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Original scientific paper

ENGLE & GRANGER COINTEGRATION TEST FOR GDP AND PUBLIC CONSUMPTION IN THE REPUBLIC OF NORTH MACEDONIA

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Abstract
In this paper, we test cointegration between GDP and Public consumption of the Republic of North Macedonia, for quarterly data of twenty years' time series (2000Q1-2019Q4). We present results of two methods for cointegration test: first, residual regression test table and second, Engle & Granger cointegration test and Philips Ouliaris test. Both methods provides same conclusions. We did not find the presence of spurious regression. ADF Unit Root Test on residuals confirms that residuals are not stationary and that series are not cointegrated. Engle-Granger cointegration test and Phillips Ouliaris cointegration test results confirms that GDP and Public consumption of the Republic of North Macedonia are not cointegrated and can be used for further analyze using VAR(p) model..

Keywords: cointegration, VAR, stationarity, public consumption, probability

JEL Classification: C1,C32, C35

INTRODUCTION

Fiscal policy is powerful tool of economic policy used by governments to influence economic development, stabilization or to affect and prevent economic cycles in the national economy (Lane, P. 2003). Fiscal policy can use different instruments as well as methods, and one of them is public consumption. There are many arguments in economic theory and practice for importance of the state budget for distribution and allocation of public expenditures and using budget or public consumption for economic policy goals fulfillment (Cochrane, 2001). There are no doubts in academic or expert community about public consumption importance and influence on the GDP, but there are significant differences between countries, especially about "time lag" of GDP on the changes (shocks) in public consumption, intensity of the influence etc. In order to evaluate impact of public consumption towards GDP of the Republic of North Macedonia we can use VAR(p) model. VAR model is useful for determination of mutual influence of time series.

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However, before use of VAR model, it is necessary to make cointegration test in order to determine if time series are non-stationary (Johansen, 1995). Cointegration naturally arises in economics and finance and in economics, cointegration is most often associated with economic theories that imply equilibrium relationships between time series variables. We can provide many examples for it, so for example the permanent income model implies cointegration between consumption and income, with consumption being the common trend. Money demand models imply cointegration between money, income, prices and interest rates. Growth theory models imply cointegration between income, consumption and investment, with productivity being the common trend. Purchasing power parity implies cointegration between the nominal exchange rate and foreign and domestic prices (Alexander, C. 2001).

The focus of our analysis will be cointegration test of GDP and public consumption of the Republic of North Macedonia in order to determine if time series are non-stationary and if VAR(p) model can be used.

1. METHODOLOGY

In univariate models, a stochastic trend can be removed applying first differences. Then, the stationary series can be estimated and forecasted using Box-Jenkins 3 steps method. (Hamilton, 1994)

Treating Non-Stationary variables in multivariate models is not straightforward, because there can be a linear combination of integrated variables that is stationary, in such case we say the variables are cointegrated (Lutkepohl, H. 1993).

If the link between the variables is not stationary, we are in the presence of a spurious regression, which means residuals are not stationary. Spurious regression are those between variables with a similar trend but do not have an economic sense. This mean that series can have statistics' significance, but no economic interpretation. (Hansen, 1992).

According to literature (Newbold and Granger, 1974), spurious regressions have:

- High R^2 and low Durbin Watson statistic (Rule of thumb: R^2>DW)
- T-Statsitic are very high: Variables are highly significant.
- Residuals are not stationary.

However, non - stationary variables can have a stationary linear combination, which means log run equilibrium. If the errors are not stationary, there is no lung run equilibrium, changes are permanent. There is a linear combination of variables and this is a stationary (Johansen, 1988). We are working with not stationary variables and levels but there can be linear combination of variables and going to make their residuals stationary.

In order to identify if two variables are cointegrated we will use Engle & Granger two steps method (Engle and Granger, 1987). The first step is test the variables for their order of integration. It is very important that the variables have to be of the same integration order. That's why we need to estimate the long-run equilibrium model by OLS, after that to save the residuals and finally, test if the residuals are stationary.

