Time Series Econometrics: Some Basic Concepts

Non-Stationary Variables

Outline

Stationary: What & Why?

1. What & Why
2. How to Test Stationarity
3. How to overcome Non-Stationarity

Spurious Regression

Cointegration and Error Correction Model

Stationary

- Data: Stationary and Non Stationary
- Stationary: The mean, variance and covariance is constant and time invariant
  - E.g. let's $\mathbf{Y_t}$ be a stochastic process, then;
  - **Mean:** $E(Y_t) = \mu$ .... (1)
  - **Variance:** $var(Y_t) = E(Y_t - \mu)^2 = \sigma^2$ .... (2)
  - **Covariance:** $\gamma_k = E[(Y_t - \mu)(Y_{t+k} - \mu)]$ .... (3)
    - Where γ_k, the covariance (or auto-covariance) at lag k,
    - If $k = 0$, we obtain γ_0, which is simply the variance of Y ($= \sigma^2$); if $k = 1$, γ_1 is the covariance between two adjacent values of Y

Non-stationary

- The mean and variance is time varying or not constant:

✓ Random walk without drift (increasing in variance - $\mathbf{Y_t = Y_{t-1} + u_t}$)

✓Random walk with drift (variance and mean is not constant

$Y_t = \delta + Y_{t-1} + u_t$)

✓Random walk with drift around a stochastic trend ($Y_t = \beta_1 + \beta_2 t + Yt_{-1} + ut$)

Why?

- If the data is not stationary, than the OLS estimation is bias because the mean and the variance is time varying and not constant

➢ Unable to make prediction about the relationship among dependent and independent variables

➢ Unable to perform forecasting for short term and also for the long term.

Unit Root Test – Three Types

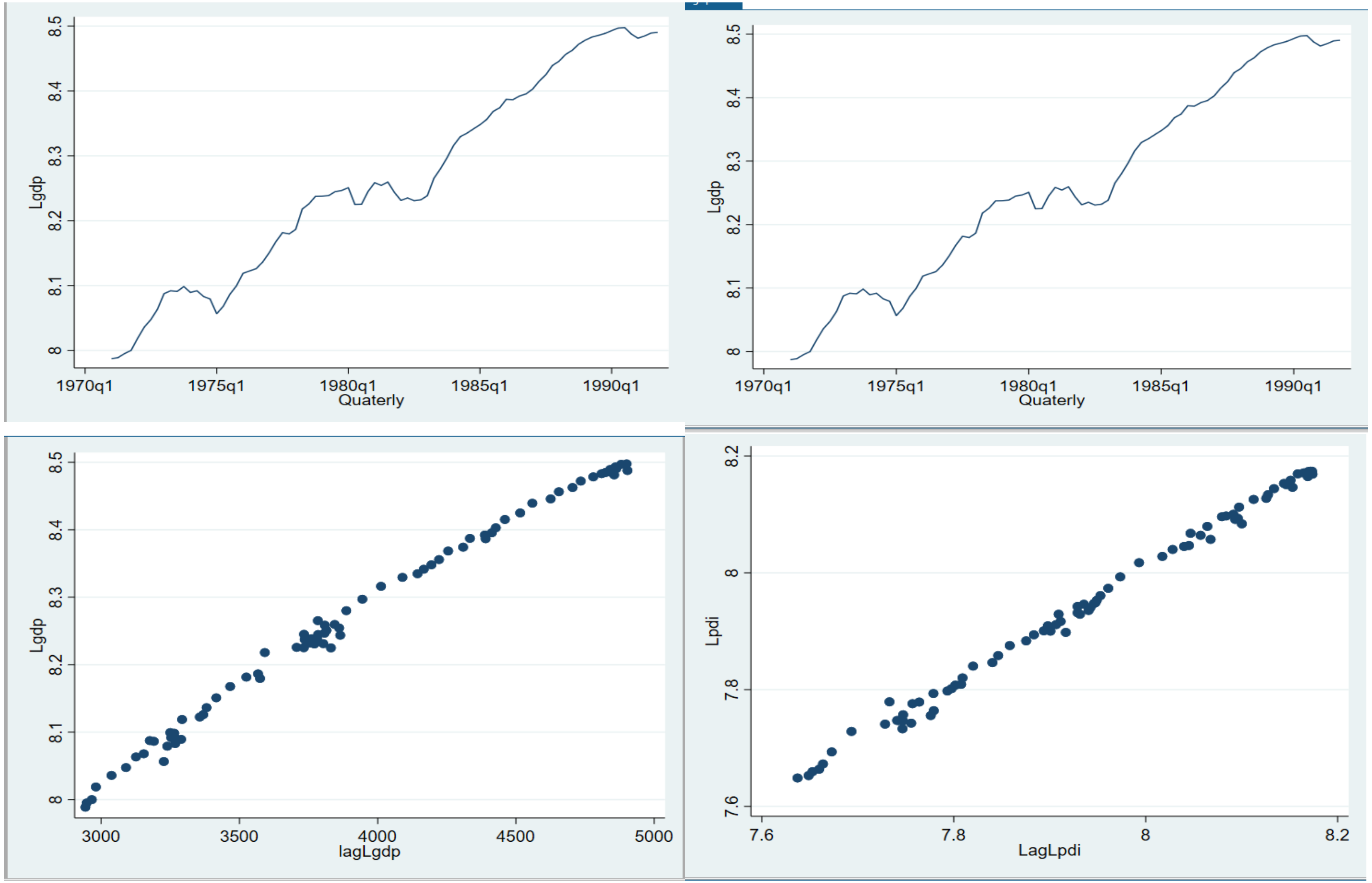
- By graphical analysis – Plot the graph whether to see the trend has change or has a constant variation
- Autocorrelation function (ACF) - Box–Pierce *Q* statistic
- Unit Root Test

i. Augmented Dickey Fuller Test (ADF)

How to detect stationary and non stationary

- In practice we face two important questions:
  - How do we find out if a given time series is stationary or not?
  - Is there a way that it can be made stationary?
- Prominently discussed tests in the literature are:
  - Graphical Analysis
  - The Unit Root Test

Graphical approach LGDP and LPDI



Autocorrelation Function (ACF)-significant test

- **Q test – the standard error test**
- Hypothesis
- H_0: $\rho_k = 0$ (stationary)
- H_a: $\rho_k \neq 0$ (nonstationary)
- K = lag
- Critical value **α** = 5%
- $-1.96(se) < \rho_k < 1.96(se) = -1.96\left(\sqrt{\frac{1}{n}}\right) < \rho_k < 1.96\left(\sqrt{\frac{1}{n}}\right).\, n = high\ observations$
- If the statistic Q < $\chi^2(\alpha)$ do not reject H null, mean the time series is stationary

Autocorrelation Function (ACF) for LGDP

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Series: LGDP Workfile: TIME SERIES PART 1::Untitled\

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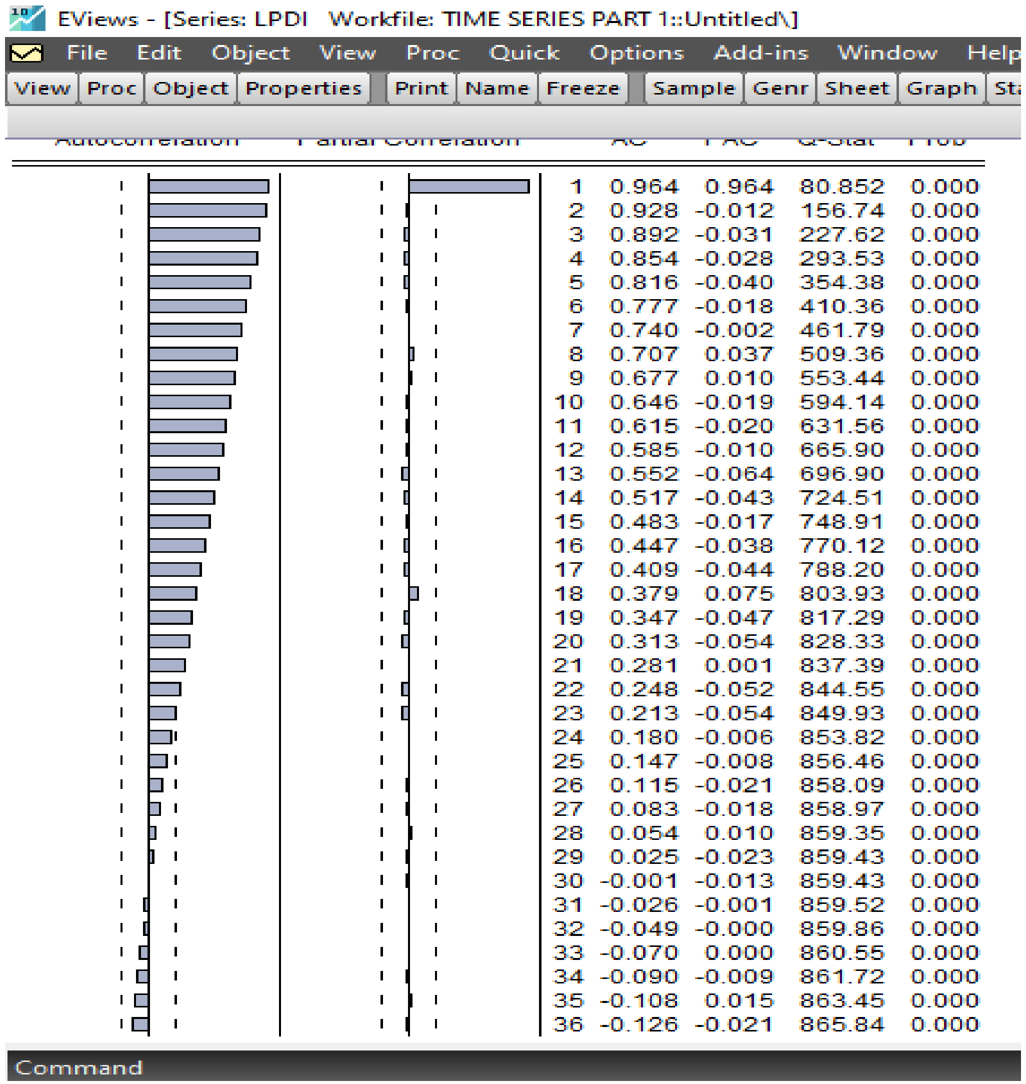
Correlogram of LGDP

Date: 07/11/21 Time: 19:00
Sample: 1971Q1 1991Q4
Included observations: 84

	AC	PAC	Q-Stat	Prob
1	0.965	0.965	81.085	0.000
2	0.928	-0.056	156.92	0.000
3	0.890	-0.029	227.50	0.000
4	0.851	-0.030	292.85	0.000
5	0.812	-0.016	353.15	0.000
6	0.773	-0.024	408.53	0.000
7	0.735	-0.017	459.19	0.000
8	0.698	0.001	505.48	0.000
9	0.665	0.033	548.06	0.000
10	0.632	-0.027	587.00	0.000
11	0.597	-0.040	622.29	0.000
12	0.563	-0.020	654.05	0.000
13	0.527	-0.037	682.33	0.000
14	0.492	-0.013	707.34	0.000
15	0.456	-0.041	729.14	0.000
16	0.420	-0.023	747.88	0.000
17	0.380	-0.080	763.46	0.000
18	0.342	0.009	776.28	0.000
19	0.307	0.004	786.76	0.000
20	0.274	0.004	795.22	0.000
21	0.243	-0.001	801.98	0.000
22	0.211	-0.042	807.16	0.000
23	0.178	-0.034	810.92	0.000
24	0.146	-0.025	813.50	0.000
25	0.117	0.006	815.16	0.000
26	0.089	0.002	816.14	0.000
27	0.064	0.016	816.65	0.000
28	0.038	-0.035	816.84	0.000
29	0.013	-0.013	816.86	0.000
30	-0.008	0.030	816.87	0.000
31	-0.028	-0.012	816.97	0.000
32	-0.046	0.002	817.27	0.000
33	-0.063	-0.002	817.82	0.000
34	-0.078	-0.002	818.70	0.000
35	-0.092	-0.001	819.93	0.000
36	-0.102	0.017	821.51	0.000

