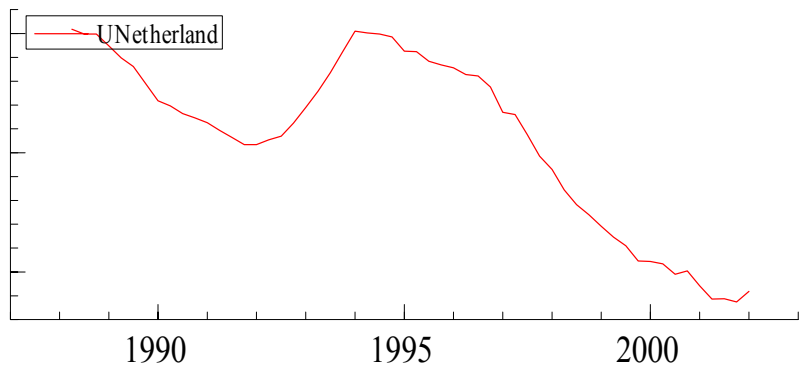
Unemployment Rates in OECD Economies: 1988:1-2002:1



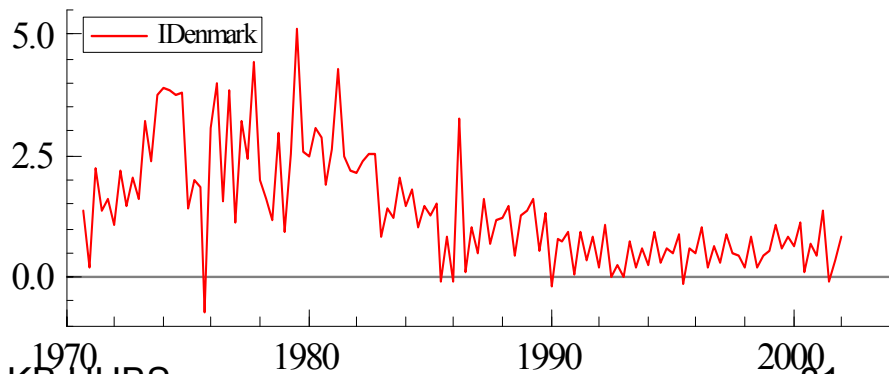
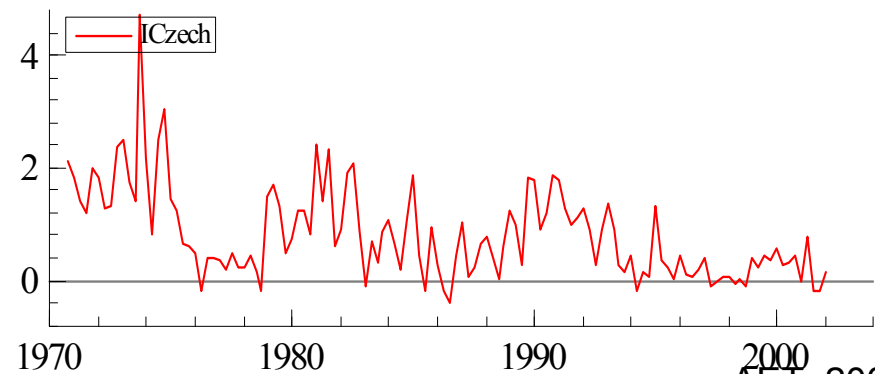