$Y_t = \beta_0 + \beta_1 z_t + e_t$

If the variables are cointegrated, the OLS estimates will yield “superconsistent” parameters β_0 and β_1, as they converge faster than they do using stationary variables. (Watson, 1987)

The Augmented Dickey Fuller Statistic are not valid for the residuals unit root test, because residuals are not observable. There are two outcomes: first, to use the residual regression test table or second, proceed with the Engle & Granger cointegration test or Philips Ouliaris.

In order to test null hypothesis we use F-statistics. For the cointegration test we use the method of ordinary least squares - OLS (Lack, C. and Lenz, C. 2000). If p-value > 0.05 we can not reject null hypothesis, that means we accept null hypothesis. In a case when p-value < 5% we reject null hypothesis and accept alternative hypothesis (Lane, 2003). Before cointegration test we will analyze the data.

2. DATA

We start our analysis using time series data for 20 years, for the period 2000- 2019 in millions Macedonian currency (denars). We present time series data for GDP and public consumption of the Republic of North Macedonian for the period 2000 Q1-2019 Q4 on the following figure:

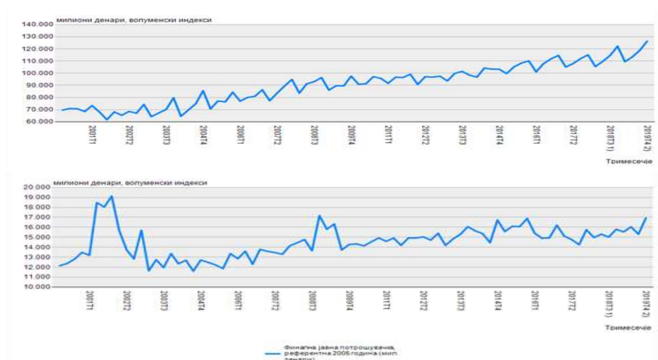


Figure 1. GPD and Public consumption of North Macedonia 2000Q1-2019Q4
Source: State statistics of the Republic of North Macedonia

The time series charts clearly show that GDP and public consumption of the Republic of North Macedonia have growing trend and that increased significantly in last 10 years. GDP minimum level was during Q3 of 2001 (during war conflict in the country), while maximum quartile level was realized during 2919Q4 (126.360 millions denars). Maximum amount of public consumption was realized in 2001Q4 (used for weapons and military equipment in terms of war conflict in the country), while minimum level was in

2004Q3 as a result of limited budget spending before parliamentary elections in the country, as shown on the following Table:

Table 1. GPD and Public consumption of North Macedonia 2000Q1- 2019Q4

Years	GDP	Rank GDP	Public Cons	Rank Public Cons
2000Q1	69617	70	12144	76
2000Q2	70967	65	12367	72
2000Q3	70743	66	12813	67
2000Q4	68467	72	13483	59
2001Q1	73289	64	13193	64
2001Q2	68059	74	18477	2
2001Q3	**61742**	**80**	18033	3
2001Q4	68122	73	**19120**	**1**
2002Q1	65391	77	15697	18
2002Q2	68527	71	13751	54
2002Q3	67072	76	12828	66
2002Q4	74273	63	15701	17
2003Q1	64254	79	11637	79
2003Q2	67256	75	12744	68
2003Q3	70098	68	11962	77
2003Q4	79773	57	13358	61
2004Q1	64540	78	12348	73
2004Q2	69659	69	12694	70
2004Q3	74784	62	**11604**	**80**
2004Q4	85550	51	12714	69
2005Q1	70626	67	12483	71
2005Q2	77089	59	12224	75
2005Q3	76410	61	11858	78
2005Q4	84322	52	13357	62
2006Q1	76991	60	12850	65
2006Q2	79988	56	13597	57
2006Q3	81024	55	12297	74
2006Q4	86289	49	13782	53
2007Q1	77365	58	13584	58