For LGDP, the value of the Q statistic up to lag 36 is about 821.51 The probability of obtaining such a Q value under the null hypothesis that the sum of 36 squared estimated autocorrelation coefficients is zero is practically zero show the that LGDP is nonstationary

ACF for LPDI



	AC	PAC	Q-Stat	Prob
1	0.964	0.964	80.852	0.000
2	0.928	-0.012	156.74	0.000
3	0.892	-0.031	227.62	0.000
4	0.854	-0.028	293.53	0.000
5	0.816	-0.040	354.38	0.000
6	0.777	-0.018	410.36	0.000
7	0.740	-0.002	461.79	0.000
8	0.707	0.037	509.36	0.000
9	0.677	0.010	553.44	0.000
10	0.646	-0.019	594.14	0.000
11	0.615	-0.020	631.56	0.000
12	0.585	-0.010	665.90	0.000
13	0.552	-0.064	696.90	0.000
14	0.517	-0.043	724.51	0.000
15	0.483	-0.017	748.91	0.000
16	0.447	-0.038	770.12	0.000
17	0.409	-0.044	788.20	0.000
18	0.379	0.075	803.93	0.000
19	0.347	-0.047	817.29	0.000
20	0.313	-0.054	828.33	0.000
21	0.281	0.001	837.39	0.000
22	0.248	-0.052	844.55	0.000
23	0.213	-0.054	849.93	0.000
24	0.180	-0.006	853.82	0.000
25	0.147	-0.008	856.46	0.000
26	0.115	-0.021	858.09	0.000
27	0.083	-0.018	858.97	0.000
28	0.054	0.010	859.35	0.000
29	0.025	-0.023	859.43	0.000
30	-0.001	-0.013	859.43	0.000
31	-0.026	-0.001	859.52	0.000
32	-0.049	-0.000	859.86	0.000
33	-0.070	0.000	860.55	0.000
34	-0.090	-0.009	861.72	0.000
35	-0.108	0.015	863.45	0.000
36	-0.126	-0.021	865.84	0.000

- For LPDI, the value of the *Q* statistic up to lag 36 is about 865.84 The probability of obtaining such a *Q* value under the null hypothesis that the sum of 36 squared estimated autocorrelation coefficients is zero is practically zero – show the that LPDI is nonstationary

Perform Unit Root Test to Test For Stationarity: Augmented Dickey Fuller Test

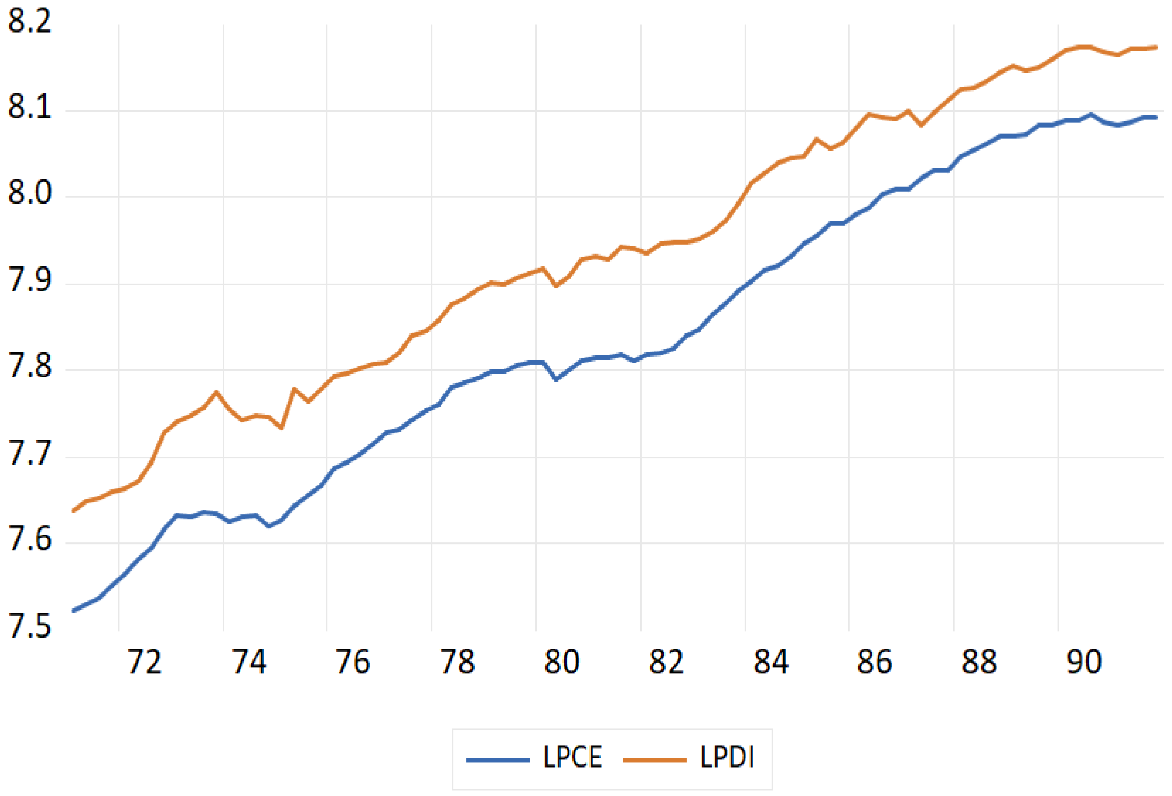
- H null: Series has unit root (meaning series is non-stationarity)
- Series assumptions (your decision-Augmented Dickey Fuller Approach):

1. Constant (i.e intercept) ($\Delta \boldsymbol{Y}_{\boldsymbol{t-1}} = \boldsymbol{\alpha} + \boldsymbol{\delta} \boldsymbol{Y}_{\boldsymbol{t-1}} + \boldsymbol{\varepsilon}_{\boldsymbol{t}}$)
2. Constant and trend ($\Delta \boldsymbol{Y}_{\boldsymbol{t-1}} = \boldsymbol{\alpha} + \boldsymbol{\alpha}_{\boldsymbol{2}} \boldsymbol{t} + \boldsymbol{Y}_{\boldsymbol{t-1}} + \boldsymbol{\varepsilon}_{\boldsymbol{t}}$)
3. None ($\Delta \boldsymbol{Y}_{\boldsymbol{t-1}} = \boldsymbol{Y}_{\boldsymbol{t-1}} + \boldsymbol{\varepsilon}_{\boldsymbol{t}}$)

$$\Delta \boldsymbol{Y}_{\boldsymbol{t}} = \boldsymbol{\alpha} + \emptyset \boldsymbol{t} + \boldsymbol{\gamma}^{\boldsymbol{c}} \boldsymbol{Y}_{\boldsymbol{t-1}} + \sum_{\boldsymbol{i=1}}^{\boldsymbol{n}} \emptyset \Delta \boldsymbol{Y}_{\boldsymbol{t-i}} + \boldsymbol{\varepsilon}$$

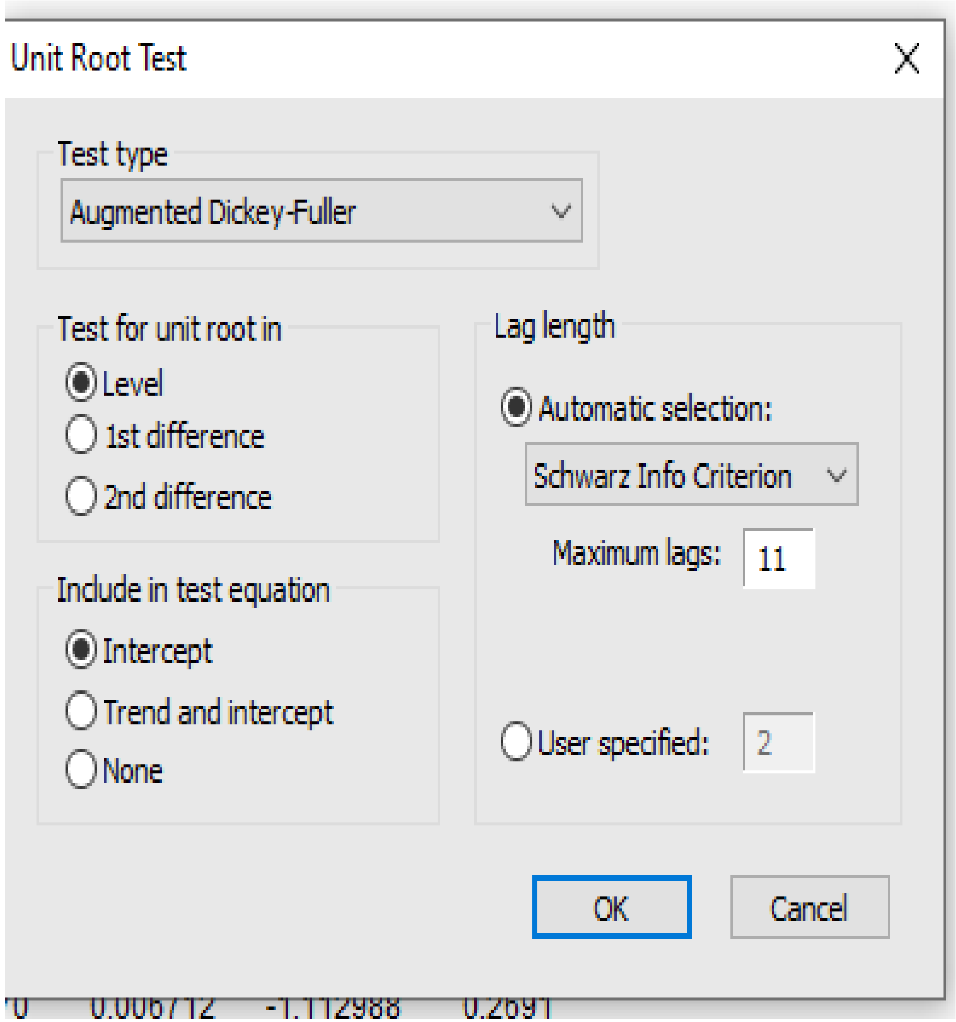
- If H null is accepted (i.e series has a unit root), it must be differenced to see if stationarity is achieved after 1st differencing

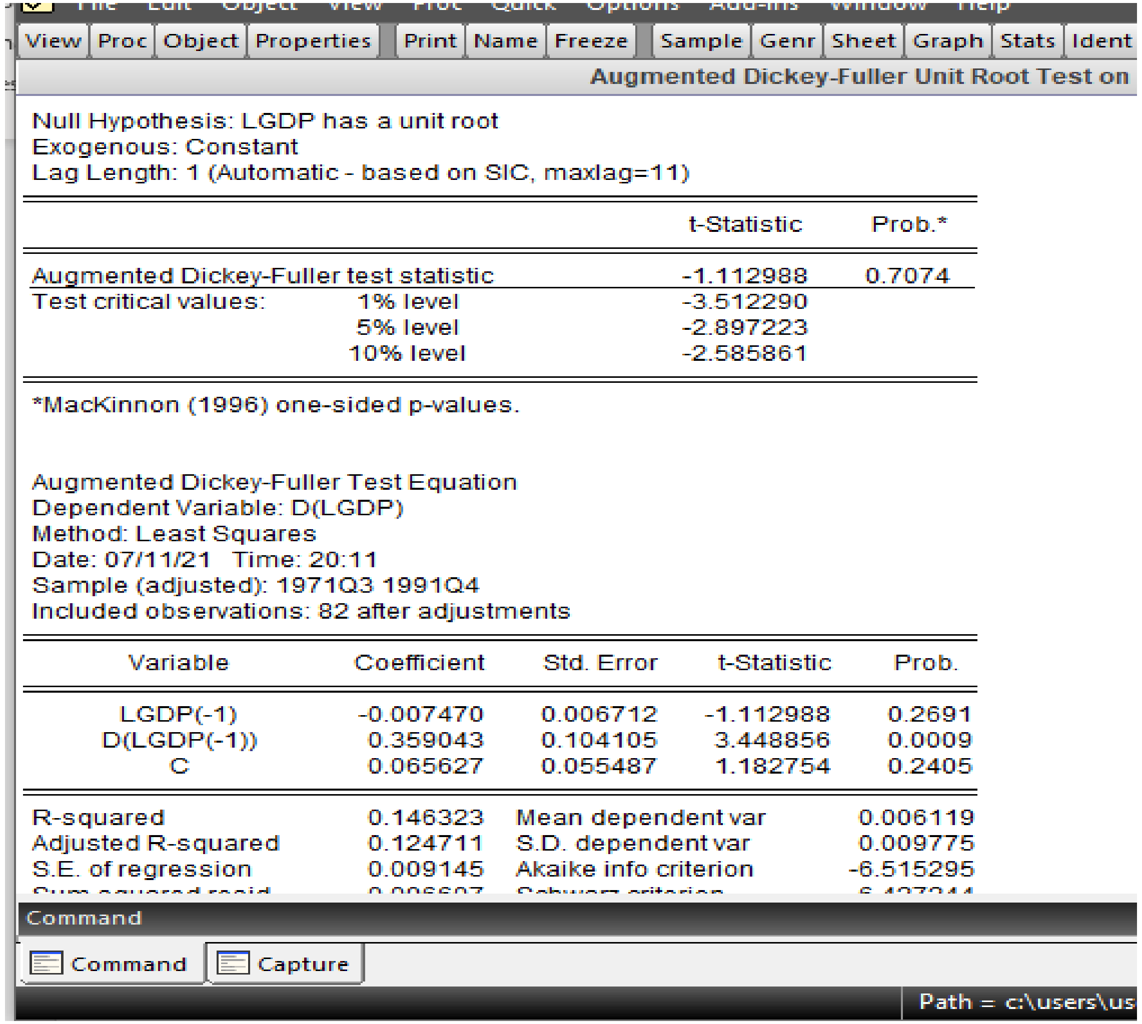
Visualize to determine the your decision:



- The LGDP and LPDI seems o be drifting or a drift - but not a deterministic trends

The ADF test – at level for LGDP





Null Hypothesis: LGDP has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.112988	0.7074
Test critical values:	1% level	-3.512290	
	5% level	-2.897223	
	10% level	-2.585861	

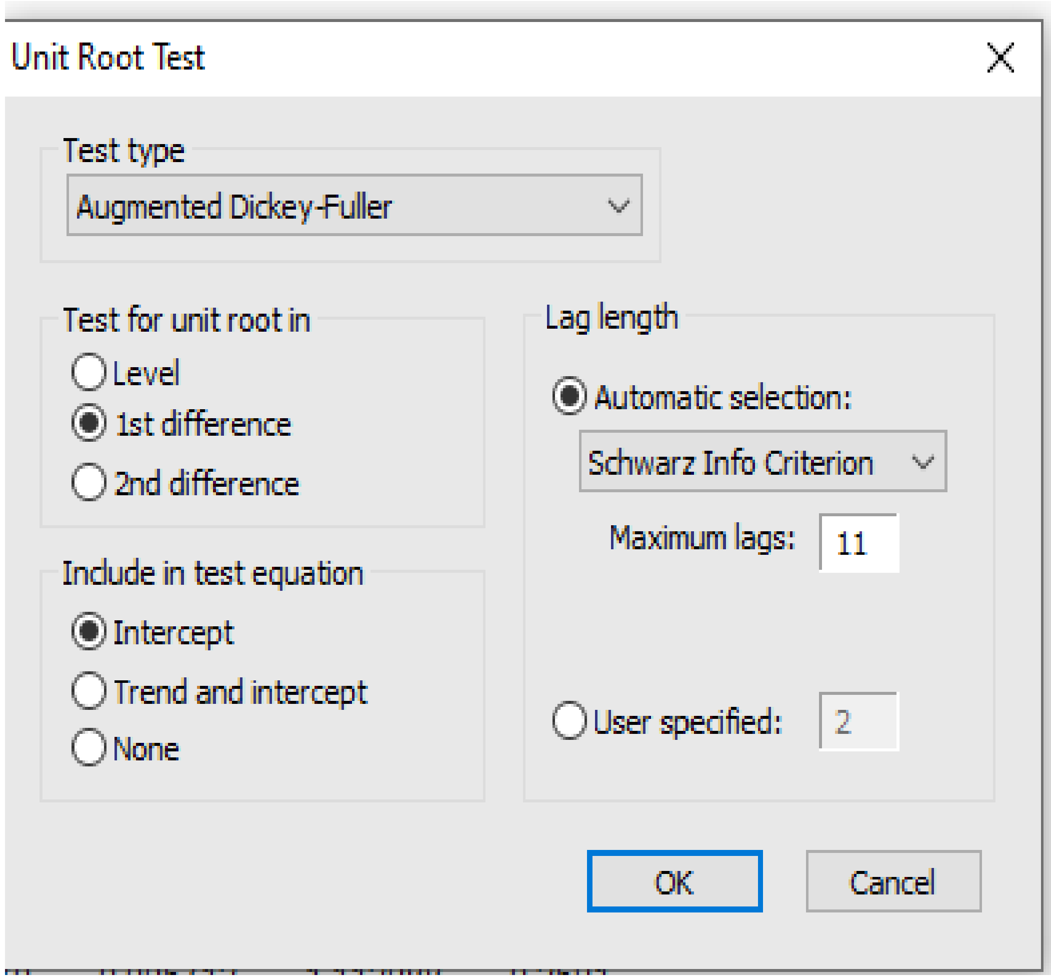
*MacKinnon (1996) one-sided p-values.

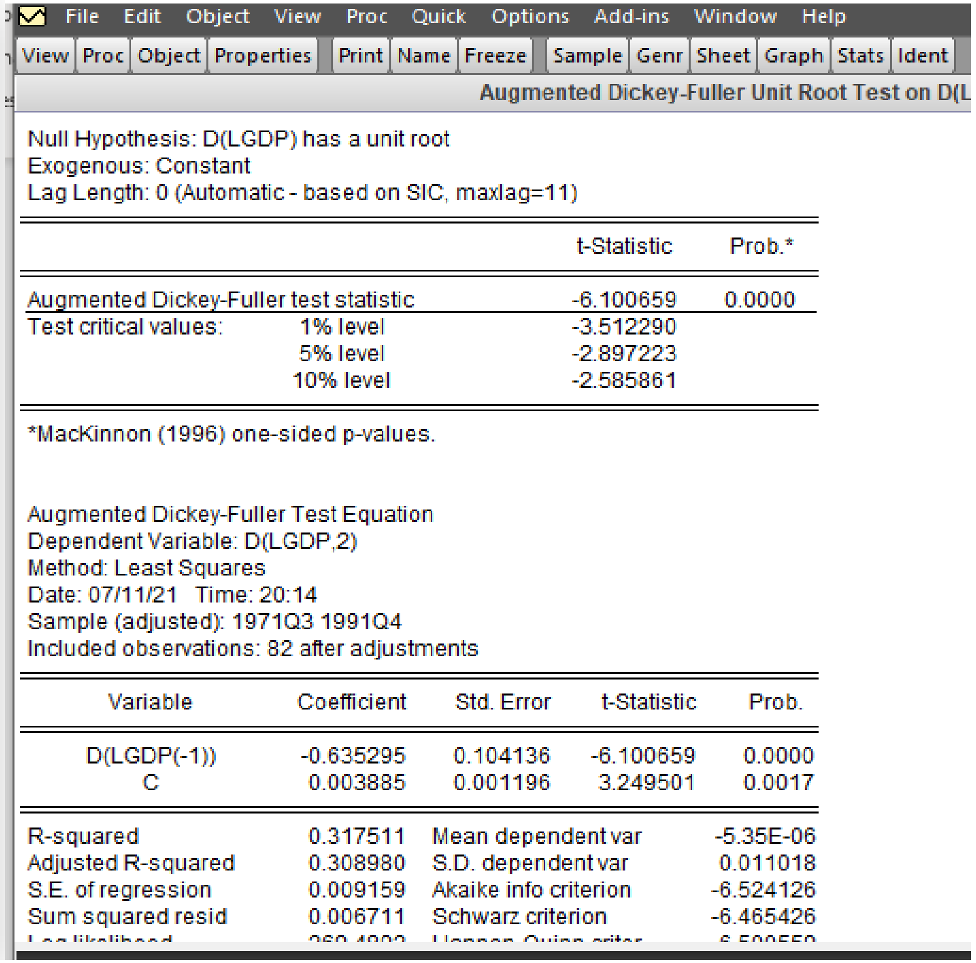
Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LGDP)
Method: Least Squares
Date: 07/11/21 Time: 20:11
Sample (adjusted): 1971Q3 1991Q4
Included observations: 82 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LGDP(-1)	-0.007470	0.006712	-1.112988	0.2691
D(LGDP(-1))	0.359043	0.104105	3.448856	0.0009
C	0.065627	0.055487	1.182754	0.2405

R-squared	0.146323	Mean dependent var	0.006119
Adjusted R-squared	0.124711	S.D. dependent var	0.009775
S.E. of regression	0.009145	Akaike info criterion	-6.515295

The ADF test – First Difference for LGDP





Augmented Dickey-Fuller Unit Root Test on D(L

Null Hypothesis: D(LGDP) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.100659	0.0000
Test critical values:	1% level	-3.512290	
	5% level	-2.897223	
	10% level	-2.585861	

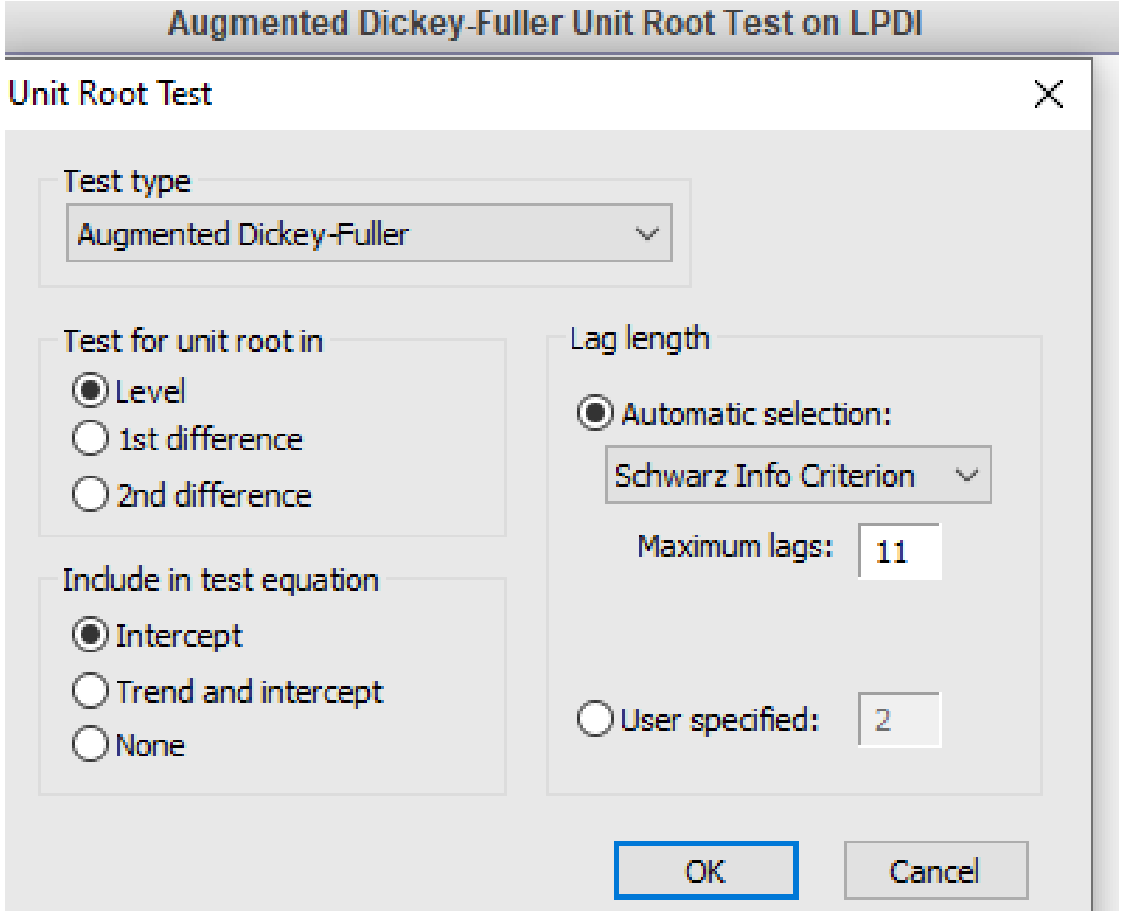
*MacKinnon (1996) one-sided p-values.