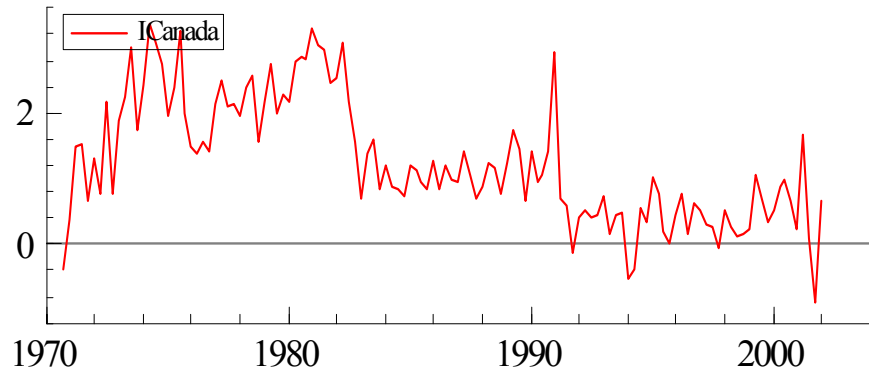
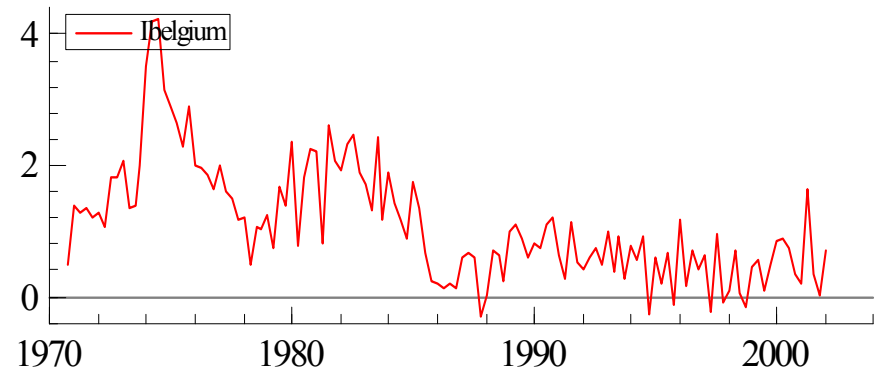
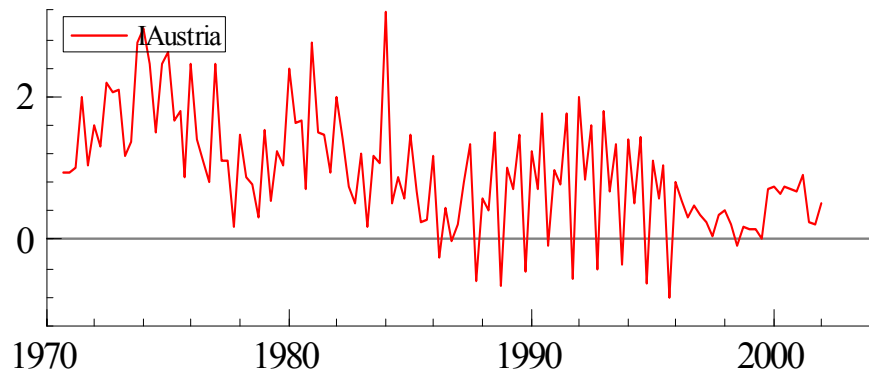
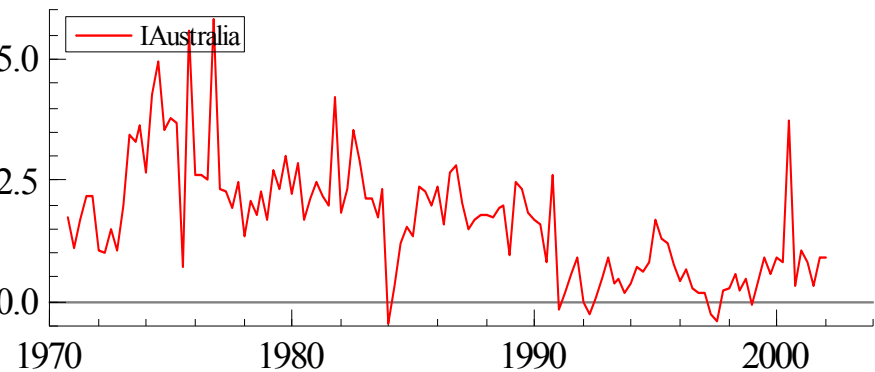
Unemployment Rates in OECD Economies: 1988:1-2002:1