2007Q2	83626	53	13468	60
2007Q3	89439	48	13291	63
2007Q4	94855	38	14148	51
2008Q1	83620	54	14440	45
2008Q2	91196	43	14767	40
2008Q3	92996	40	13656	56
2008Q4	96367	36	17174	4
2009Q1	86104	50	15810	14
2009Q2	89708	46	16334	8
2009Q3	89512	47	13725	55
2009Q4	97549	29	14266	47
2010Q1	90878	44	14338	46
2010Q2	91270	42	14137	52
2010Q3	97119	30	14546	43
2010Q4	95795	37	14934	34
2011Q1	91638	41	14595	42
2011Q2	96665	34	14924	35
2011Q3	96417	35	14191	49
2011Q4	99117	26	14935	33
2012Q1	90713	45	14920	36
2012Q2	97105	31	15040	29
2012Q3	96710	33	14715	41
2012Q4	97558	28	15399	23
2013Q1	93617	39	14187	50
2013Q2	99844	24	14826	38
2013Q3	101440	22	15298	27
2013Q4	98362	27	16056	12
2014Q1	96746	32	15647	19
2014Q2	104229	19	15363	24
2014Q3	103324	20	14457	44
2014Q4	103236	21	16725	7
2015Q1	99679	25	15575	20
2015Q2	105177	17	16097	10

2015Q3	108275	13	16069	11
2015Q4	110118	10	16885	6
2016Q1	101100	23	15421	22
2016Q2	107841	15	14898	37
2016Q3	111758	9	14940	32
2016Q4	114605	6	16207	9
2017Q1	105084	18	15110	28
2017Q2	107915	14	14773	39
2017Q3	111969	8	14253	48
2017Q4	115045	4	15755	16
2018Q1	105440	16	14978	31
2018Q2	109714	11	15305	26
2018Q3	114645	5	15018	30
2018Q4	122183	2	15798	15
2019Q1	109446	12	15541	21
2019Q2	113443	7	16044	13
2019Q3	118781	3	15311	25
2019Q4	**126360**	**1**	16923	5

Source: State statistics of the Republic of North Macedonia

The lowest public consumption share in the GDP was in 2017 with 12,73%, while the highest share was in 2001Q3 with 29.1% as shown on the following figure:

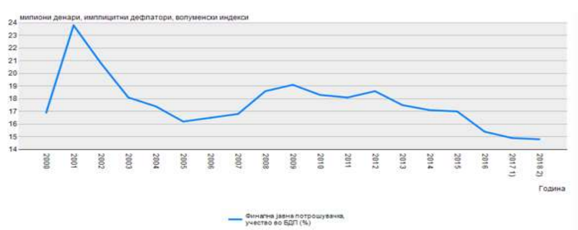


Figure 2. Public consumption share in GDP of North Macedonia 2000Q1- 2019Q4
Source: State statistics of the Republic of North Macedonia

3. EMPIRICAL RESULTS

We will start cointegration test with Method 1 (residual regression test table), where we will make unit root test on the OLS residuals. In the first step, we will check the stationarity, where both variables have to be integrated of the same order. The procedure is to use Graph-Correlogram-Formal Test.

Time series analysis was performed by using Eviews software for statistical analysis, where we import quarterly data for twenty years period for the GDP and the public consumption of the Republic of North Macedonia (total 80 observations). We can present the variables in the graph, as follows:

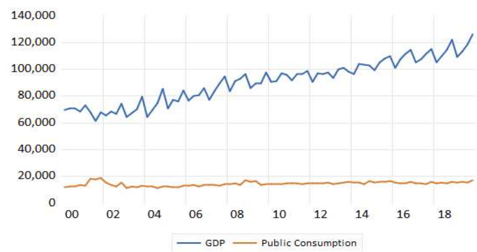


Figure 3. GDP and Public Consumption
Source: Eviews software

We can see that GDP has significant increase, while public consumption has moderate increase. Both variables are not closely aligned, or both variables are not moving closely, so there is a question if there is a long-run relation between variables. This can be a sign that variables may not be cointegrated. We need to convert both variables into logs, because the estimates of our linear regression are not going to be so easy to interpret, so we generate log values into the software. The value of a lngdp are present in a graph, as it follows:

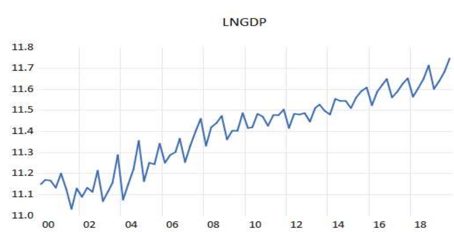
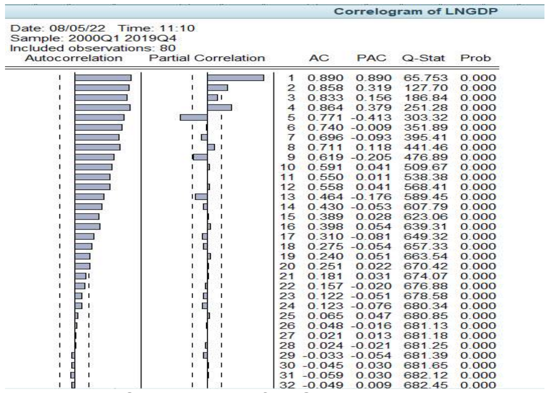


Figure 4. LNGDP
Source: Authors' calculations in Eviews software

We can still see the positive growth trend of the GDP and that can be a sigh that variable is not stationary. We proceed with correlogram analysis in levels checking for stationarity.



Correlogram of LNGDP

Date: 08/05/22 Time: 11:10
Sample: 2000Q1 2019Q4
Included observations: 80

Lag	AC	PAC	Q-Stat	Prob
1	0.890	0.890	65.753	0.000
2	0.858	0.319	127.70	0.000
3	0.833	0.156	186.84	0.000
4	0.864	0.379	251.28	0.000
5	0.771	-0.413	303.32	0.000
6	0.740	-0.009	351.89	0.000
7	0.696	-0.093	395.41	0.000
8	0.711	0.118	441.46	0.000
9	0.619	-0.205	476.89	0.000
10	0.591	0.041	509.67	0.000
11	0.550	0.011	538.38	0.000
12	0.558	0.041	568.41	0.000
13	0.464	-0.176	589.45	0.000
14	0.430	-0.053	607.79	0.000
15	0.389	0.028	623.06	0.000
16	0.398	0.054	639.31	0.000
17	0.310	-0.081	649.32	0.000
18	0.275	-0.054	657.33	0.000
19	0.240	0.051	663.54	0.000
20	0.251	0.022	670.42	0.000
21	0.181	0.031	674.07	0.000
22	0.157	-0.020	676.88	0.000
23	0.122	-0.051	678.58	0.000
24	0.123	-0.076	680.34	0.000
25	0.065	0.047	680.85	0.000
26	0.048	-0.016	681.13	0.000
27	0.021	0.013	681.18	0.000
28	0.024	-0.021	681.25	0.000
29	-0.033	-0.054	681.39	0.000
30	-0.045	0.030	681.65	0.000
31	-0.059	0.030	682.12	0.000
32	-0.049	0.009	682.45	0.000

Figure 5. Correlogram of LNGDP
Source: Authors' calculations in Eviews software

Correlogram is decaying in a very slowly pattern, going slowly autocorrelation and that is a sign that this variable is not stationary. We proceed checking for stationarity with formal unit root by using Augmented Dickey-Fuller Test (ADF) with including intercept. Test results are as shown on the figure bellow:

Augmented Dickey-Fuller Unit Root Test on LNGDP

Null Hypothesis: LNGDP has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.149181	0.9675
Test critical values:	1% level	-3.519050	
	5% level	-2.900137	
	10% level	-2.587409	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNGDP)
Method: Least Squares
Date: 08/05/22 Time: 11:12
Sample (adjusted): 2001Q1 2019Q4
Included observations: 76 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNGDP(-1)	0.004054	0.027172	0.149181	0.8818
D(LNGDP(-1))	-0.873047	0.079850	-10.93355	0.0000
D(LNGDP(-2))	-0.807097	0.089088	-9.059538	0.0000
D(LNGDP(-3))	-0.781337	0.077655	-10.06158	0.0000
C	-0.022584	0.309672	-0.072930	0.9421

R-squared	0.710454	Mean dependent var	0.008063
Adjusted R-squared	0.694142	S.D. dependent var	0.072930
S.E. of regression	0.040334	Akaike info criterion	-3.519730
Sum squared resid	0.115504	Schwarz criterion	-3.366393
Log likelihood	138.7498	Hannan-Quinn criter.	-3.458449
F-statistic	43.55288	Durbin-Watson stat	1.538626
Prob(F-statistic)	0.000000		

