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GRANGER CAUSALITY TEST FOR THE GOVERNMENT'S CAPITAL EXPENDITURES ON THE GDP OF THE REPUBLIC NORTH MACEDONIA IN VAR ENVIRONMENT

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Abstract
In this paper, we test Granger causality in VAR environment of the State Budget's capital expenditures on the GDP. There is no doubt that capital expenditures for infrastructure projects, energetic, communications and similar have direct and indirect impact on the GDP growth, but non-essential capital spending raise the question if this part of public consumption as well part of the State Budget resources have influence on the Macedonian GDP growth. We are testing the impact of capital expenditures on the GDP by using econometric model of the Granger causality in VAR environment in order to determine if there is two-ways connections between GDP and capital expenditures from the Budget of the Republic of North Macedonia. We did not find Granger Causality between capital expenditures and GDP of the Republic of North Macedonia for the analyzed period 2006-2019. It implicates that capital expenditures cannot be used for the accurate GDP forecasts with acceptable level of certainty.

Key words**:** Granger causality, VAR, environment, capital expenditures, probability

JEL Classification: C1, C32, C35

INTRODUCTION

Theoretical literature for fiscal economy prevails with attitudes for the importance and positive impact of the state's capital expenditures on the GDP (Ilzetzki, and all, 2010), (Ostry and all, 2010), (Hebous, 2010), (Rahman, 2010).

However, we can find many evidences in the countries that public expenditures are using for financing different expenditures (e.g. monuments, facades, vehicles, furniture and similar spending for the public administration needs) and are all classified as capital investments in the Budget, as it was a case with the project "Skopje 2014".

There is no doubt that capital expenditures for infrastructure projects, energetic, communications and similar have direct and indirect impact on the GDP growth, but non-essential spending like mentioned above raise the question if this part of public consumption as well part of the State Budget resources have influence on the North Macedonian GDP growth.

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We are testing the impact of capital expenditures on the GDP by using econometric model of the Granger causality in VAR environment in order to determine if there is two-ways connections between GDP and capital expenditures from the Budget of the Republic of North Macedonia. We are testing Granger Causality between capital expenditures and GDP of the Republic of North Macedonia for the analyzed period 2006-2019. The main task of this paper is to determine if capital expenditures canbe used for the accurate GDP forecasts with acceptable level of certainty.

1. METHODOLOGY

Granger causality is the concept usually used for analysis of multiple time series and interaction between them. The main question here is to determine causality between series and how each series influence other series, or if one series have causal impact on the other series. By answering this question can help us for future forecast, in a case when we are able with certainty to determine one variable.

This mean that when Granger causality exists, as aimpact of one variable on the other variable, by determination of one variable, as independent variable in the model, we can predict dependent variable(Lutkepohl, 1993).

Granger causality can be determined between variables, between lags and variables, as well between variables and their own legs. Same, if we know the values of one time series and its legs, and we already have detected connection and influence between time series, we can easily forecast the values of another time series. If time series are connected on that way, we can say that one time series has Granger causality on the other time series.

It is important to emphasize that during model development we are not sure if one time series influence another time series, but we know with certainty that if we know one of them, we can predict another time series. In our analyze we will try to answer the question is if capital expenditures as a part of total budget expenditures have Granger causality on the GDP, or vice-versa GDP have Granger causality for the capital expenditures.

We will answer this question by testing the following main hypothesis:

$H_{1.0}$.: There is no two-ways impact between capital expenditures and the GDP of the Republic of North Macedonia.

$H_{2.0}$.: There is two-ways impact between capital expenditures and the GDP of the Republic of North Macedonia.

In fact, by using Granger Causality in VAR model we will focus to determine existence of two-ways influence and that is connection between GDP and capital expenditures from the Budget of the Republic of North Macedonia.

Main hypothesis is testing through two individual hypothesis, stated as null and alternative hypothesis:

Individual hypothesis 1.1.:

$H_{1.1.0}$.: Capital expenditures are not Granger causal with the GDP.

$H_{1.1.0}$.: Capital expenditures are Granger causal with the GDP.

Individual hypothesis 1.2.:

$H_{2.1.0.}$: GDP is not Granger causal with capital expenditures.

$H_{2.2.0}$.: GDP is Granger causal with capital expenditures.

In order to test null hypothesis we use F-statistics. For the VAR model testing 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 that capital expenditures have Granger causality on GDP, and for the second individual hypothesis that GDP has Granger causality on capital expenditures(Lane, 2003).

2. DATA

In our research we use time series with 56 observations, quarterly data for the GDP and capital expenditures from 2006Q1 to2019Q4, as shown on the following Table:

Table 1. GPD and Capital expenditures of North Macedonia 2006Q1- 2019Q4

Years	GDP	Capital Exp
2006Q1	76991,00	1087,12
2006Q2	79988,00	2120,45
2006Q3	81024,00	2750,65
2006Q4	86289,00	3307,71
2007Q1	77365,00	1106,00
2007Q2	83626,00	1672,00
2007Q3	89439,00	2381,00
2007Q4	94855,00	8582,00
2008Q1	83620,00	2600,00
2008Q2	91196,00	3446,00
2008Q3	92996,00	2977,00
2008Q4	96367,00	11039,00
2009Q1	86104,00	2592,13
2009Q2	89708,00	3670,00
2009Q3	89512,00	2792,00
2009Q4	97549,00	4374,00
2010Q1	90878,00	3228,80
2010Q2	91270,00	2730,40
2010Q3	97119,00	4941,00
2010Q4	95795,00	4434,00
2011Q1	91638,00	4015,00
2011Q2	96665,00	4884,00
2011Q3	96417,00	4273,00
2011Q4	99117,00	4538,00