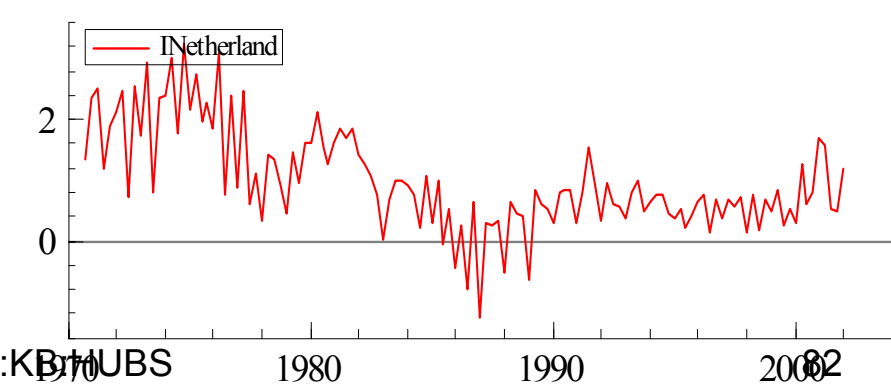
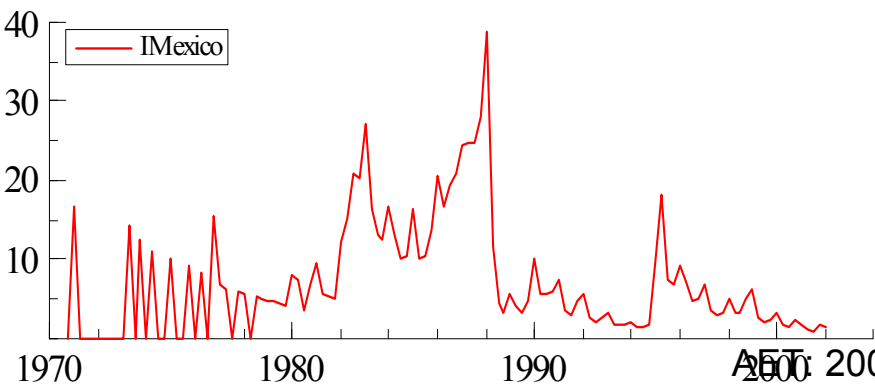
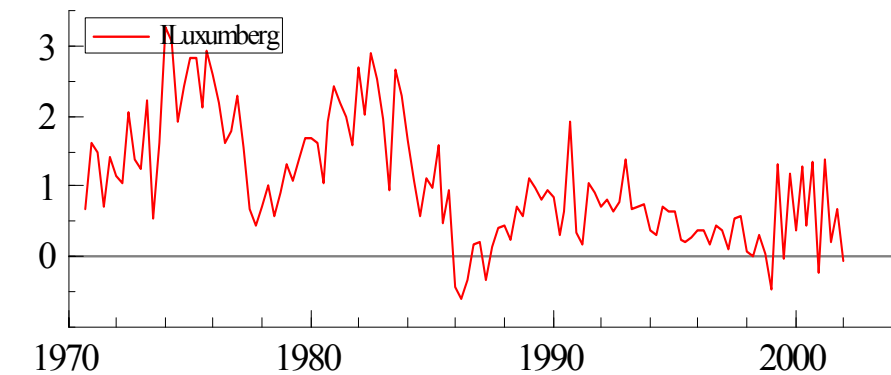
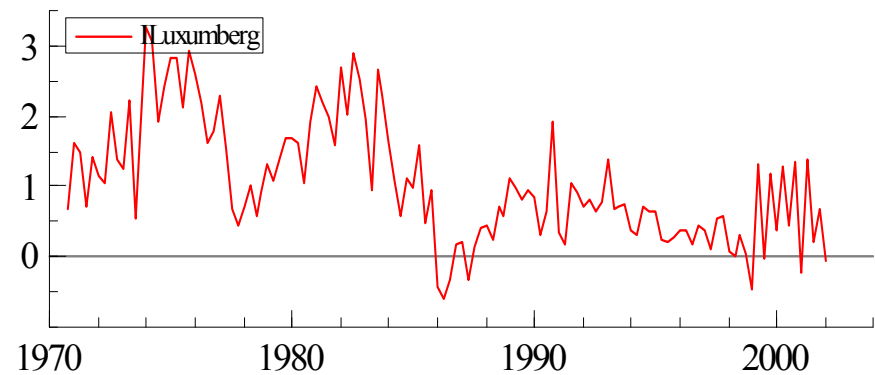