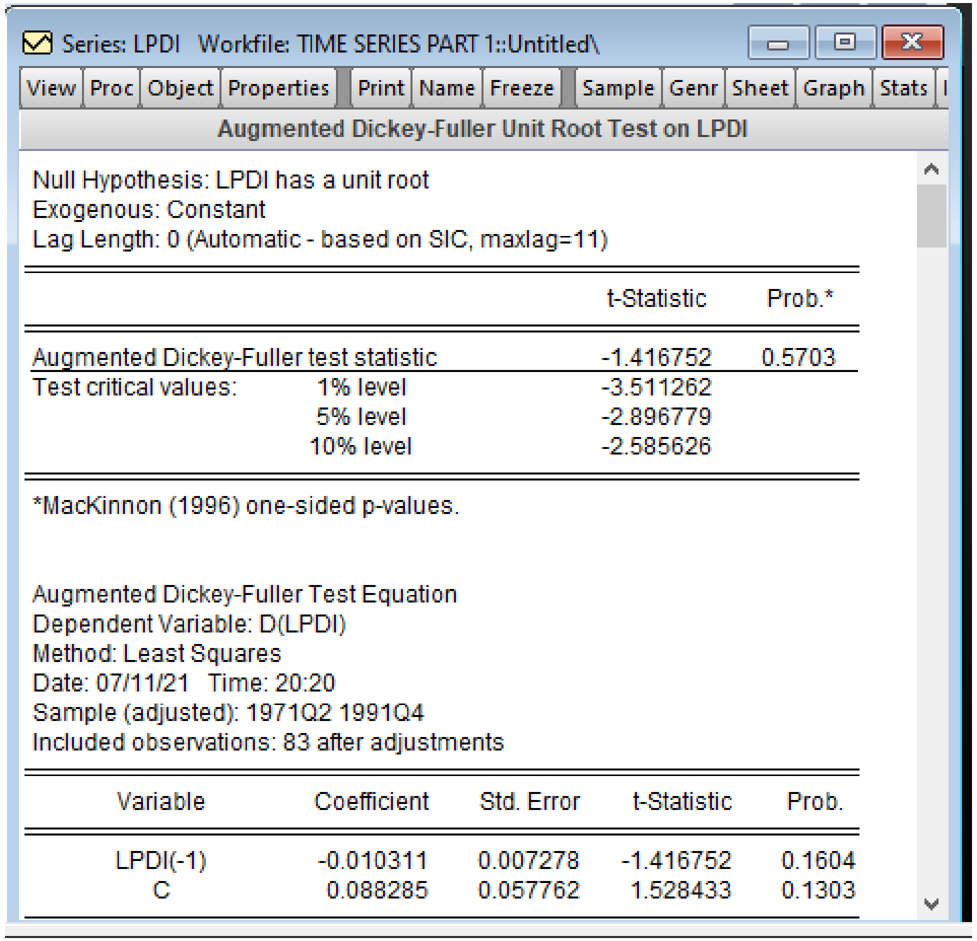
Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LGDP,2)
Method: Least Squares
Date: 07/11/21 Time: 20:14
Sample (adjusted): 1971Q3 1991Q4
Included observations: 82 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LGDP(-1))	-0.635295	0.104136	-6.100659	0.0000
C	0.003885	0.001196	3.249501	0.0017

R-squared	0.317511	Mean dependent var	-5.35E-06
Adjusted R-squared	0.308980	S.D. dependent var	0.011018
S.E. of regression	0.009159	Akaike info criterion	-6.524126
Sum squared resid	0.006711	Schwarz criterion	-6.465426

ADF test – LPDI at Level





Augmented Dickey-Fuller Unit Root Test on LPDI

Null Hypothesis: LPDI has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=11)

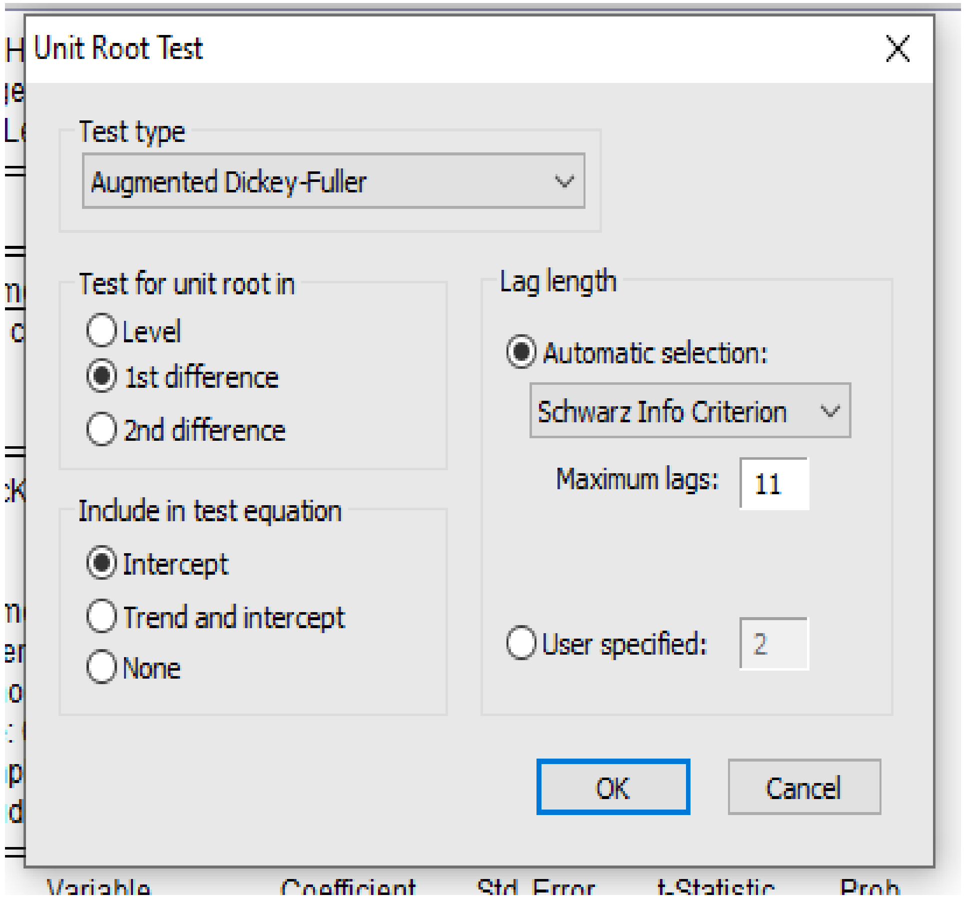
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.416752	0.5703
Test critical values:	1% level	-3.511262	
	5% level	-2.896779	
	10% level	-2.585626	

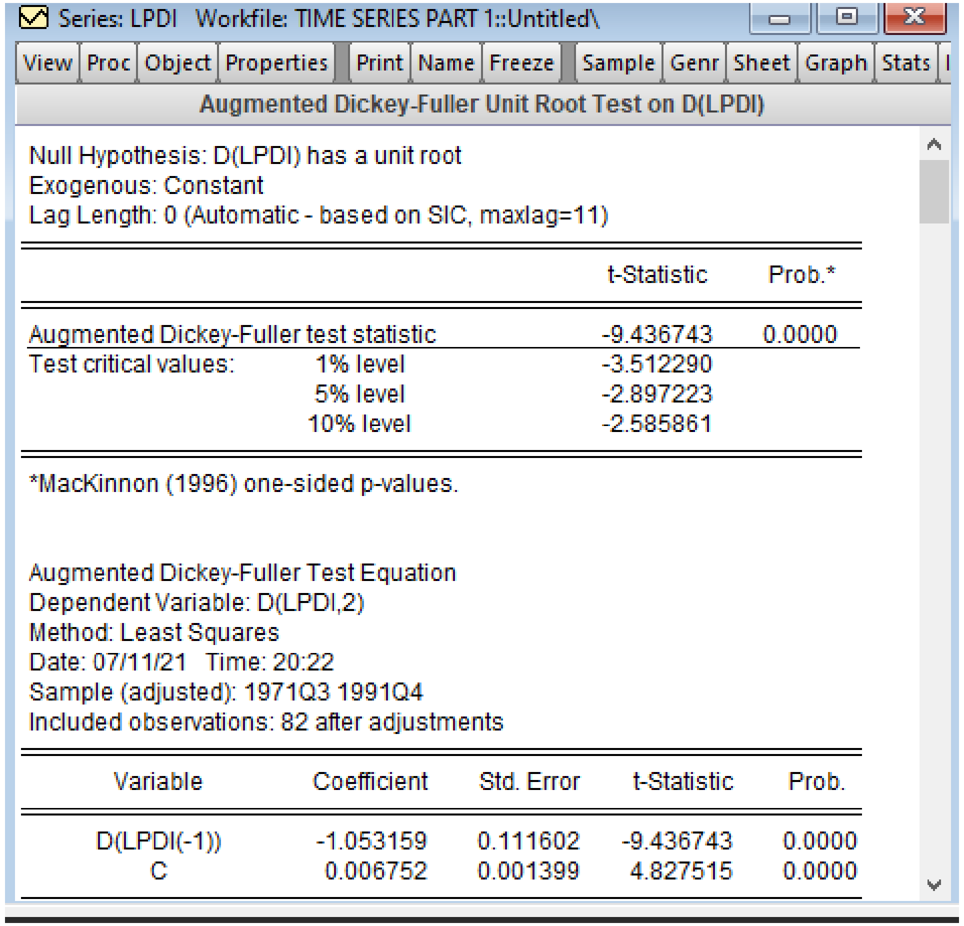
*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LPDI)
Method: Least Squares
Date: 07/11/21 Time: 20:20
Sample (adjusted): 1971Q2 1991Q4
Included observations: 83 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LPDI(-1)	-0.010311	0.007278	-1.416752	0.1604
C	0.088285	0.057762	1.528433	0.1303

The ADF test – First Difference for LPDI





Augmented Dickey-Fuller Unit Root Test on D(LPDI)

Null Hypothesis: D(LPDI) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=11)