Table 1. (continued)

2012Q1	90713,00	4215,00
2012Q2	97105,00	3715,00
2012Q3	96710,00	4419,00
2012Q4	97558,00	6408,00
2013Q1	93617,00	4045,00
2013Q2	99844,00	3980,00
2013Q3	101440,00	3954,00
2013Q4	98362,00	4632,00
2014Q1	96746,00	4308,00
2014Q2	104229,00	4139,00
2014Q3	103324,00	3147,00
2014Q4	103236,00	6029,00
2015Q1	99679,00	4144,00
2015Q2	105177,00	3466,00
2015Q3	108275,00	3748,00
2015Q4	110118,00	7309,00
2016Q1	101100,00	3142,00
2016Q2	107841,00	2999,00
2016Q3	111758,00	4730,00
2016Q4	114605,00	6103,00
2017Q1	105084,00	5055,00
2017Q2	107915,00	3628,00
2017Q3	111969,00	2842,00
2017Q4	115045,00	8338,00
2018Q1	105440,00	1794,00
2018Q2	109714,00	2227,00
2018Q3	114645,00	2576,00
2018Q4	122183,00	5550,00
2019Q1	109446,00	1615,00
2019Q2	113443,00	3665,00
2019Q3	118781,00	3275,00
2019Q4	126360,00	9258,00

Source: State statistics of the Republic of North Macedonia

Time series analysis was performed by using Eviews software for statistical analysis, as shown on following figures.

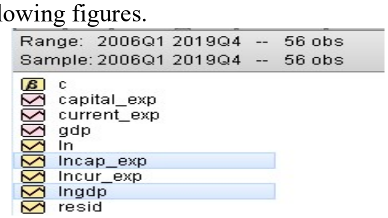

Figure 1. Variables inEviews
Source: Eviews software

In order to determine non-stationarity of time series we use Logs for the GDP and capital expenditures. Calculated logs are shown on the following Table:

Table 2. Calculated logs for the GDP and capital expenditures

	LNGDP	LNCAP_EXP
2006Q1	11.25144381088757	6.991290956052084
2006Q2	11.28963190240489	7.65938266609569
2006Q3	11.30250068606379	7.919591799266365
2006Q4	11.36545740660683	8.104012595332194
2007Q1	11.25628976092377	7.00850518208228
2007Q2	11.33410975550552	7.421775793644648
2007Q3	11.40131210764664	7.775275846486862
2007Q4	11.46010468878664	9.05742226555147
2008Q1	11.33403800491055	7.863266724009574
2008Q2	11.42076631545144	8.144969417087875
2008Q3	11.44031176045772	7.998671361015776
2008Q4	11.47591909834107	9.309189736018352
2009Q1	11.36331114694413	7.860235210535466
2009Q2	11.40431523024618	8.207946941048616
2009Q3	11.40212797348756	7.934513463882264
2009Q4	11.48811009484546	8.383433201236712
2010Q1	11.41727322667057	8.07986583015929
2010Q2	11.42157742551092	7.912203397592498
2010Q3	11.48369230969995	8.50532301884575
2010Q4	11.46996577053009	8.397057390176256
2011Q1	11.4256013117985	8.297792626380861
2011Q2	11.4790066717666	8.493719835230595
2011Q3	11.47643781359878	8.360071435644025
2011Q4	11.50405624950116	8.420241665339788
2012Q1	11.41545595549073	8.346404870435956
2012Q2	11.48354814625955	8.220133957151859
2012Q3	11.47947208871101	8.39366870513074
2012Q4	11.48820235191472	8.765302488748196
2013Q1	11.44696726990568	8.305236829492592
2013Q2	11.51136424690327	8.289037098278482

Table 2. (continued)

2013Q3	11.52722276967105	8.282483003730561
2013Q4	11.4964098295923	8.440744019252831
2014Q1	11.4798442663681	8.36822903827628
2014Q2	11.5543456805206	8.328209491748731
2014Q3	11.54562496113324	8.054204897064408
2014Q4	11.54477290840935	8.704336438489406
2015Q1	11.50971030186823	8.329416783939319
2015Q2	11.56339992420376	8.150756470275551
2015Q3	11.59242956608283	8.228977643358312
2015Q4	11.60930779708653	8.896861744480391
2016Q1	11.52386540500856	8.052614818815566
2016Q2	11.58841319910017	8.00603417874901
2016Q3	11.62409109828038	8.46168048148598
2016Q4	11.64924671232847	8.716535732544495
2017Q1	11.56251530931022	8.528133131454572
2017Q2	11.58909915919307	8.196436811235028
2017Q3	11.62597732625071	7.952263308657046
2017Q4	11.65307863515363	9.028578658440742
2018Q1	11.56589734973633	7.492203042618741
2018Q2	11.60563225890444	7.708410667257368
2018Q3	11.64959567634509	7.853993087224244
2018Q4	11.71327519983913	8.62155320674048
2019Q1	11.60318655591497	7.387090235656758
2019Q2	11.63905578711444	8.206583614320752
2019Q3	11.68503674046016	8.094073148069352
2019Q4	11.74689025491602	9.133243321591216

Source: Authors' calculations in Eviewssoftware

We present calculated log values for the GDP and capital expenditures in a chart in order to determine if time series are stationary:

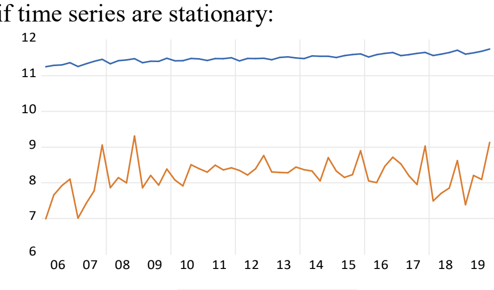

Figure 2. LNGDP and LNCAPEX
Source: Authors' calculations in Eviewssoftware

We need chart's presentation to see if time series are stationary, due to the fact that if time series are non-stationary, regression is spurious and the model is not correct. Stationarity means that variables' mean, variance and covariance are constant through the time and there is no seasonality (Kilian, 2011). We can notice from the chart that

LNGDP time series has moderate growth, which implies that its mean is not constant through the time, and this means that time series are non-stationary. It is difficult to determine stationarity of capital expenditures time series. In order to determine stationarity of time series we also use following measures: R^2 and Durbin-Watson statistics,and we develop following equation with following variables: lngdp, c andlnpcap_exp.

We proceed with analysis with Equation estimates, as shown on following Figure:

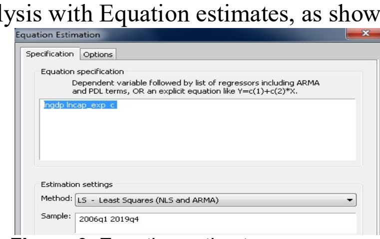

Figure 3. Equation estimates
Source: Eviews software

Equation estimates results performed by the method of Least Squares-NLS and ARMA are shownon following table as follows:

Table 3. Caption Least Squares Method

Dependent Variable: LNGDP
Method: Least Squares
Date: 03/30/20 Time: 22:00
Sample: 2006Q1 2019Q4
Included observations: 56

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNCAP_EXP	0.115276	0.029216	3.945631	0.0002
C	10.55274	0.240186	43.93580	0.0000

R-squared	0.223781	Mean dependent var	11.49893
Adjusted R-squared	0.209407	S.D. dependent var	0.113381
S.E. of regression	0.100813	Akaike info criterion	-1.716041
Sum squared resid	0.548815	Schwarz criterion	-1.643707
Log likelihood	50.04914	Hannan-Quinn criter.	-1.687997
F-statistic	15.56800	Durbin-Watson stat	0.242990
Prob(F-statistic)	0.000232		

Source: Authors' calculations in Eviewssoftware

The main rule of the method of Least Squares is if $R^2 >$ Durbin-Watson statistics it is spurious regression. If we determine spurious regression, we can not use it for hypothesis testing as well for the forecasting, or the result of a such regression is useless. Equation estimates results confirmed that R-squared (0,223) < (0,2429), as it is value of the Durbin-Watson statistics. It confirms that regression is not spurious and variables can be used in the model, which means that one or both of the variables are non-stationary.

Time series non-stationarity is determined if time series have unit roots. In order to determine non-stationarity of the time series we use ADF Test (Augmented Dickey-Fuller Test), which is test for unit roots. Unit roots are important for time series proper modeling. If we determine time series to have unit roots, they are non-stationary and we can not use typical autoregression models like AR, ARIMA, VARand others. This means that we need to make certain transformations to eliminate unit roots from the time series. If we are not able to eliminate unit roots, at least we need to be aware that time series have unit roots and to use another methods of analysis. Unit roots are synonyms for non-stationarity of time series or for variables' random walk. Unit root test is applicable for all time series models. We use in our analysis logs data for GDP and will perform ADF unit root test. We make evaluation by the levels, using interceptandAkaike Info Criterion that automatically offers 10 legs, and ADF test are shown on the Figure bellow as follows:

Augmented Dickey-Fuller Unit Root Test on GDP

Null Hypothesis: GDP has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.231081	0.9275
Test critical values:	1% level	-3.562669	
	5% level	-2.918778	
	10% level	-2.597285	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(GDP)
Method: Least Squares
Date: 03/30/20 Time: 22:02
Sample (adjusted): 2007Q1 2019Q4
Included observations: 52 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDP(-1)	-0.009683	0.041903	-0.231081	0.8183
D(GDP(-1))	-0.872354	0.085566	-10.19516	0.0000
D(GDP(-2))	-0.879171	0.089062	-9.871418	0.0000
D(GDP(-3))	-0.884822	0.082165	-10.76879	0.0000
C	3488.820	4172.642	0.836118	0.4073

R-squared	0.786355	Mean dependent var	770.5962
Adjusted R-squared	0.768173	S.D. dependent var	5751.987
S.E. of regression	2769.491	Akaike info criterion	18.78193
Sum squared resid	3.60E+08	Schwarz criterion	18.96955
Log likelihood	-483.3301	Hannan-Quinn criter.	18.85386
F-statistic	43.24790	Durbin-Watson stat	1.538509

Figure 4. Augmented Dickey-Fuller Test results
Source: Authors' calculations in Eviewssoftware

Null hypothesis of Augmented Dickey-Fuller Testis:GDP has unit root. ADF test use 3 legs from the maximum 10 legs, based on Akaike Info Criterion. ADF test results are represented in t-statistics andp-value. ADFtest statistics resultfort-statistics is -0,231and is less than test critical values for 1%, 5% and 10%, which means that null hypothesis can not be rejected. Same, p-value >5%, which indicates that null hypothesis can not be rejected. This means that this time series has unit root. The lower part of result is regression of unit root, where we can see that ADF uses 3 legs and where p-value of constant c >5%, and we can not reject null hypothesis, which confirms time series non-stationarity. We proceed testing with Augmented Dickey-Fuller Unit Root Test by using GDP first difference, with 2 legs, based on Akaike(AIC), with maximum 10 legs as well as onintercept.