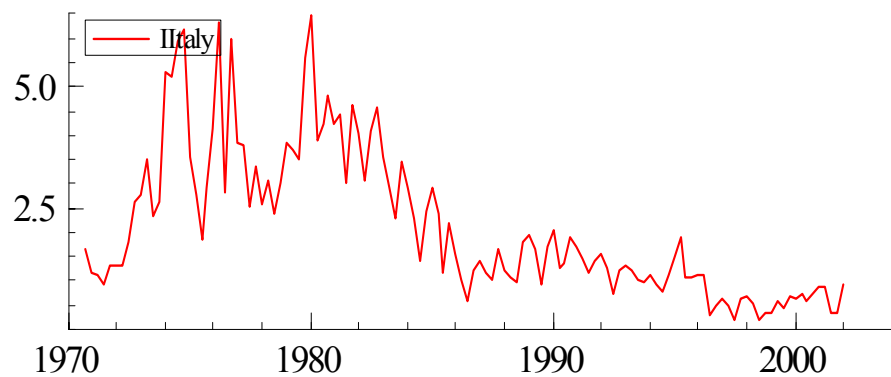
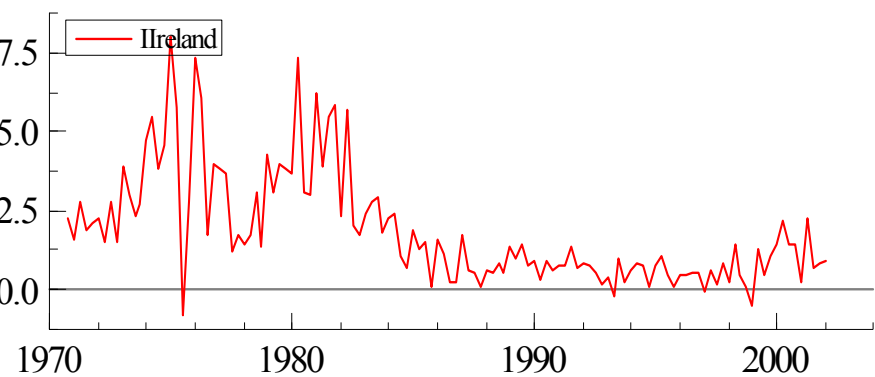
Unemployment Rates in OECD Economies: 1988:1-2002:1