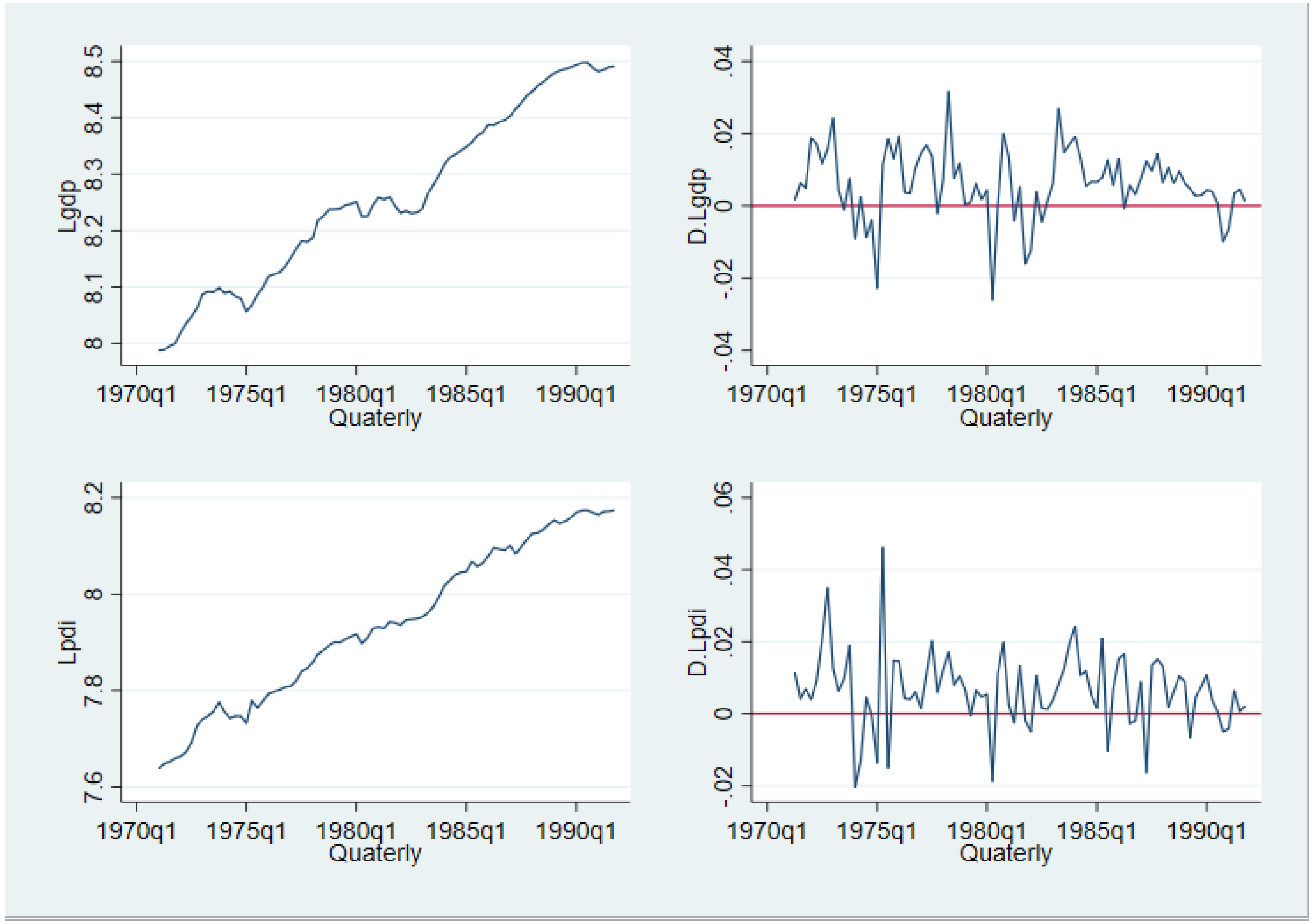
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.436743	0.0000
Test critical values:	1% level	-3.512290	
	5% level	-2.897223	
	10% level	-2.585861	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LPDI,2)
Method: Least Squares
Date: 07/11/21 Time: 20:22
Sample (adjusted): 1971Q3 1991Q4
Included observations: 82 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LPDI(-1))	-1.053159	0.111602	-9.436743	0.0000
C	0.006752	0.001399	4.827515	0.0000

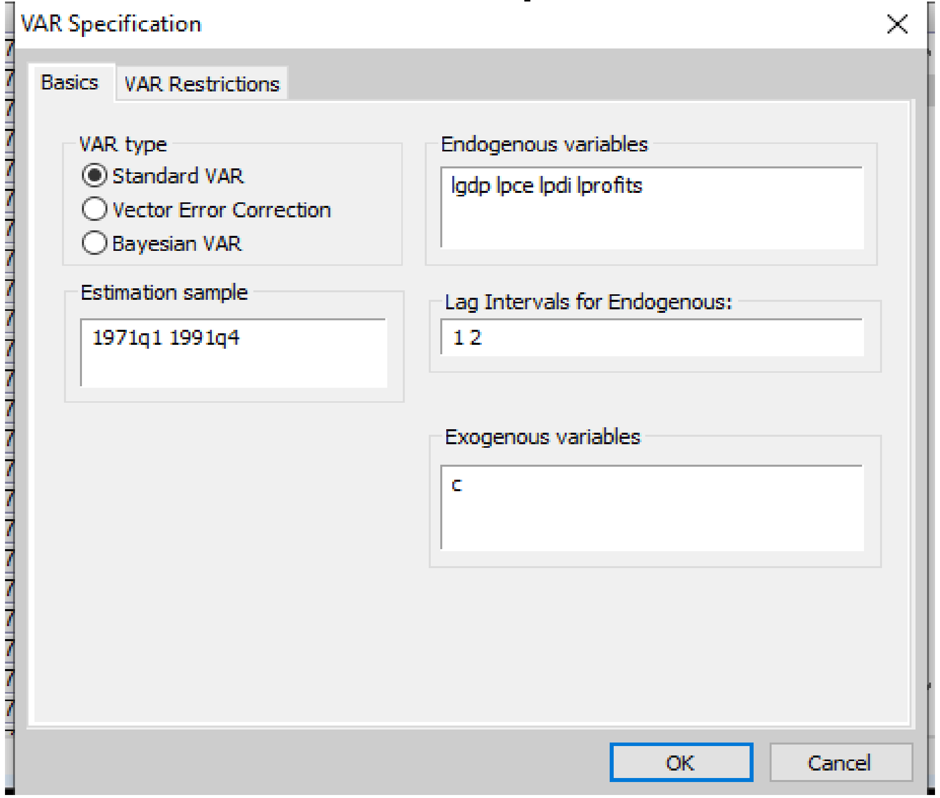
Lets compare the data for level and first difference –



- Seem to show that the first difference is stationary – now we are going to test – ADF test – (also can apply ACF in this case – you can try it later)

Lag selection- Before Cointegration

- Before performing cointegration test and VEC modelling, we need to determine the optimal number of lags



Vector Autoregression Estimates
Date: 07/11/21 Time: 20:43
Sample (adjusted): 1971Q3 1991Q4
Included observations: 82 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	LGDP	LPCE	LPDI	LPROFITS
LGDP(-1)	0.619799	-0.098604	-0.088364	-2.498874
	(0.14932)	(0.13192)	(0.18546)	(1.29700)
	[4.15093]	[-0.74748]	[-0.47646]	[-1.92666]
LGDP(-2)	-0.058921	-0.265094	-0.077570	0.746310
	(0.14609)	(0.12907)	(0.18145)	(1.26898)
	[-0.40332]	[-2.05395]	[-0.42750]	[0.58812]
LPCE(-1)	0.642212	1.093103	0.826566	3.506485
	(0.15536)	(0.13726)	(0.19297)	(1.34953)
	[4.13363]	[7.96386]	[4.28342]	[2.59831]
LPCE(-2)	-0.045537	0.332415	-0.343753	-0.466922
	(0.18726)	(0.16544)	(0.23258)	(1.62657)
	[-0.24318]	[2.00933]	[-1.47797]	[-0.28706]
LPDI(-1)	0.007415	0.004783	0.575371	-0.176102
	(0.09614)	(0.08493)	(0.11941)	(0.83508)
	[0.07713]	[0.05631]	[4.81850]	[-0.21088]
LPDI(-2)	-0.237745	-0.118214	0.048937	-1.364373
	(0.09638)	(0.08515)	(0.11971)	(0.83719)
	[-2.46672]	[-1.38832]	[0.40879]	[-1.62970]
LPROFITS(-1)	0.005711	-0.027753	-0.056451	1.112872
	(0.01487)	(0.01314)	(0.01847)	(0.12916)
	[0.38410]	[-2.11259]	[-3.05653]	[8.61611]
LPROFITS(-2)	-0.003098	0.023917	0.059836	-0.163436

Lag selection

- Based on LR FPE AIC SC HQ, the lag selected is lag 1 and 2
- We use this for cointegration test

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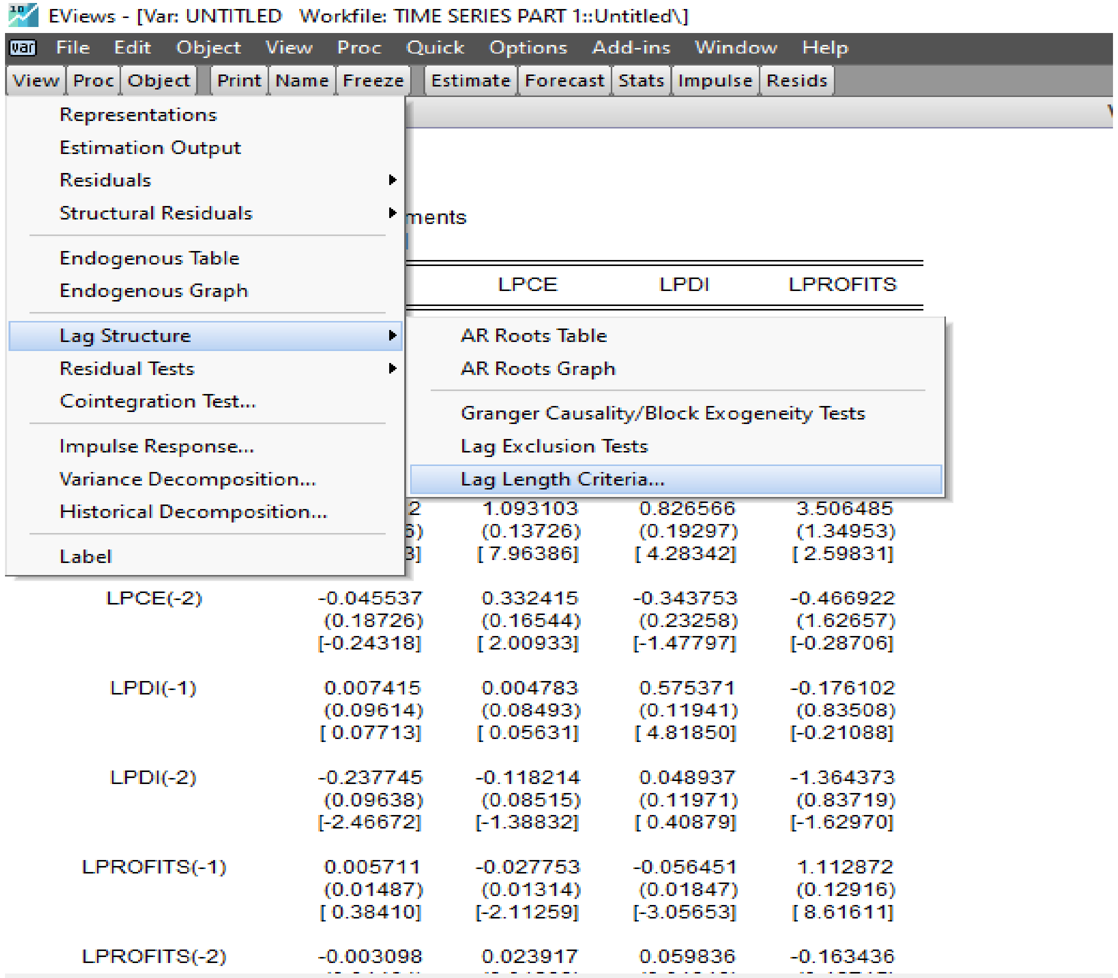
VAR Lag Order Selection Criteria
Endogenous variables: LGDP LPCE LPDI LPROFITS
Exogenous variables: C
Date: 07/11/21 Time: 20:45
Sample: 1971Q1 1991Q4
Included observations: 77