Figure 6. Augmented Dickey-Fuller Unit Root Test results
Source: Authors' calculations in Eviews software

Null Hypothesis: LOGGDP has a unit root. Due to the fact that p>0.05, series has unit root, which means that null hypothesis can not be rejected. We can conclude that series has unit root and is not stationary in levels. We conduct the test again using first differences to check if in the first differences variable is a stationary, and the test's results are presented as follows:

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

Null Hypothesis: D(LNGDP) has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.602170	0.0000
Test critical values:	1% level	-3.520307	
	5% level	-2.900670	
	10% level	-2.587691	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNGDP,2)
Method: Least Squares
Date: 08/05/22 Time: 11:13
Sample (adjusted): 2001Q2 2019Q4
Included observations: 75 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNGDP(-1))	-2.447148	0.436821	-5.602170	0.0000
D(LNGDP(-1),2)	0.802268	0.337489	2.377164	0.0202
D(LNGDP(-2),2)	0.230639	0.228671	1.008609	0.3166
D(LNGDP(-3),2)	-0.294661	0.116059	-2.538882	0.0133
C	0.016424	0.005345	3.072759	0.0030

R-squared	0.909560	Mean dependent var	-8.27E-05
Adjusted R-squared	0.904392	S.D. dependent var	0.125281
S.E. of regression	0.038737	Akaike info criterion	-3.599677
Sum squared resid	0.105042	Schwarz criterion	-3.445178
Log likelihood	139.9879	Hannan-Quinn criter.	-3.537987
F-statistic	175.9977	Durbin-Watson stat	1.883287
Prob(F-statistic)	0.000000		

Figure 7. Augmented Dickey-Fuller Test results for 1 difference LOGGDP
Source: Authors' calculations in Eviews software

We can see that $p < 0.05$ and we can reject the null hypothesis and to confirm the series is integrated at level 1. We are doing the same test with Log of public consumption (lnpublic_cons). We check the graph and confirm that public consumption has positive trend.

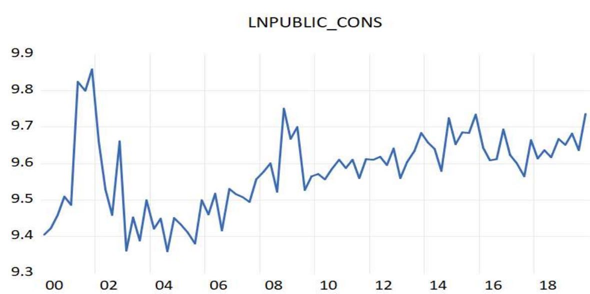
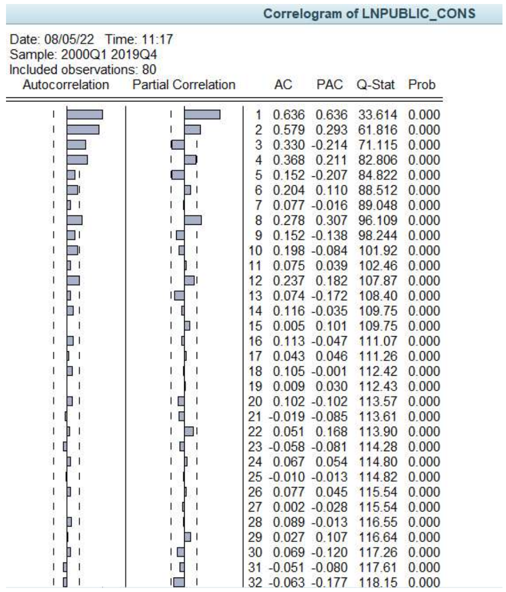


Figure 8. LNGDP
Source: Authors' calculations in Eviews software

We complement this with correlogram and check with the levels, as shown on next figure:


Correlogram of LNPUBLIC_CONS

Date: 08/05/22 Time: 11:17
Sample: 2000Q1 2019Q4
Included observations: 80

Lag	AC	PAC	Q-Stat	Prob
1	0.636	0.636	33.614	0.000
2	0.579	0.293	61.816	0.000
3	0.330	-0.214	71.115	0.000
4	0.368	0.211	82.806	0.000
5	0.152	-0.207	84.822	0.000
6	0.204	0.110	88.512	0.000
7	0.077	-0.016	89.048	0.000
8	0.278	0.307	96.109	0.000
9	0.152	-0.138	98.244	0.000
10	0.198	-0.084	101.92	0.000
11	0.075	0.039	102.46	0.000
12	0.237	0.182	107.87	0.000
13	0.074	-0.172	108.40	0.000
14	0.116	-0.035	109.75	0.000
15	0.005	0.101	109.75	0.000
16	0.113	-0.047	111.07	0.000
17	0.043	0.046	111.26	0.000
18	0.105	-0.001	112.42	0.000
19	0.009	0.030	112.43	0.000
20	0.102	-0.102	113.57	0.000
21	-0.019	-0.085	113.61	0.000
22	0.051	0.168	113.90	0.000
23	-0.058	-0.081	114.28	0.000
24	0.067	0.054	114.80	0.000
25	-0.010	-0.013	114.82	0.000
26	0.077	0.045	115.54	0.000
27	0.002	-0.028	115.54	0.000
28	0.089	-0.013	116.55	0.000
29	0.027	0.107	116.64	0.000
30	0.069	-0.120	117.26	0.000
31	-0.051	-0.080	117.61	0.000
32	-0.063	-0.177	118.15	0.000

Figure 8. Correlogram of Public Consumotion
Source: Authors' calculations in Eviews software

We can see the autocorrelation is moving in a very slow pattern, that is a sign that variable is not stationary. We complement this with unit root test, using standard ADF and Shwartz Info Criterion, using the first difference.The test's results are as follows:

View | Proc | Object | Properties | Print | Name | Freeze | Sample | Genr | Sheet | Graph | Stats | Ident

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

Null Hypothesis: D(LNPUBLIC_CONS) has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.092948	0.0000
Test critical values:	1% level	-3.519050	
	5% level	-2.900137	
	10% level	-2.587409	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNPUBLIC_CONS,2)
Method: Least Squares
Date: 08/05/22 Time: 11:18
Sample (adjusted): 2001Q1 2019Q4
Included observations: 76 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNPUBLIC_CONS(-1))	-1.667373	0.235075	-7.092948	0.0000
D(LNPUBLIC_CONS(-1),2)	0.315656	0.190315	1.658596	0.1015
D(LNPUBLIC_CONS(-2),2)	0.316276	0.112118	2.820927	0.0062
C	0.004839	0.008991	0.538183	0.5921

R-squared	0.749700	Mean dependent var	0.000646
Adjusted R-squared	0.739271	S.D. dependent var	0.152998
S.E. of regression	0.078123	Akaike info criterion	-2.209860
Sum squared resid	0.439434	Schwarz criterion	-2.087190
Log likelihood	87.97470	Hannan-Quinn criter.	-2.160835
F-statistic	71.88509	Durbin-Watson stat	1.903631
Prob(F-statistic)	0.000000		

Figure 9. Augmented Dickey-Fuller Test results
Source: Authors' calculations in Eviews software

We confirm that series has not a unit root, which means that are stationary. We reject the null hypothesis due to the fact that p-value is significant and smaller than 0.05. We confirm that our both variables are integrated of the same order (first difference) and confirm that both are stationary at first difference. After checking stationarity, we are going to estimate the long run model:

$Y_t=\beta_0+ \beta_1 z_t +e_t$

We need to save the residuals and to perform ADF test on the residuals and use the residual regression test table.