Quarterly Inflation Rates in OECD Economies: 1970:1-2002:1

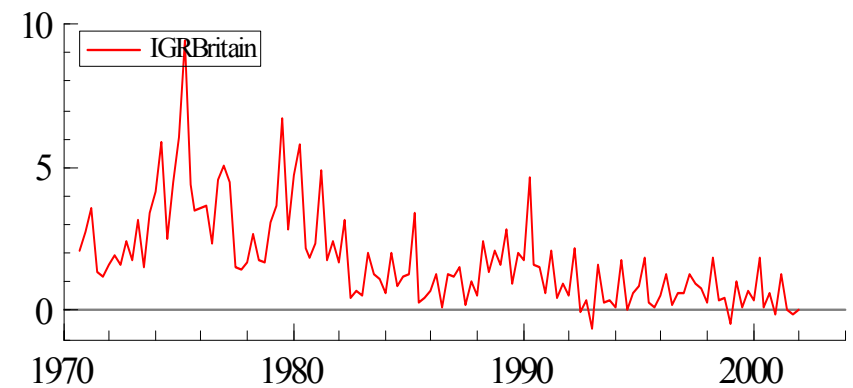
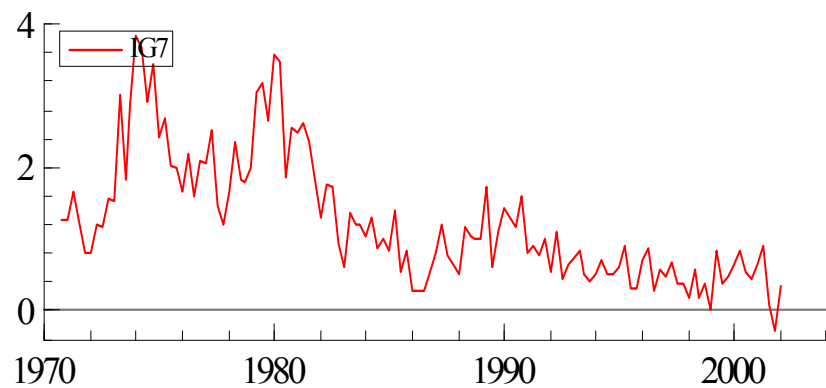
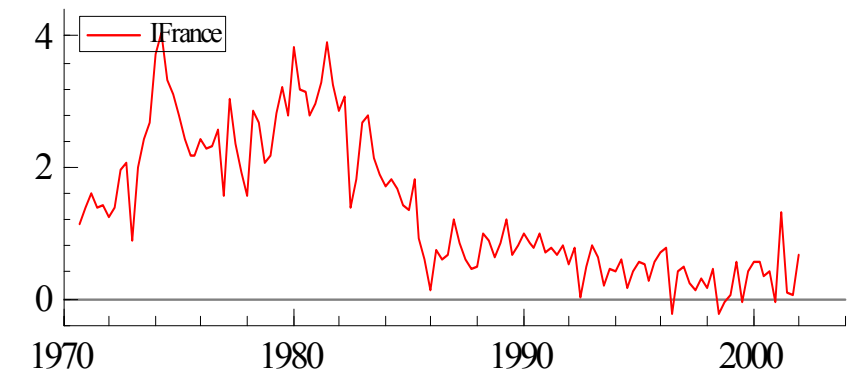
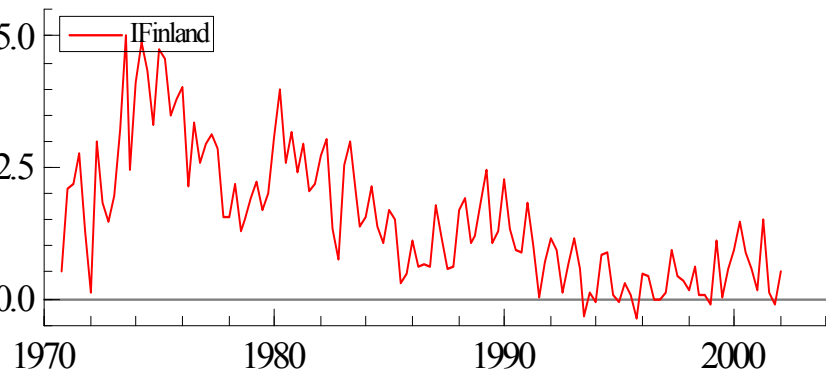
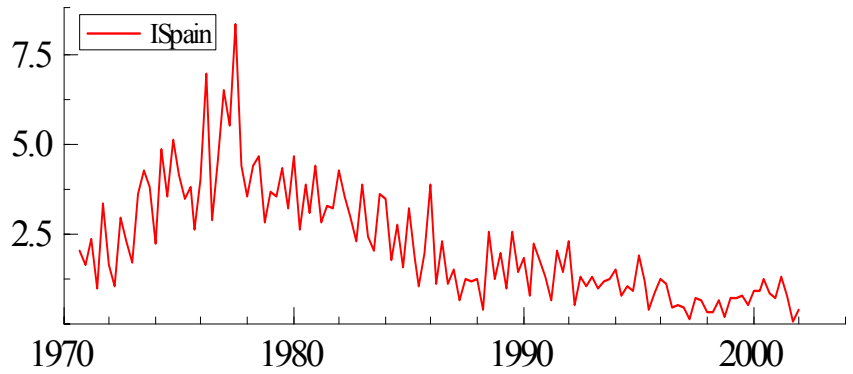
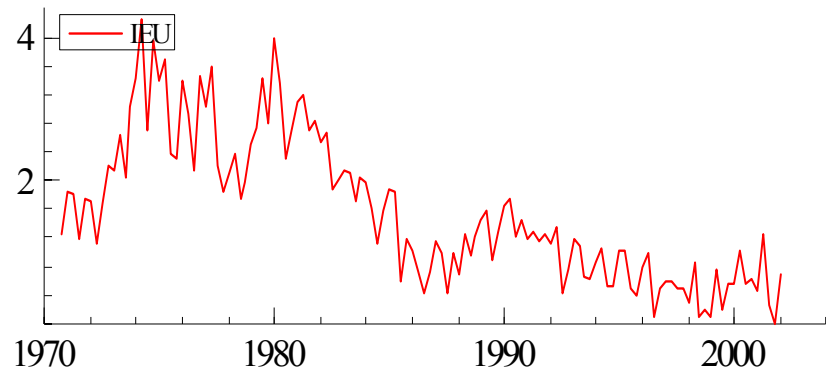