Augmented Dickey-Fuller Unit Root Testis shown as follows:

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

Null Hypothesis: D(GDP) has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-18.09180	0.0000
Test critical values:	1% level	-3.562669	
	5% level	-2.918778	
	10% level	-2.597285	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(GDP,2)
Method: Least Squares
Date: 03/30/20 Time: 22:03
Sample (adjusted): 2007Q1 2019Q4
Included observations: 52 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GDP(-1))	-3.646921	0.201579	-18.09180	0.0000
D(GDP(-1),2)	1.768158	0.147167	12.01463	0.0000
D(GDP(-2),2)	0.885562	0.081289	10.89395	0.0000
C	2529.204	403.0883	6.274566	0.0000

R-squared	0.921451	Mean dependent var	44.50000
Adjusted R-squared	0.916541	S.D. dependent var	9491.590
S.E. of regression	2742.046	Akaike info criterion	18.74460
Sum squared resid	3.61E+08	Schwarz criterion	18.89470
Log likelihood	-483.3596	Hannan-Quinn criter.	18.80214
F-statistic	187.6935	Durbin-Watson stat	1.542049
Prob(F-statistic)	0.000000		

Figure 5. Augmented Dickey-Fuller Unit Root Test Results
Source: Authors' calculations in Eviewssoftware

Null hypothesis of ADF test is:LNGDP first difference has unit roots. We use 2 legs in the test. ADFtest statistics result for t-statistics is -18,09, but we use absolute value which means that is bigger than test critical values for 1%, 5% and 10%, which means that null hypothsis is rejected.

We can see that p-value = 0and is < 5%, which indicates that null hypothesis: First difference of LNGDP has unit root, is rejected. This means that time series has no unit roots, and that by using 2 legs this time series is non-stationary. The lower part of the result is regression of the unit root test where ADF test uses 2 legs and where p-value of constant *c*< 5%, which confirms variable is significant and that R^2< Durbin-Watson, and we can reject null hypothesis, and to prove that time series DLNGDP is stationary after 2 legs.

This can be seen on the following Figure with First difference LNGDP results:

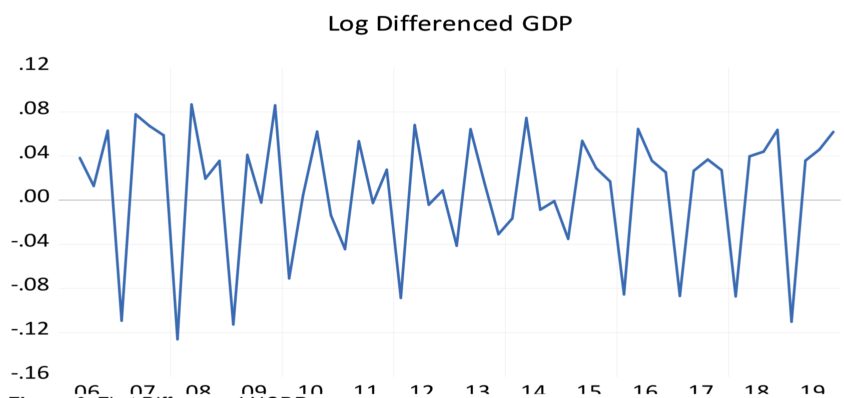

Figure 6. First Difference LNGDP
Source: Authors' calculations in Eviewssoftware

We can clearly see that that first difference of LNGDP is stationary and that has clear mean reversion, which means that oscillates around 0,000.

3. EMPIRICAL RESULTS

Analysis proceed with VAR estimates. For the VAR estimates we use unrestricted VAR model, due to the fact that we need to use time series first difference in order to avoid non-stationarity. On the next Figure we present the model with 2 legs:

Vector Autoregression Estimates

Vector Autoregression Estimates
Date: 04/01/20 Time: 17:41
Sample (adjusted): 2006Q4 2019Q4
Included observations: 53 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	D(LNGDP)	D(LNCAP_EXP)
D(LNGDP(-1))	-0.114815	5.747680
	(0.17150)	(1.71341)
	[-0.66949]	[3.35453]
D(LNGDP(-2))	-0.108113	5.571455
	(0.17172)	(1.71563)
	[-0.62959]	[3.24747]
D(LNCAP_EXP(-1))	-0.065104	-1.111412
	(0.01661)	(0.16596)
	[-3.91932]	[-6.69691]
D(LNCAP_EXP(-2))	-0.024902	-0.510912
	(0.01845)	(0.18435)
	[-1.34953]	[-2.77138]
C	0.011137	-0.039897
	(0.00649)	(0.06486)
	[1.71563]	[-0.61517]
R-squared	0.439100	0.496724
Adj. R-squared	0.392359	0.454784
Sum sq. resids	0.099088	9.890854
S.E. equation	0.045435	0.453938
F-statistic	9.394201	11.84377
Log likelihood	91.27029	-30.71869
Akaike AIC	-3.255483	1.347875
Schwarz SC	-3.069606	1.533752
Mean dependent	0.008385	0.022899
S.D. dependent	0.058286	0.614769

Figure 7. VAR Estimates
Source: Authors' calculations in Eviewssoftware

Dependent variables in the model are GDP and capital expenditures, while independent variables are GDP (-1) and (-2), and capital expenditures (-1) and (-2).