$e_t = X_t-\beta_0+ \beta_1 M_t$

Where e_t is I(0) if variables are cointegrated. We need to emphasize that the statistics of the ADF test are not appropriate, so we will use the table values. We proceed with Eviews and use Equation Estimates, using least square method (NLS and ARMA), using log values, and the test's results are shown on next figure:

Dependent Variable: LNGDP
Method: Least Squares
Date: 08/05/22 Time: 11:39
Sample: 2000Q1 2019Q4
Included observations: 80

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.434692	1.605207	2.139720	0.0355
LNPUBLIC_CONS	0.831555	0.167557	4.962836	0.0000

R-squared	0.239986	Mean dependent var	11.40057
Adjusted R-squared	0.230243	S.D. dependent var	0.183757
S.E. of regression	0.161221	Akaike info criterion	-0.787398
Sum squared resid	2.027394	Schwarz criterion	-0.727848
Log likelihood	33.49594	Hannan-Quinn criter.	-0.763523
F-statistic	24.62974	Durbin-Watson stat	0.261316
Prob(F-statistic)	0.000004		

Figure 10. Equation estimates and Least Square Method
Source: Authors' calculations in Eviews software

Now we have a model of long run regression where constant C is significant and public consumption is significant. We can conclude that 1% increase of GDP will cause 0.83% increase of public consumption. If the R^2>DW we could be in the presence of a spurious regression, and this is not a case in our model.

If t-Statsistic is really high, and t-Statistic is very significant, this can be another indicator of a spurious regression, and this is not a case in our model. Moreover, t-Statistic in our model is close to 2, and that is a sign that regression is valid. This are signs that regression is not spurious. However, there can still be a long run relationship, so we need to check if residuals are stationary. If residuals are not stationary, we confirm that regression is spurious, and opposite, if residuals are stationary, we confirm that variables are cointegrated, which means that there is a relation on long run.

We are going to produce residuals long term series and save it. We conduct the unit root test of residuals (ordinary one), without trend and intercept (using levels and None for trend on the test details), and the test's results are shown on the following figure:

Augmented Dickey-Fuller Unit Root Test on RESID_LONG_TERM

Null Hypothesis: RESID_LONG_TERM has a unit root
Exogenous: None
Lag Length: 3 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.287516	0.1810
Test critical values:	1% level	-2.595745	
	5% level	-1.945139	
	10% level	-1.613983	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RESID_LONG_TERM)
Method: Least Squares
Date: 08/05/22 Time: 11:49
Sample (adjusted): 2001Q1 2019Q4
Included observations: 76 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID_LONG_TERM(-1)	-0.078446	0.060928	-1.287516	0.2020
D(RESID_LONG_TERM(-1))	-0.072443	0.122730	-0.590264	0.5569
D(RESID_LONG_TERM(-2))	-0.350868	0.111918	-3.135041	0.0025
D(RESID_LONG_TERM(-3))	-0.085768	0.117876	-0.727610	0.4692

R-squared	0.175929	Mean dependent var	0.005577
Adjusted R-squared	0.141593	S.D. dependent var	0.083323
S.E. of regression	0.077199	Akaike info criterion	-2.233659
Sum squared resid	0.429100	Schwarz criterion	-2.110989
Log likelihood	88.87904	Hannan-Quinn criter.	-2.184634
Durbin-Watson stat	1.954627		

Figure 11. Augmented Dickey-Fuller Unit Root Test on Residuals results

Source: Authors' calculations in Eviews software

Null Hypothesis is that long term residuals has a unit root and due to the fact that p-value is bigger than 0.05 we can not reject it. This confirm that residuals are not stationary, and this mean that series are not cointegrated.

Using tables is one method. We will put aside the table and implement the cointegration test provided by EViews. We will conduct the Engle and Granger and Phillips-Ouliaris tests. Both test are residual-based test for cointegration. The tests are simply unit root tests applied to the series residuals.

The null hypothesis for both cointegration tests is: "Series are not cointegrated". Therefore, rejecting the null hypothesis will result in our series being cointegrated.

Engle and Granger and Phillips-Ouliaris tests differ on the method of accounting for serial correlation in the residual series. Engle and Granger test uses a parametric, ADF approach, while Phillips-Ouliaris test uses a non parametric P.Perron approach. By using the Eviews software we conduct cointegration test (Fully-modified OLS (FMOLS), and test's results are as follows:

Dependent Variable: LNGDP
Method: Fully Modified Least Squares (FMOLS)
Date: 08/05/22 Time: 12:06
Sample (adjusted): 2000Q2 2019Q4
Included observations: 79 after adjustments
Cointegrating equation deterministics: C
Long-run covariance estimate (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNPUBLIC_CONS	1.138307	0.312888	3.638063	0.0005
C	0.497363	2.998185	0.165888	0.8687