Quarterly Inflation Rates in OECD Economies: 1970:1-2002:1



2007:K10:BRUHS

Quarterly Inflation Rates in OECD Economies: 1970:1-2002:1



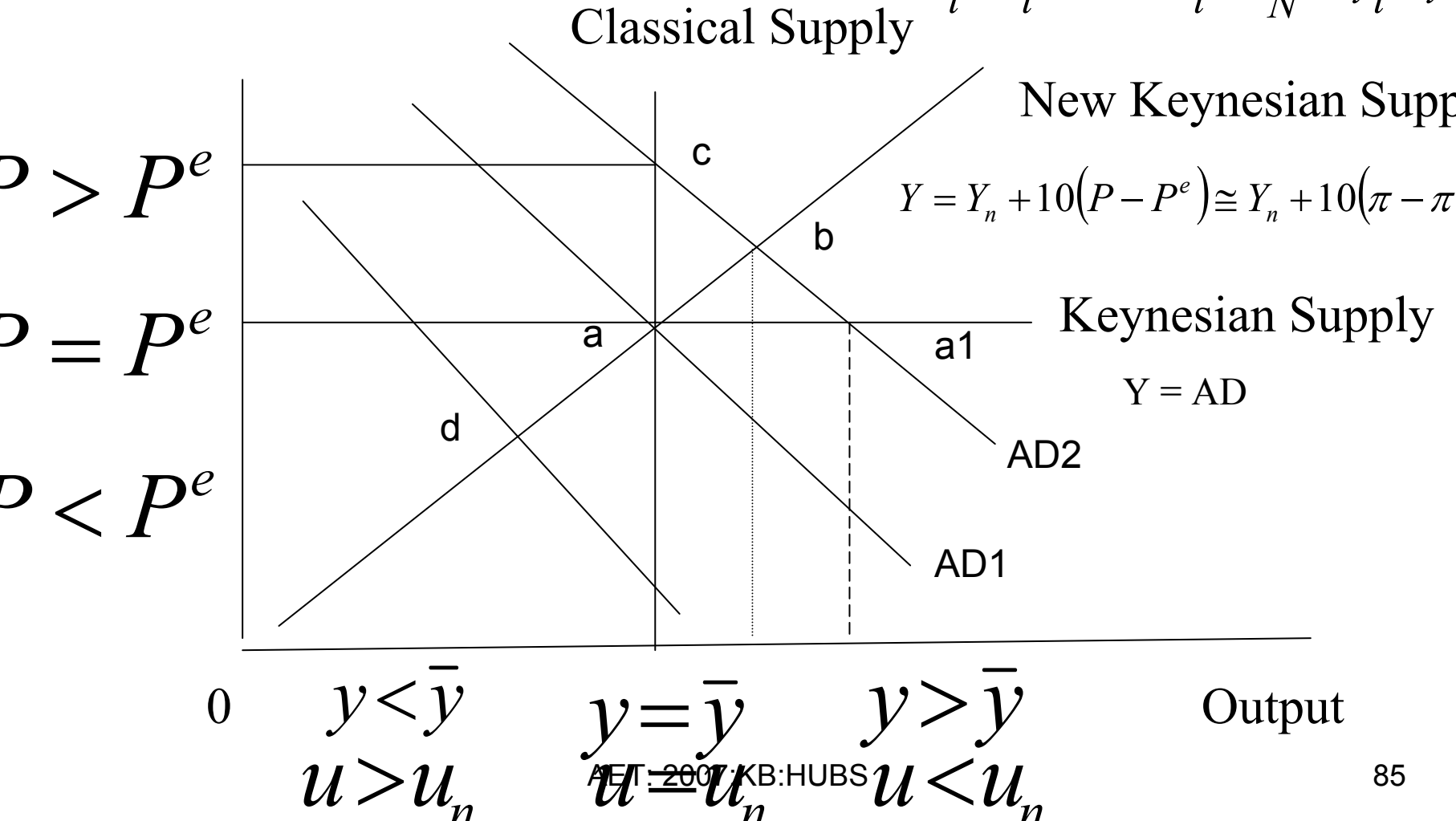
Classical, Keynesian and New Keynesian Aggregate Supply curves