Null hypothesis of the model is:Capital expenditures (-1) and (-2) have no impact on GDP. Model results are presented and in the first row are coefficients of Vector Autoregression, in the second row are standard errors (shown in small brackets), while in the third row is t-statistics(shown in medium brackets), as a value calculated as quotient between coefficient and standard error. Main condition for the statistical significance is *t-statistics > 2*.

Before the coefficients analysis and t-statistics, we additionally analyses the structure of legs (VAR Lag Order Selection Criteria), in order to determine exact number of legs in the model. Results are on the following Figure:

VAR Lag Order Selection Criteria
Endogenous variables: D(LNGDP) D(LNCAP_EXP)
Exogenous variables: C
Date: 04/01/20 Time: 17:43
Sample: 2006Q1 2019Q4
Included observations: 50

Lag	LogL	LR	FPE	AIC	SC	HQ
0	44.26983	NA	0.000632	-1.690793	-1.614312	-1.661669
1	63.04339	35.29428	0.000350	-2.281735	-2.052293	-2.194362
2	80.86080	32.07134	0.000202	-2.834432	-2.452027	-2.688810
3	104.8548	41.26972*	9.09e-05	-3.634193	-3.098826*	-3.430322*
4	108.9730	6.753852	9.08e-05*	-3.638921*	-2.950593	-3.376802
5	110.5994	2.537152	0.000101	-3.543976	-2.702686	-3.223608

* 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

Figure 8. VAR Lag Order Selection Criteria
Source: Authors' calculations in Eviewssoftware

Model offers different criterions like:LR (sequential modified LR test statistic), FPE (Final Prediction Error), AIC (Akaike information criterion), SC (Schwarz information criterion) andHQ (Hannan-Quinn information criterion). We can see that FPE andAICinformation criterion suggest 4 legs, while LR, SC andHQindicates 3 legs. We accept FPE andAICinformation criterions, and in following analysis we will estimate

VAR model with 4 legs..The change of VAR specification and determination of maximum 4 legs in accordance with Akaike (AIC) is shown on the following Figure:

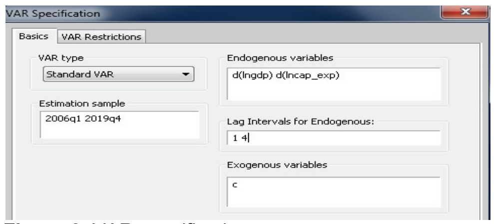

Figure 9. VAR specification
Source: Authors' calculations in Eviewssoftware

VAR estimates with 4 legs are presented on the following Figure:

Vector Autoregression Estimates

Vector Autoregression Estimates
Date: 04/01/20 Time: 17:45
Sample (adjusted): 2007Q2 2019Q4
Included observations: 51 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	D(LNGDP)	D(LNCAP_EXP)
D(LNGDP(-1))	-0.406524	5.973586
	(0.17341)	(2.19298)
	[-2.34428]	[2.72396]
D(LNGDP(-2))	-0.409227	5.626257
	(0.19013)	(2.40437)
	[-2.15239]	[2.34002]
D(LNGDP(-3))	-0.243744	2.643153
	(0.19997)	(2.52889)
	[-1.21888]	[1.04518]
D(LNGDP(-4))	0.353998	4.195384
	(0.16459)	(2.08144)
	[2.15077]	[2.01562]
D(LNCAP_EXP(-1))	-0.029765	-1.020964
	(0.01393)	(0.17616)
	[-2.13669]	[-5.79554]
D(LNCAP_EXP(-2))	-0.027130	-0.736358
	(0.01780)	(0.22507)
	[-1.52435]	[-3.27162]
D(LNCAP_EXP(-3))	-0.029270	-0.531533
	(0.01746)	(0.22084)
	[-1.67609]	[-2.40686]
D(LNCAP_EXP(-4))	-0.001908	-0.003654
	(0.01411)	(0.17843)
	[-0.13525]	[-0.02048]
C	0.013212	-0.085917
	(0.00577)	(0.07293)
	[2.29107]	[-1.17812]
R-squared	0.806632	0.730841
Adj. R-squared	0.769799	0.679573
Sum sq. resids	0.030897	4.941235
S.E. equation	0.027123	0.342999
F-statistic	21.90024	14.25521
Log likelihood	116.5614	-12.84350
Akaike AIC	-4.218094	0.856608
Schwarz SC	-3.877183	1.197518
Mean dependent	0.009620	0.041662
S.D. dependent	0.056530	0.605938

Determinant resid covariance (dof adj.)	6.56E-05
Determinant resid covariance	4.45E-05
Log likelihood	110.7735
Akaike information criterion	-3.638178
Schwarz criterion	-2.956357
Number of coefficients	18

Figure 10. VAR Estimates
Source: Authors' calculations in Eviewssoftware

During analysis of the VAR model we need to estimate coefficients that are "blue" (best linear unbiased estimators), which means that offer the best answer for the VAR character. Model determined 18 coefficients and we have to determine their significance. In order to do that, we need to determine *p-value*. Testing and interpretation of coefficient significance will be done by VAR system development and estimation of autocorrelation of the residuals, residuals normality and residuals' heterostedacitity.

We have used unrestricted VAR method, because we assume that time series are cointegrated (have no long term causality, which means that we assume short-term causality. Moreover, this model use time series first difference in order to avoid non-stationarity of variables. In order to determine cointegration we use Johansen cointegration test or any other cointegration tests and if there is no cointegration we can proceed with the use of the model.