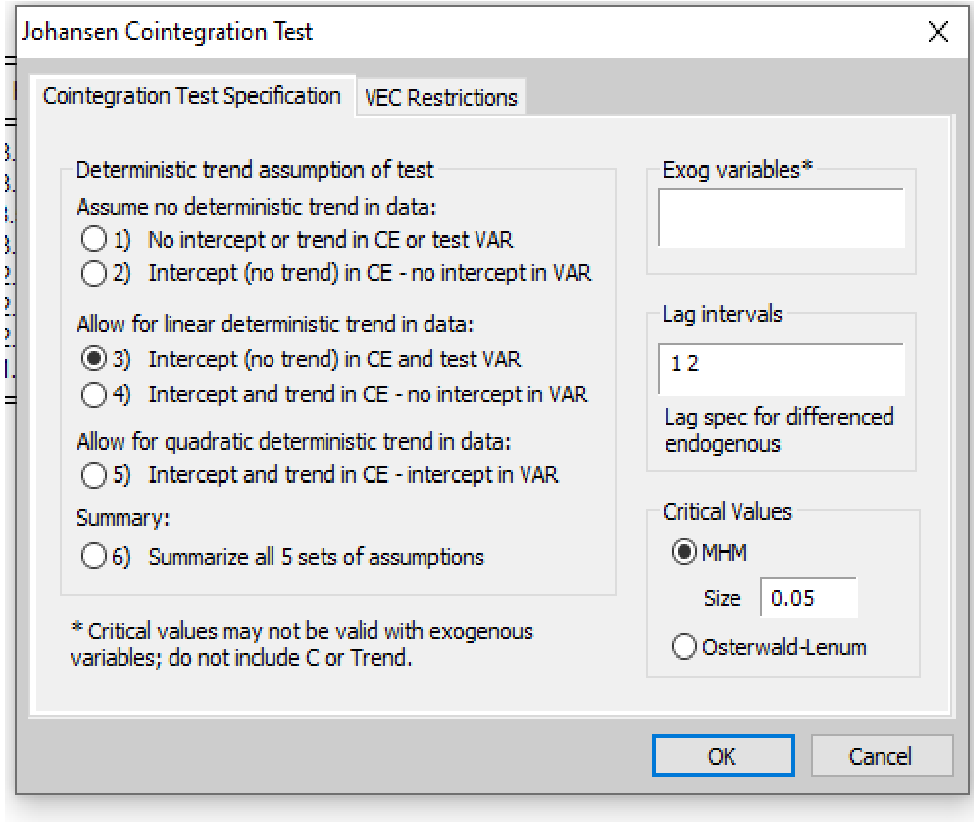
Lag	LogL	LR	FPE	AIC	SC	HQ
0	533.1356	NA	1.26e-11	-13.74378	-13.62203	-13.69508
1	935.9573	753.3289	5.47e-16	-23.79110	-23.18232*	-23.54759
2	961.2313	44.63980*	4.32e-16*	-24.03198*	-22.93618	-23.59367*
3	974.5866	22.20104	4.66e-16	-23.96329	-22.38046	-23.33017
4	982.3693	12.12881	5.87e-16	-23.74985	-21.68000	-22.92193
5	988.8470	9.422142	7.72e-16	-23.50252	-20.94564	-22.47979
6	1002.830	18.88567	8.48e-16	-23.45012	-20.40622	-22.23259
7	1013.049	12.74066	1.04e-15	-23.29997	-19.76904	-21.88763

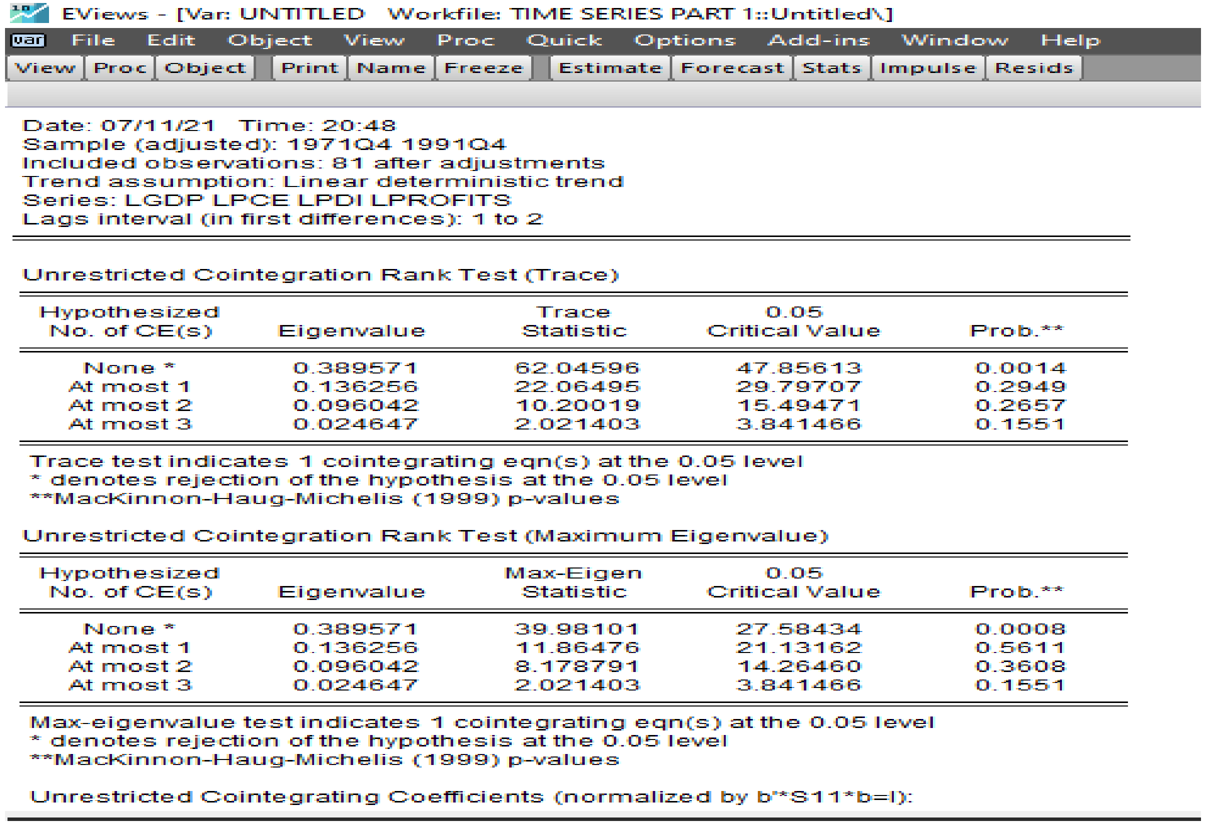
* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion



Cointegration

- After verifying variables are I(1), we run Johansen Cointegration Test
- The LAGS determined by lag selections criteria (here, 1 2 or 2 lags

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Date: 07/11/21 Time: 20:48
Sample (adjusted): 1971Q4 1991Q4
Included observations: 81 after adjustments
Trend assumption: Linear deterministic trend
Series: LGDP LPCE LPDI LPROFITS
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.389571	62.04596	47.85613	0.0014
At most 1	0.136256	22.06495	29.79707	0.2949
At most 2	0.096042	10.20019	15.49471	0.2657
At most 3	0.024647	2.021403	3.841466	0.1551

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.389571	39.98101	27.58434	0.0008
At most 1	0.136256	11.86476	21.13162	0.5611
At most 2	0.096042	8.178791	14.26460	0.3608
At most 3	0.024647	2.021403	3.841466	0.1551

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

Vector Error Correction model

- If nonstationary but I(1) time series are cointegrated, we can run the VECM to examine both the short-run and long-run dynamics of the series
- *Conventional* ECM for cointegrated series:

$$\Delta y_t = \beta_0 + \sum_{i=1}^{n} \beta_i \Delta y_{t-i} + \sum_{i=0}^{n} \delta_i \Delta x_{t-i} + \varphi z_{t-1} + \mu_t$$

- z is the ECT and is the OLS residuals from the following long-run cointegrating regression:

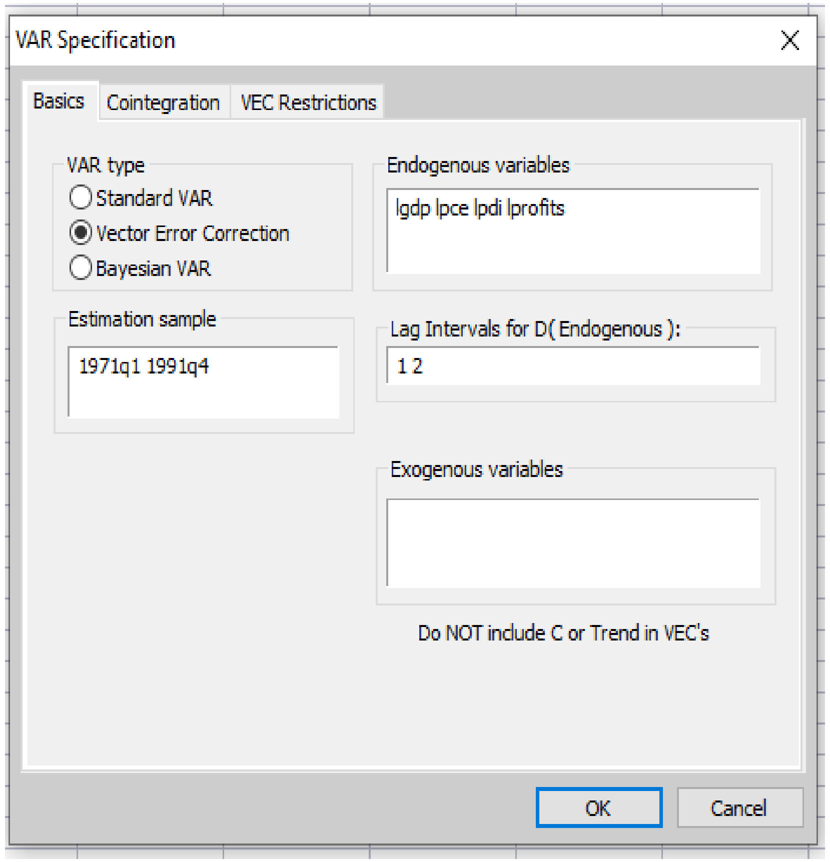
$$y_t = \beta_0 + \beta_1 x_t + \varepsilon_t$$

...and is defined as

$$z_{t-1} = ECT_{t-1} = y_{t-1} - \beta_0 - \beta_1 x_{t-1}$$

- The term, *error-correction*, relates to the fact that last period deviation from long-run equilibrium (the *error*) influences the short-run dynamics of the dependent variable
- Thus, the coefficient of ECT, φ, is the *speed of adjustment*, because it measures the speed at which Y returns to equilibrium after a change in X.

Vector Error Correction model



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Vector Error Correction Estimates
Date: 07/11/21 Time: 20:52
Sample (adjusted): 1971Q4 1991Q4
Included observations: 81 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LGDP(-1)	1.000000
LPCE(-1)	-1.326357 (0.13437) [-9.87064]
LPDI(-1)	0.478409 (0.14309) [3.34331]
LPROFITS(-1)	0.012763 (0.00782) [1.63203]
C	-1.724477

Error Correction:	D(LGDP)	D(LPCE)	D(LPDI)	D(LPROFITS)
CointEq1	-0.342926 (0.08798) [-3.89777]	-0.448602 (0.07148) [-6.27560]	-0.307187 (0.10507) [-2.92357]	-2.443886 (0.73924) [-3.30596]
D(LGDP(-1))	0.051226 (0.17755) [0.28852]	0.343598 (0.14426) [2.38183]	0.214043 (0.21204) [1.00943]	0.318199 (1.49183) [0.21329]
D(LGDP(-2))	0.137742 (0.15382) [0.89550]	0.272724 (0.12498) [2.18221]	0.588286 (0.18370) [3.20243]	-0.760001 (1.29242) [-0.58804]
D(LPCE(-1))	0.101643 (0.23268) [0.43683]	-0.601986 (0.18905) [-3.18421]	0.187181 (0.27789) [0.67359]	-0.410255 (1.95507) [-0.20984]
D(LPCE(-2))	-0.031397 (0.20637) [-0.15214]	-0.361252 (0.16768) [-2.15443]	-0.452834 (0.24647) [-1.83728]	-1.253149 (1.73403) [-0.72268]
D(LPDI(-1))	0.188508 (0.11012) [1.71183]	0.222084 (0.08947) [2.48213]	-0.105357 (0.13151) [-0.80111]	1.362502 (0.92527) [1.47254]
D(LPDI(-2))	-0.057598 (0.10160) [-0.56693]	0.120343 (0.08255) [1.45788]	-0.141553 (0.12133) [-1.16664]	0.578921 (0.85365) [0.67817]
D(LPROFITS(-1))	0.007016 (0.01505) [0.46613]	-0.022089 (0.01223) [-1.80608]	-0.045967 (0.01798) [-2.55699]	0.166455 (0.12648) [1.31609]
D(LPROFITS(-2))	-0.002102 (0.01647) [-0.12761]	-0.020981 (0.01338) [-1.56763]	-0.004498 (0.01967) [-0.22865]	0.004291 (0.13841) [0.03100]