R-squared	0.189088	Mean dependent var	11.40373
Adjusted R-squared	0.178556	S.D. dependent var	0.182728
S.E. of regression	0.165613	Sum squared resid	2.111928
Long-run variance	0.087603		

Figure 12. Fully Modified Least Square Method Test results
Source: Authors' calculations in Eviews software

Test results do not differ from previous test. We now proceed with the Engle&Granger test, and the test's results are as follows:

Cointegration Test - Engle-Granger
Date: 08/05/22 Time: 12:07
Equation: UNTITLED
Specification: LNGDP LNPUBLIC_CONS C
Cointegrating equation deterministics: C
Null hypothesis: Series are not cointegrated
Automatic lag specification (lag=3 based on Schwarz info criterion, maxlag=11)

	Value	Prob.*
Engle-Granger tau-statistic	-1.287516	0.8352
Engle-Granger z-statistic	-3.950695	0.8096

*MacKinnon (1996) p-values.

Intermediate Results:	
Rho - 1	-0.078446
Rho S.E.	0.060928
Residual variance	0.005960
Long-run residual variance	0.002617
Number of lags	3
Number of observations	76
Number of stochastic trends**	2

**Number of stochastic trends in asymptotic distribution.

Engle-Granger Test Equation:
Dependent Variable: D(RESID)

Figure 13. Cointegration Test – Eangle-Granger results
Source: Authors' calculations in Eviews software

Null hypothesis is that series are not cointegrated. If p-value < 0.05 we can reject the hypothesis. However, we can see that p-value is bigger than 0.05, that means that we can not reject null hypothesis. We confirm using Engle-Granger method that series are not cointegrated. The method 1 and 2 provides us the same conclusions.

We are performing third cointegration test of Philips-Ouliaris, and test's results are as shown on the following figure:

Cointegration Test - Phillips-Ouliaris
Date: 08/05/22 Time: 12:09
Equation: UNTITLED
Specification: LNGDP LNPUBLIC_CONS C
Cointegrating equation deterministics: C
Null hypothesis: Series are not cointegrated
Long-run variance estimate (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)
No d.f. adjustment for variances

	Value	Prob.*
Phillips-Ouliaris tau-statistic	-1.863998	0.6002
Phillips-Ouliaris z-statistic	-7.044803	0.5531

*MacKinnon (1996) p-values.

Intermediate Results:	
Rho - 1	-0.124723
Bias corrected Rho - 1 (Rho* - 1)	-0.089175
Rho* S.E.	0.047841
Residual variance	0.006316
Long-run residual variance	0.004534
Long-run residual autocovariance	-0.000891
Number of observations	79
Number of stochastic trends**	2

**Number of stochastic trends in asymptotic distribution.

Figure 14. Cointegration Test – Phillips –Ouilaris results
Source: Authors' calculations in Eviews software

Null hypothesis is: Series are not cointegrated. However, p-values are higher than 0.05, and we can not reject the null hypothesis, that finally confirms that series are not cointegrated.

CONCLUSION

In this paper we present two methods for testing cointegration, tabular regression test and Engle-Granger cointegration test and Phillips Ouliaris cointegration test.

In order to test time series stationarity, we integrated both series on same order. We used for both series first difference. Stationarity was checked by unit root test, using standard ADF test and Shwartz criterion. We concluded that both variables are integrated with same order (first difference) and confirm that are stationary on the first difference. As a second step, we check the residuals and by using Least Square method confirmed that constant C is significant and that 1% increase of GDP causes 0.83% public consumption growth. We did not find the presence of spurious regression. ADF Unit Root Test on residuals confirms that residuals are not stationary and that series are not cointegrated.

First method results were confirmed by the Engle-Granger cointegration test and Phillips Ouliaris cointegration test. There was no difference in conclusions provided with second method cointegration tests. The value of p-value was higher that 0.05 and we could not reject the Null Hypothesis: Series are not cointegrated.

That finding confirms that GDP and Public consumption of the Republic of North Macedonia are not cointegrated and can be used for further analyze using VAR(p) model. There is no doubt that both time series have significant mutual influence, but the character and intensity of influence could be determined by further investigation.

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