VAR results will be confirmed after residuals autocorrelation estimation. In order to do thet we test residuals with two methods. First, we make VAR Residual Portmanteu Test for Autocorellations) and results are shown on the next Figure:

VAR Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: No residual autocorrelations up to lag h
Date: 04/01/20 Time: 17:46
Sample: 2006Q1 2019Q4
Included observations: 51

Lags	Q-Stat	Prob.*	Adj Q-Stat	Prob.*	df
1	0.545254	---	0.556159	---	---
2	1.459705	---	1.507934	---	---
3	5.430554	---	5.726962	---	---
4	7.540648	---	8.016638	---	---
5	8.814352	0.0659	9.428788	0.0512	4

*Test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution

Figure 11. VAR Residual Portmanteu Test for Autocorellations
Source: Authors' calculations in Eviews software

Null hypothesis of VAR Residual Portmanteau Test for Autocorrelations is:there is no autocorrelation between residuals and legs - h.

There is no values for the first 4 legs, due to the fact that model use 4 legs. The value for the p-valuefor the fifth leg is >0,05, which indicates that null hypothesis can not be rejected, or we can confirm that there is no autocorrelation between residuals.

In order to make additional check for residual autocorrelation we use VAR Residual Serial Correlation LM. Test results are shown on the following Figure:

VAR Residual Serial Correlation LM Tests
Date: 04/01/20 Time: 17:47
Sample: 2006Q1 2019Q4
Included observations: 51

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	4.449593	4	0.3486	1.129837	(4, 78.0)	0.3486
2	1.800844	4	0.7723	0.449617	(4, 78.0)	0.7724
3	5.758140	4	0.2180	1.474393	(4, 78.0)	0.2180
4	3.383122	4	0.4959	0.853213	(4, 78.0)	0.4959
5	2.049639	4	0.7266	0.512544	(4, 78.0)	0.7267

Null hypothesis: No serial correlation at lags 1 to h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	4.449593	4	0.3486	1.129837	(4, 78.0)	0.3486
2	9.698289	8	0.2868	1.241604	(8, 74.0)	0.2874
3	10.95738	12	0.5326	0.917642	(12, 70.0)	0.5343
4	18.01574	16	0.3230	1.154635	(16, 66.0)	0.3271
5	21.76017	20	0.3537	1.111772	(20, 62.0)	0.3616

*Edgeworth expansion corrected likelihood ratio statistic.

Figure 12. VAR Residual Serial Correlation LM
Source: Authors' calculations in Eviews software

First null hypothesis of the VAR Residual Serial Corellation LM test is:there is no series correlation for the legs - h.

The calculatedp-valuefor all 5 legs are >0,05, which indicates that we cannot reject null hypothesis, which means that we can confirm no autocorrelation between residuals. Second null hypothesis of the VAR Residual Serial Corellation LM test is:there is no serial correlation for the legs 1 to h. The calculated p-valuefor all 5 legs are >0,05, which indicates that we cannot reject null hypothesis, which means that we can confirm no autocorrelation between residuals for the legs 1 toh.

The analysis proceed with Multivariate Normality Test in order to test residuals normality and we use ortogonalization method of Cholesky of covariance (Lutkepohl), as presented on the following Figure:

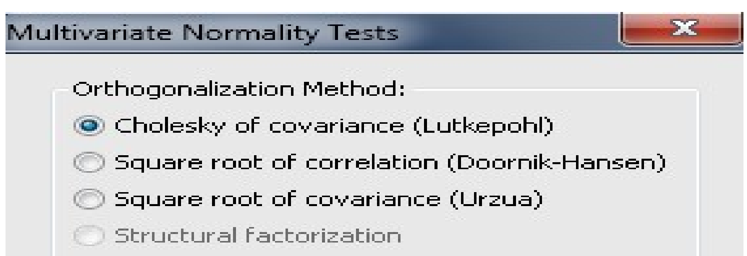

Figure 13. VAR Multivariate Normality Test
Source: Eviewssoftware

VAR Residual Normality Test (Cholesky) results are presented as follows:

VAR Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: Residuals are multivariate normal
Date: 04/01/20 Time: 17:48
Sample: 2006Q1 2019Q4
Included observations: 51

Component	Skewness	Chi-sq	df	Prob.*
1	-0.112236	0.107075	1	0.7435
2	-0.132969	0.150286	1	0.6983
Joint		0.257360	2	0.8793

Component	Kurtosis	Chi-sq	df	Prob.
1	2.530987	0.467443	1	0.4942
2	2.100856	1.717976	1	0.1900
Joint		2.185419	2	0.3353

Component	Jarque-Bera	df	Prob.
1	0.574517	2	0.7503
2	1.868262	2	0.3929
Joint	2.442779	4	0.6549

*Approximate p-values do not account for coefficient estimation

Figure 14. VAR Residual Normality Test (Cholesky)
Source: Authors' calculations in Eviewssoftware

Null hypothesis of VAR Residual Normality Test is:residuals are multi-variant normal. The calculated values for the a p-value for Skewness (0,8223), andKurtosis (0,4443), as well for the series normal distribution, as Jarque-Bera(0,7337) are > 0,05, which indicates that null hypothesis can not be rejected, which means that we confirm residuals normality. This is also confirmed on the Figure of the model unit roots, where we can see that all roots lies in unique circle, which means that VAR model variables are stationary.