Supply curves

$$P_t > P_t^e \Rightarrow u_t < u_N \Rightarrow y_t > \bar{y}$$

$$P_t < P_t^e \Rightarrow u_t > u_N \Rightarrow y_t < \bar{y}$$

$$P_t = P_t^e \Rightarrow u_t = u_N \Rightarrow y_t = \bar{y}$$



Specification of the Panel Data Model

$$u_{i,t} = \beta_{0,i,t} + \beta_{1,i,t} \pi_{i,t} + e_{i,t}$$

$$e_{i,t} \sim N(0, \sigma_i^2)$$

$$\beta_{1,OLS} = \frac{\sum_i \sum_t (\pi_{i,t} - \bar{\pi})(u_{i,t} - \bar{u})}{\sum_i \sum_t (\pi_{i,t} - \bar{\pi})^2} = \frac{t_{xy}}{t_{xx}}$$

$$y = \sum_i \sum_t (\pi_{i,t} - \bar{\pi})(u_{i,t} - \bar{u}) = \sum_i \sum_t (\pi_{i,t} - \bar{\pi}_i + \bar{\pi}_i - \bar{\pi})(u_{i,t} - \bar{u}_i + \bar{u}_i - \bar{u})$$

$$\sum_i \sum_t ((\pi_{i,t} - \bar{\pi}_i)(u_{i,t} - \bar{u}_i)) + T \sum_i (\bar{\pi}_i - \bar{\pi})(\bar{u}_i - \bar{u}) = W_{xy} + b_{xy}$$

Specification of the Panel Data Model

Between Group Effect

$$\hat{\beta}_b = \frac{\sum_t (\pi_{i,t} - \bar{\pi})(u_{i,t} - \bar{u})}{\sum_t (\pi_{i,t} - \bar{\pi})^2}$$

Within Group Effect

$$\hat{\beta}_W = \frac{\sum_i (\pi_{i,t} - \bar{\pi}_t)(u_{i,t}^t - \bar{u}_t)}{\sum_i (\pi_{i,t} - \bar{\pi}_t)^2}$$

$$t_{xx}\beta_{OLS} = t_{xy} = W_{xy} + b_{xy} = \hat{\beta}_W \frac{W_{xx}}{W_{xx} + b_{xx}} + \hat{\beta}_W \frac{b_{xx}}{W_{xx} + b_{xx}}$$

$$u_{i,t} = \alpha_{1,1}D_{1,i} + \alpha_{1,2}D_{2,i} + \dots + \alpha_{1,m}D_{m,i} + \alpha_{1,i}\pi_{i,t} + e_{i,t}$$

Dynamic Panel

$$u_{i,t} = \beta_{0,i,t} + \beta_{1,i,t}\pi_{i,t} + \gamma_{1,i}u_{i,t-1} + e_{i,t}$$