The output

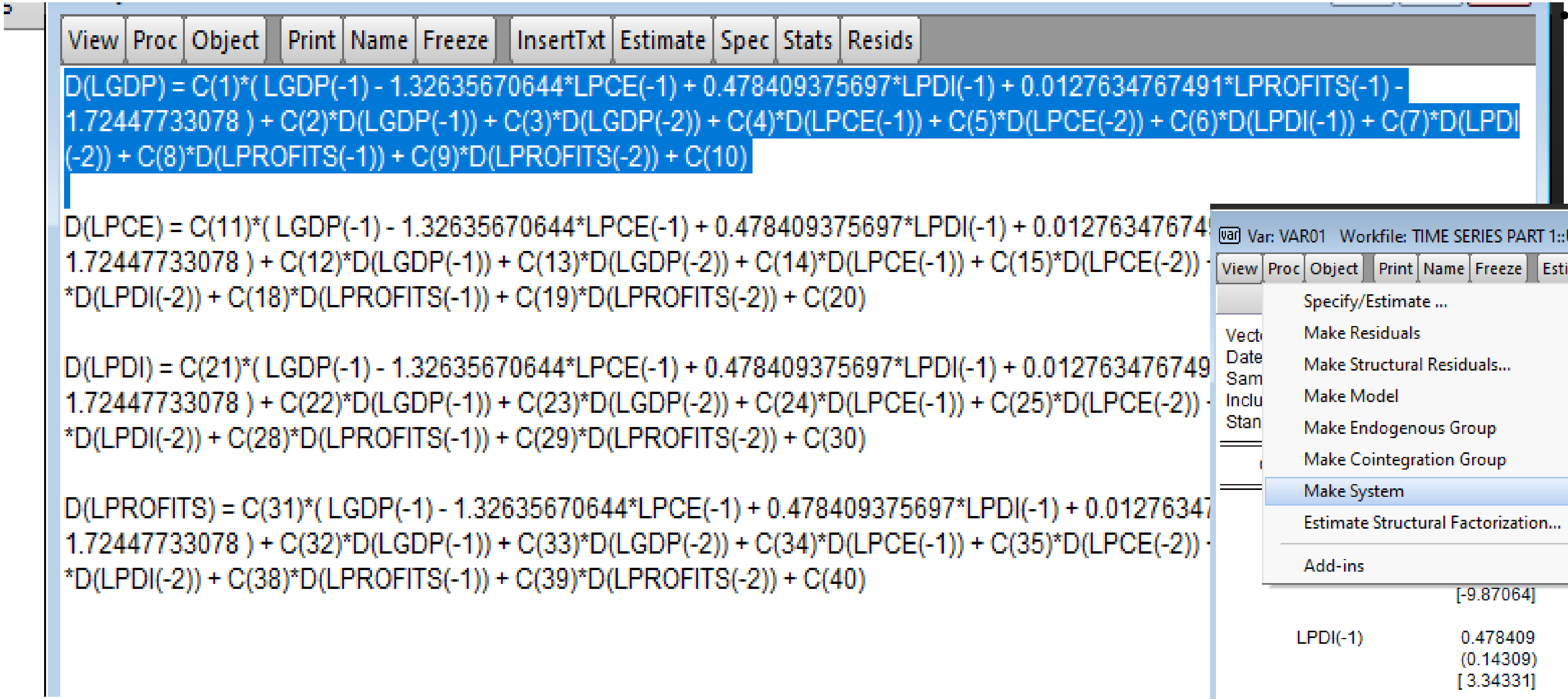
- **Estimated VECM with LGDP as target variable:**
- $DLGDP_t = -0.34292582(\text{ECT}(-1))$ +0.051225999D(LGDP(-1)) + 0.137742438D(LGDP(-2))+ 0.101643257D(LPCE(-1)) -0.031397295D(LPCE(-2)) + 0.188508359D(LPDI(-1)) + 0.057597656D(LPDI(-2)) + 0.007016434 D(LPROFITS(-1)) -0.00210206 D(LPROFITS(-2)) +

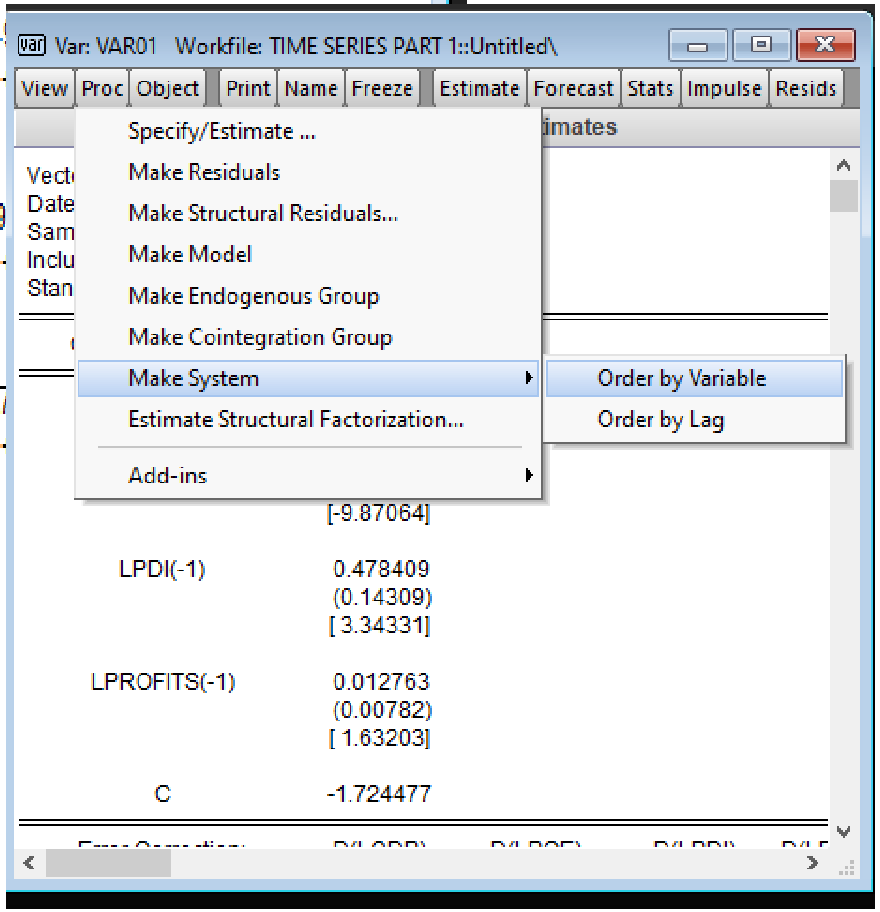
0.003549

Cointegrating equation (long-run model):

- Ect(-1) = 1.000 LGDP(-1) -1.32636 LPCE(-1) +0.478409 LPDI(-1) +0.012763477 LPROFITS(-1) -1.72448

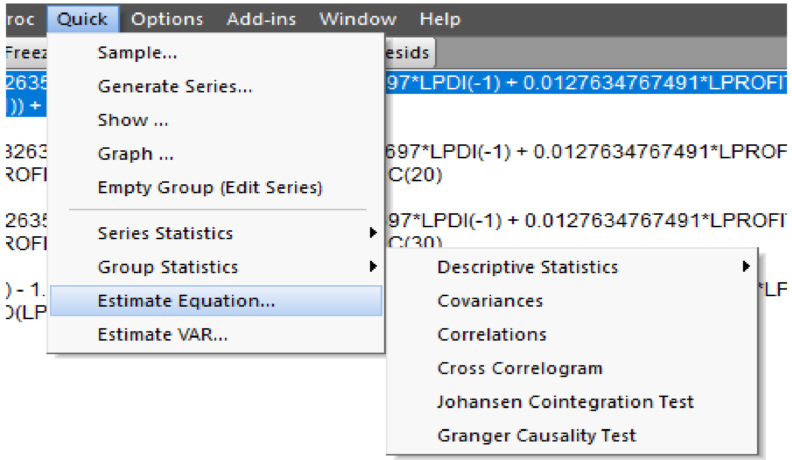
Make into a system to estimate – finding P value

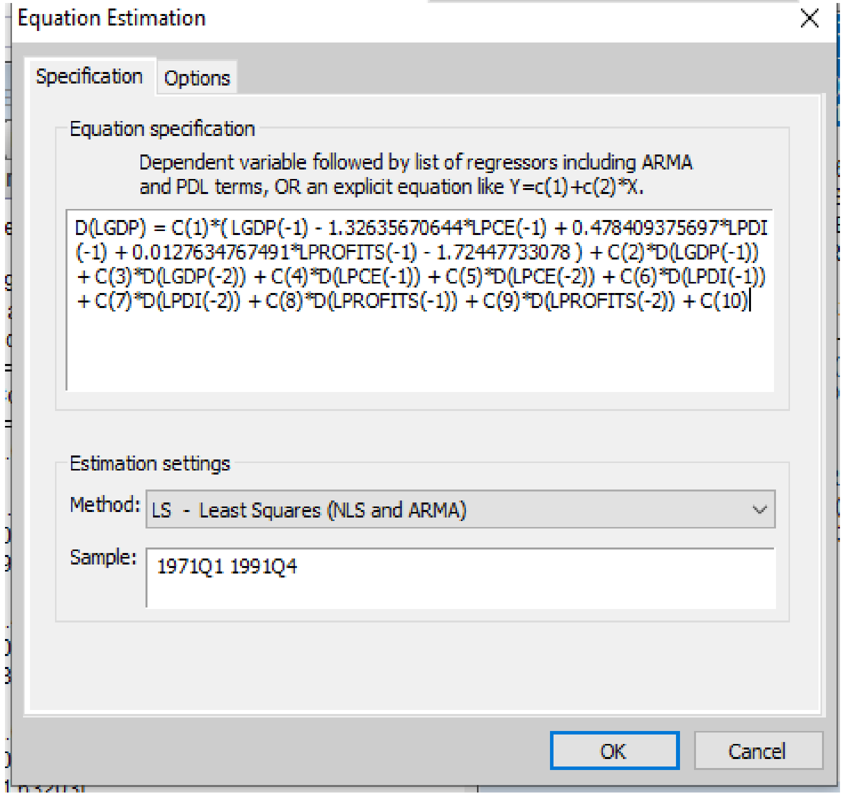


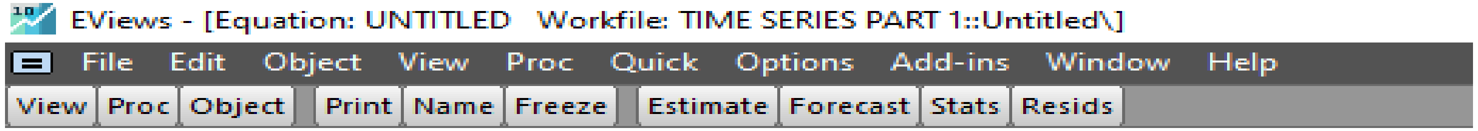


- To find P value for C(1) – the error correction term

Finding A p Value for the error correction term – abut 34 percent departure from long run equilibrium corrected each period – the independent variable granger causes LGDP in the long run