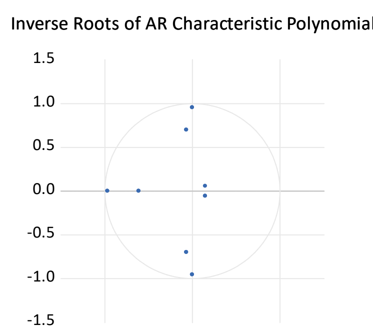

Figure 15. Model Unit Roots
Source: Authors' calculations in Eviewssoftware

In order to use VAR model we need to confirm that there is no residuals heteroscedasticity. We use VAR Residual Heteroscedasticity Test (Levels and Squares), list square method, and test results are shown as follows:

VAR Residual Heteroskedasticity Tests (Levels and Squares)
Date: 04/01/20 Time: 17:48
Sample: 2006Q1 2019Q4
Included observations: 51

Joint test:

Chi-sq	df	Prob.
37.14656	48	0.8718

Individual components:

Dependent	R-squared	F(16,34)	Prob.	Chi-sq(16)	Prob.
res1*res1	0.280256	0.827441	0.6481	14.29308	0.5769
res2*res2	0.203143	0.541726	0.9040	10.36029	0.8471
res2*res1	0.304372	0.929792	0.5460	15.52295	0.4867

Figure 16. VAR Residual Heteroscedasticity Test (Levels and Squares)
Source: Authors' calculations in Eviewssoftware

Null hypothesis of VAR Residual Heteroscedasticity Test is:residuals are not heteroscedastic. The p-value is > 5%, and we can not reject null hypothesis, which menas that we confirm that residuals are heterscedastic(Akgiray, 1989).

Model residuals are homoscedastic, and it fulfills another one model of least squares assumptions. Finally, we proceed with Granger causality test and results are shown on the following Figure:

VAR Granger Causality/Block Exogeneity Wald Tests
Date: 04/01/20 Time: 17:50
Sample: 2006Q1 2019Q4
Included observations: 51

Dependent variable: D(LNGDP)

Excluded	Chi-sq	df	Prob.
D(LNCAP_EXP)	6.647071	4	0.1558
All	6.647071	4	0.1558

Dependent variable: D(LNCAP_EXP)

Excluded	Chi-sq	df	Prob.
D(LNGDP)	12.13904	4	0.0163
All	12.13904	4	0.0163

Figure 17. VAR Granger Causality/Block Exogeneity Wald Test
Source: Authors' calculations in Eviewssoftware

Null hypothesis of the model is:capital expenditures and all capital expenditures legs together are not Granger causal on GDP.

The value of Chi-sq test, as well probability(p-value=0,1558> 5%) confirms that null hypothesis can not be rejected, even for the first leg, nor by all 4 legs for the capital expenditures.

This leads us to conclusion that capital expenditures are not Granger causal on GDP.

The second dependent variable are capital expenditures.

Null hypothesis is: GDP, for the first leg and all other 4 legs are not Granger causal on capital expenditures.

The value of Chi-sq test, as well probability(p-value=0,0163>0,05) confirms that null hypothesis can be rejected and to accept alternative hypothesis that GDP, first leg and other 4 legs are Granger causal on the capital expenditures.

We can conclude that GDP has Granger causality on capital expenditures.

For the VAR system estimation we use the Ordinary Least Square Method, as shown on the following Figure:

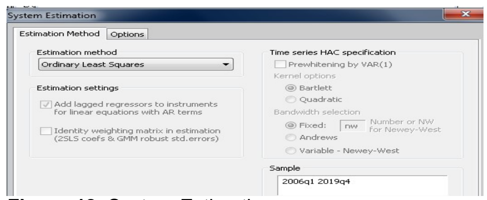

Figure 18. System Estimation
Source: Eviewssoftware

System estimation results are shown on the following Figure:

System: UNTITLED
Estimation Method: Least Squares
Date: 04/01/20 Time: 17:51
Sample: 2007Q2 2019Q4
Included observations: 51
Total system (balanced) observations 102

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.406524	0.173411	-2.344277	0.0214
C(2)	-0.409227	0.190127	-2.152393	0.0342
C(3)	-0.243744	0.199974	-1.218882	0.2263
C(4)	0.353998	0.164591	2.150773	0.0344
C(5)	-0.029765	0.013930	-2.136689	0.0355
C(6)	-0.027130	0.017798	-1.524355	0.1312
C(7)	-0.029270	0.017463	-1.676088	0.0974
C(8)	-0.001908	0.014109	-0.135248	0.8927
C(9)	0.013212	0.005767	2.291068	0.0245
C(10)	5.973586	2.192982	2.723956	0.0078
C(11)	5.626257	2.404365	2.340018	0.0217
C(12)	2.643153	2.528894	1.045181	0.2989
C(13)	4.195384	2.081439	2.015617	0.0470
C(14)	-1.020964	0.176164	-5.795544	0.0000
C(15)	-0.736358	0.225075	-3.271618	0.0016
C(16)	-0.531533	0.220841	-2.406860	0.0183
C(17)	-0.003654	0.178428	-0.020479	0.9837
C(18)	-0.085917	0.072927	-1.178117	0.2421

Determinant residual covariance 4.45E-05

Equation: D(LNGDP) = C(1)*D(LNGDP(-1)) + C(2)*D(LNGDP(-2)) + C(3)*D(LNGDP(-3)) + C(4)*D(LNGDP(-4)) + C(5)*D(LNCAP_EXP(-1)) + C(6)*D(LNCAP_EXP(-2)) + C(7)*D(LNCAP_EXP(-3)) + C(8)*D(LNCAP_EXP(-4)) + C(9)

Observations: 51

R-squared	0.806632	Mean dependent var	0.009620
Adjusted R-squared	0.769799	S.D. dependent var	0.056530
S.E. of regression	0.027123	Sum squared resid	0.030897
Durbin-Watson stat	2.094188		