Determinants of Unemployment in OECD economies: Results from a Static Panel Data Model (OLS Estimation)

	Coefficient	Std.Error	t-value	t-prob
CPI	-0.0259	0.0010	-25.2000	0.0000
Australia	0.2600	0.0063	41.1000	0.0000
Austria	-0.1519	0.0039	-38.6000	0.0000
Belgium	-0.0252	0.0033	-7.7400	0.0000
Canada	0.0238	0.0004	58.8000	0.0000
Check Rep.	-0.2657	0.0052	-51.4000	0.0000
Denmark	0.2006	0.0000	5525.0000	0.0000
EU	0.2218	0.0053	42.0000	0.0000
Spain	0.6856	0.0117	58.6000	0.0000
Finland	0.2310	0.0030	76.9000	0.0000
France	0.1317	0.0014	96.6000	0.0000
Germany	0.0372	0.0001	432.0000	0.0000
Great Britain	0.4365	0.0059	74.0000	0.0000
Ireland	0.5869	0.0037	157.0000	0.0000
Italy	0.5947	0.0114	52.2000	0.0000
Japan	-0.0560	0.0100	-5.6100	0.0000
Luxumberg	-0.0798	0.0031	-25.6000	0.0000
Mexico	5.3772	0.0162	332.0000	0.0000
Netherland	0.0019	0.0085	0.2280	0.8200
Norway	0.1489	0.0033	45.5000	0.0000
NewZealand	0.4810	0.0095	50.8000	0.0000
Portugal	1.3950	0.0201	69.3000	0.0000
Sweden	0.0697	0.0086	8.1100	0.0000
USA	0.0000			
Constant	3.0476	0.0728	41.9000	0.0000

Sigma	1.766	sigma^2	3.119479
R^2	0.427		
RSS	9105.759	TSS	15881.454959
no. of observations	2944	no. of parameters	25

unemployment rate and inflation:

results from the Dynamic Panel Estimation from the OECD economies (GMM estimation)

	Coefficient	Std.Error	t-value	t-prob
Unemp(-1)	0.3947	0.1049	3.7600	0.0000
Time(-1)	0.0334	0.0032	10.3000	0.0000
Australia	-0.1658	0.0112	-14.7000	0.0000
Austria	0.1740	0.0156	11.1000	0.0000
Belgium	0.1706	0.0171	9.9600	0.0000
Canada	0.0262	0.0045	5.7800	0.0000
Che	0.2357	0.0221	10.7000	0.0000
Denmark	0.0839	0.0143	5.8900	0.0000
EU	-0.1230	0.0079	-15.6000	0.0000
Spain	-0.1886	0.0178	-10.6000	0.0000
Finland	0.0036	0.0106	0.3380	0.7350
France	0.0451	0.0117	3.8600	0.0000
Germany	0.0368	0.0063	5.8300	0.0000
Great Britain	-0.0716	0.0132	-5.4100	0.0000
Ireland	0.0443	0.0254	1.7400	0.0820
Italy	-0.2162	0.0156	-13.9000	0.0000
Japan	0.5464	0.0612	8.9300	0.0000
Luxumberg	0.1478	0.0150	9.8400	0.0000
Mexico	1.2529	0.2865	4.3700	0.0000
Netherland	0.3800	0.0370	10.3000	0.0000
Norway	-0.0797	0.0051	-15.5000	0.0000
NewZealand	-0.1538	0.0144	-10.6000	0.0000
Portugal	-0.1331	0.0538	-2.4700	0.0130
Sweden	-0.2738	0.0216	-12.7000	0.0000
USA	0.0000			
CPI	1.0005	0.1682	5.9500	0.0000
CPI(-1)	-1.0557	0.1741	-6.0600	0.0000
Constant	1.7581	0.2570	6.8400	0.0000

Sigma	1.266	Singma ²	1.603	
R ²	0.7075527			
RSS	4638.684	TSS	15861.609	
no. of observations	2921 no.	No.of parameters		

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