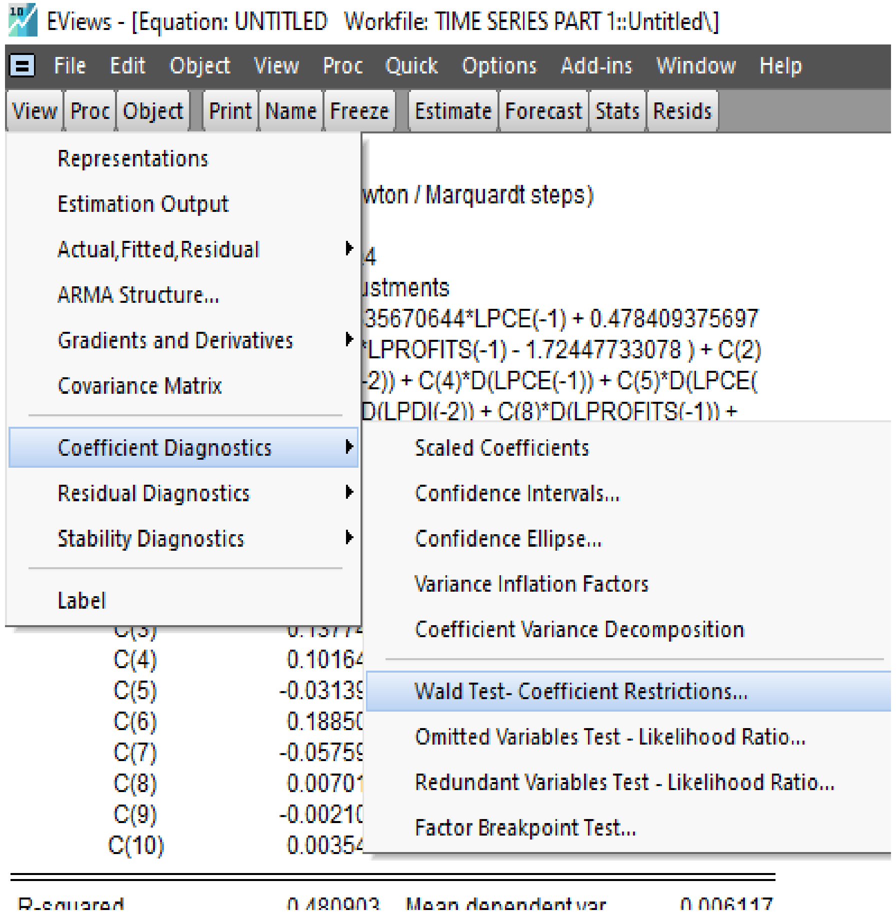


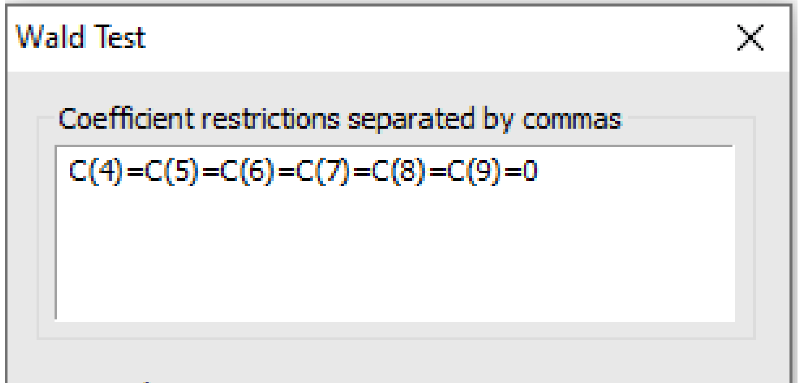
Dependent Variable: D(LGDP)
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 07/11/21 Time: 21:09
Sample (adjusted): 1971Q4 1991Q4
Included observations: 81 after adjustments
D(LGDP) = C(1)*(LGDP(-1) - 1.32635670644*LPCE(-1) + 0.478409375697 *LPDI(-1) + 0.0127634767491*LPROFITS(-1) - 1.72447733078) + C(2) *D(LGDP(-1)) + C(3)*D(LGDP(-2)) + C(4)*D(LPCE(-1)) + C(5)*D(LPCE(-2)) + C(6)*D(LPDI(-1)) + C(7)*D(LPDI(-2)) + C(8)*D(LPROFITS(-1)) + C(9)*D(LPROFITS(-2)) + C(10)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.342926	0.087980	-3.897768	0.0002
C(2)	0.051226	0.177549	0.288517	0.7738
C(3)	0.137742	0.153817	0.895497	0.3735
C(4)	0.101643	0.232682	0.436833	0.6636
C(5)	-0.031397	0.206375	-0.152137	0.8795
C(6)	0.188508	0.110121	1.711832	0.0913
C(7)	-0.057598	0.101596	-0.566927	0.5726
C(8)	0.007016	0.015053	0.466127	0.6426
C(9)	-0.002102	0.016473	-0.127607	0.8988
C(10)	0.003549	0.001617	2.195118	0.0314

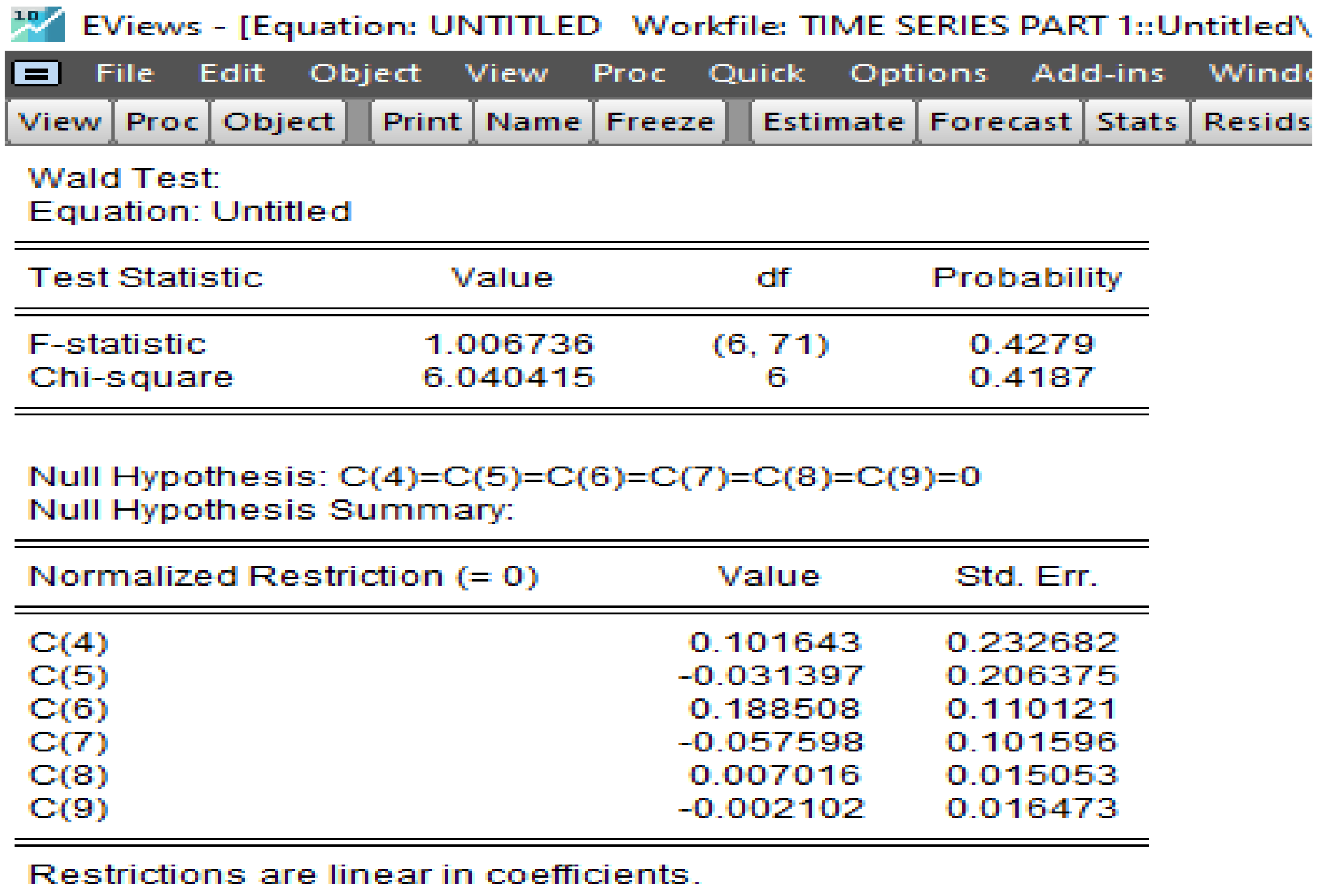
R-squared	0.480903	Mean dependent var	0.006117
Adjusted R-squared	0.415101	S.D. dependent var	0.009836
S.E. of regression	0.007522	Akaike info criterion	-6.826747
Sum squared resid	0.004018	Schwarz criterion	-6.531136
Log likelihood	286.4833	Hannan-Quinn criter.	-6.708144
F-statistic	7.308428	Durbin-Watson stat	1.975212
Prob(F-statistic)	0.000000		

Causality for the short run variables





- Does all independent variables granger cause LGDP?
- No causality between LGDP, LPCE,LPDI and LPROFITS or no short run relationship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Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	1.006736	(6, 71)	0.4279
Chi-square	6.040415	6	0.4187

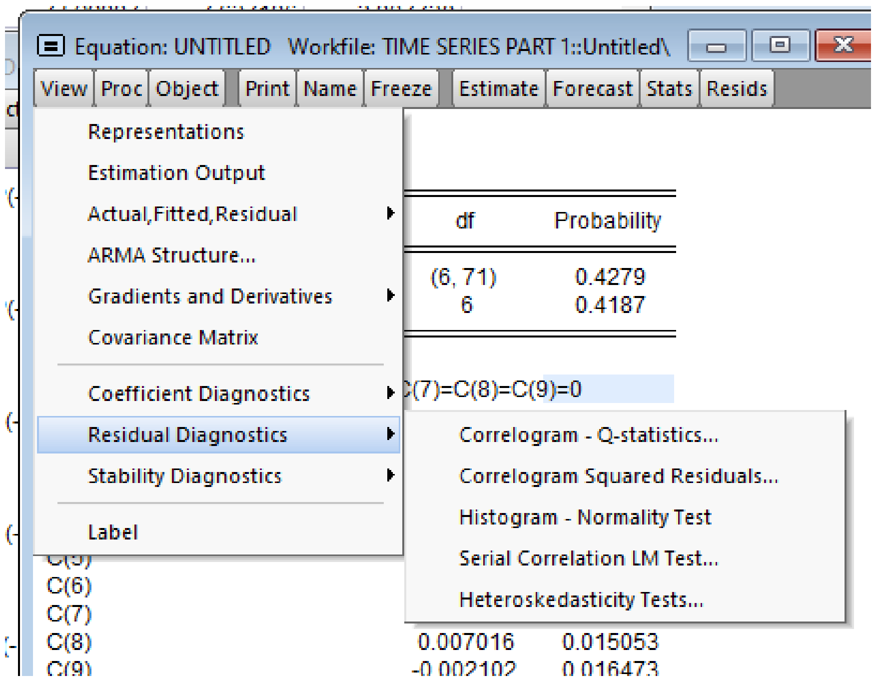
Null Hypothesis: C(4)=C(5)=C(6)=C(7)=C(8)=C(9)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(4)	0.101643	0.232682
C(5)	-0.031397	0.206375
C(6)	0.188508	0.110121
C(7)	-0.057598	0.101596
C(8)	0.007016	0.015053
C(9)	-0.002102	0.016473

Restrictions are linear in coefficients.

SERIAL CORRELATION

- P value is > than α so no serial correlation



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Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 2 lags

F-statistic	1.232481	Prob. F(2,69)	0.2979
Obs*R-squared	2.793843	Prob. Chi-Square(2)	0.2474

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 07/12/21 Time: 01:53
Sample: 1971Q4 1991Q4
Included observations: 81
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.135680	0.278611	-0.486989	0.6278
C(2)	-0.649616	0.607335	-1.069616	0.2885
C(3)	0.257058	0.224309	1.145996	0.2558
C(4)	-0.207758	0.422036	-0.492275	0.6241
C(5)	0.268153	0.267758	1.001476	0.3201
C(6)	0.082097	0.191449	0.428820	0.6694
C(7)	0.105485	0.185171	0.569661	0.5708
C(8)	0.000595	0.015013	0.039601	0.9685
C(9)	0.004189	0.017681	0.236918	0.8134
C(10)	0.000685	0.003170	0.215997	0.8296
RESID(-1)	0.806569	0.841377	0.958630	0.3411
RESID(-2)	-0.435144	0.293022	-1.485025	0.1421

R-squared	0.034492	Mean dependent var	-7.98E-18
Adjusted R-squared	-0.119430	S.D. dependent var	0.007087
S.E. of regression	0.007498	Akaike info criterion	-6.812465
Sum squared resid	0.003879	Schwarz criterion	-6.457732
Log likelihood	287.9048	Hannan-Quinn criter.	-6.670141
F-statistic	0.224087	Durbin-Watson stat	2.039448
Prob(F-statistic)	0.995219		

Key Concepts

1. Stochastic Processes
    i. Stationarity Processes
    ii. Purely Random Processes
    iii. Non-stationary Processes
2. Random Walk Models
    i. Random Walk with Drift
    ii. Random Walk without Drift
3. Unit Root Stochostic Processes
4. Deterministic and Stochastic Trends
5. The Phenomenon of Spurious Regression
6. Tests of Stationarity/non-stationarity
    i. Graphical Method
    ii. Unit Root Tests