Equation: D(LNCAP_EXP) = C(10)*D(LNGDP(-1)) + C(11)*D(LNGDP(-2)) + C(12)*D(LNGDP(-3)) + C(13)*D(LNGDP(-4)) + C(14)*D(LNCAP_EXP(-1)) + C(15)*D(LNCAP_EXP(-2)) + C(16)*D(LNCAP_EXP(-3)) + C(17)*D(LNCAP_EXP(-4)) + C(18)

Observations: 51

R-squared	0.730841	Mean dependent var	0.041662
Adjusted R-squared	0.679573	S.D. dependent var	0.605938
S.E. of regression	0.342999	Sum squared resid	4.941236
Durbin-Watson stat	2.118886		

Figure 19. System Estimation Method of Least Square
Source: Authors' calculations in Eviewssoftware

System shows model with 18 coefficients (C), from whom first nine are for defining the model of GDP as dependent variable: C(1) to C(9), and another nine fromC(10) to C (18) are for defining capital expenditures.

VAR model results confirms:

- Coefficients for the first, second and fourth legs of GDP are statistically significant for the current GDP;
- Coefficient for the first leg of the capital expenditures is statistically significant for the current GDP;
- Coefficients for the first, second and fourth legs of GDP are statistically significant for the capital expenditures;
- Coefficients for the first, second and third leg of capital expenditures are statistically significant for the capital expenditures;
- Coefficient forDurbin-Watson statistic for both variables is 2, that indicates that there is no serial correlation in the regression.

For the VAR model testing we use Wald statistical test, where for the coefficients from C(5) to C(8)we give them value =0, which means that in accordance with null hypothesis capital expenditures are not Granger causal on GDP:

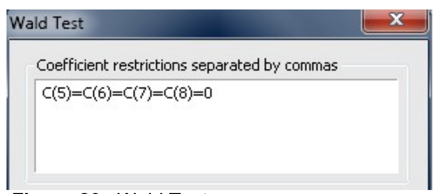

Figure 20. Wald Test
Source: Eviewssoftware

Wald Test results are as shown bellow:

Wald Test:
System: {%system}

Test Statistic	Value	df	Probability
Chi-square	4.176192	2	0.1239

Null Hypothesis: C(6)=C(7)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(6)	2.822289	1.575555
C(7)	-2.086689	1.638377

Restrictions are linear in coefficients.

Figure 21. Wald Test Results
Source: Authors' calculations in Eviewssoftware

Null hypothesis is: capital expenditures coefficients = 0, and null hypothesis could not be rejected, in accordance with Chi-square value, as well as p-value=0.1239, and that is >0,05. In accordance with that we confirm the null hypothesis that capital expenditures have no Granger causality on the GDP.We give values for the coefficients from C(10) to C(13)that are = 0, which is in accordance with the null hypothesis that GDP is not Granger causal on capital expenditures:

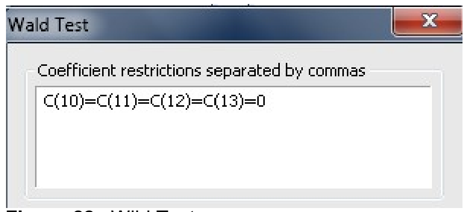

Figure 22. Wild Test
Source: Eviewssoftware

Wald Testresults are shown on the following figure:

Wald Test:
System: {%system}

Test Statistic	Value	df	Probability
Chi-square	12.13904	4	0.0163

Null Hypothesis: C(10)=C(11)=C(12)=C(13)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(10)	5.973586	2.192982
C(11)	5.626257	2.404365
C(12)	2.643153	2.528894
C(13)	4.195384	2.081439

Restrictions are linear in coefficients.

Figure 23. Wild Test Results
Source: Authors' calculations in Eviewssoftware

Null hypothesis is: GDP coefficients are =0, and this hypothesis can be rejected, in aacordance with Chi-square value, as well as p-value=0.0163, and that is <0,05. In accordance with that we confirm null hypothesis that GDP is Granger causal on capital expenditures.

Based on explained research results:

Individual hypothesis1.1.:

$H_{1.1.0.}$:Capital expenditures are not Granger causal on GDP – is accepted.

$H_{1.1.0.}$:Capital expenditures are Granger causal on GDP – is rejected.

Individual hypothesis1.2.:

$H_{1.2.0.}$:GDP is not Granger causal on capital expenditures – is rejected.

$H_{1.2.0.}$:GDP is Granger causal on capital expenditures – is accepted.

Based on accepted individual hypothesis we can confirm that:

Main hypothesis:

$H_{1.0.}$: There is no two ways impact between capital expenditures and GDP of the Republic of North Macedonia– is accepted.

$H_{1.1.}$: There is two ways impact between capital expenditures and GDP of the Republic of North Macedonia– is rejected.

CONCLUSION

This paper research finding confirms that capital expenditures, as main instrument for the GDP growth and overall economic growth, as well as a most used tool for contra cyclical economic policy, do not have Granger causality impact on the GDP of the Republic of the North Macedonia for the analyzed period 2006-2019.

This mean that determination of capital expenditures in Macedonia does not provide accurate GDP forecast.

That finding absolutely confirms that not only scope and dynamic of capital expenditures are important for providing stabilization and development effects, but more important became the structure and the quality of capital expenditures. This definitely mean that there is clear need for capital projects selection in order to select projects with propulsive influence on the national economy. This is the only way for capital expenditures can became important and crucial factor for dynamic and sustainable GDP growth.

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