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A REGRESSION MODEL OF INFLATION IN MONTENEGRO

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ABSTRACT

A regression model of inflation in Montenegro is specified and estimated employing the technique of OLS on a monthly time series data for the three year period 2010-2013. The stationary and co-integratin tests were adopted to examine the data in order to establish whether there exist a long-run relation among the variables. Several diagnostic tests were used to check for the specification of the model and problems of heteroscedasticity, autocorrelation and multicolinearity in the estimated regression model. The regression model is used to test theory on empirical data in case of Montenegro. As expected, the estimated model is another empirical evidence of the Philips curve i.e. theoretical trade-off between unemployment and inflation in a short run. Moreover, the results of the regression analysis proved theory that there is a direct relation between inflation and import-to-export ratio, while the relation inflation - GDP rate is an indirect one.

KEY WORDS: Inflation, Regression model, Stationary, Co-integration

JEL classification: C13, C22, C51
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1. INTRODUCTION

In the last decades, inflation has been one of the main problems of the world economy. The generalized increase of the prices lead to significant distortions in the economic, monetary, political and social environment. Inflation is a potential obstacle and a permanent threat to every economy. It is one of the main factors of economic crisis, it discourages investments and it determins the capital migration. Due to its multiple influences and mainly negative impact on economic development inflation is one of the most researched economic phenomenon. (Draskovic, 2007)

During 1990s Montenegro had experienced major economic, political and social instability and very volatile price dynamics with high level of inflation. The Montenegrin economy is a specific one in a sense that the monetary policy is of limited power because Montenegro has no its own currency, but instead uses euro eventhough it is not a member of eurozone. By introducing the Deutch Mark as a national currency in 1999, and in Euro in 2004, Montenegrin government has denied the main instrument of monetary policy. However, in the last decade Montenegro has achieved better price stability with periodic oscillation due to structural reforms (imtroduction of DEM, Euro, implementation of VAT, etc)(Lipovina-Bozovic, 2013).

In Montenegro, inflation is important not only for economic but also for political reasons. Montenegro has started the process of EU integration and as a candidate state for EU membership it has the task to keep inflation at certain specified level. Therefore the Central Bank of Montenegro has to control inflation and mitigate its negative impact on Montenegrin economy.

This paper contributes with the empirical research of the relations between inflation and the most important macroeconomic variables in Montenegro. The regression model is used to test theory on empirical data for Montenego, i.e. to test whether the inverse relations between inflation on one side and unemployment and GDP on the other side hold for Montenegro during the current economic crises, as well as whether there is a direct relation between import-to-export ratio and inflation.

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2. METHODOLOGY AND DATA

Consumer price index is the most often used measure of inflation. Statistical Office of Montenegro has recently started to produce CPI with the base in 2003. Its creation marked important introduction and implementation of international standard in the statistics of price dynamics in Montengro. Inflation being endogenous variable of the regression model in this paper is measured by CPI.

To develop a regression model of inflation it is necessary to identify and underline the main influence factors, i.e. exogenous variables. Those factors are very diverse and have origin within national economy as well as from external sources. Montenegro is a small and open economy using euro as its own currency. Since agricultural and processing industries make up less then 20% of GDP of Montenegro, it is an import dependent economy From the large number of known inflation influence factors, having in mind restrictions regarding the availability of data, after preliminary statistical analysis, several (level) variables including number of unemployed (UNEMP), gross domestic product rate (LOG(GDP)), minimal consumer basket (CONS_BASK) and import-to-export (IMP_EXP) ratio are chosen to constitute the set of exogeneous variables in the regression model of inflation in case of Montenegro. The statistical test of significance and omitted variable specification test indicated wages as insignificant variable and consequently it was droped from the model.

The data are obtained from MONSTAT (Statistical Office of Montenegro) and from Central bank of Montenegro. The data are of the time-series form, i.e. the monthly data from January 2010 to December 2013.

The method of analysis in this paper is the Ordinary Least Square (OLS) technique applied to a multiple regression model. The OLS is a statistical technique used to estimate structural parameters of the model in such a way as to minimize the sum of the deviations of the actual observation from their model estimated values. It is one of the most commonly used methods in estimating relationships in econometric models and it produces best, linear, unbaised estimates (BLUE) (Koutsoyiannis, 1997).

According to standard econometric procedure it is necessary to firstly check the data for possible non-stationarity. This need arises from the fact that if a time series data is non -stationary, the regression performed on variables with unit root would be “spurious” (Granger and Newbold, 1974) or “dubious” (Phillips, 1987). A series is stationary if its mean and variance are constant over time and the value of covariance between the two time periods depend only on the distance or lag between the two periods and not the actual time at which the covariance is computed (Gujarati, 2004). To test stationary several tests can be used. In this paper the Augmented Dickey Fuller (ADF) and Phillips Perron (PP) tests are implemented.

Secondly, it should be tested whether the identified non-stationary series are co-integrated. The variables are said to be co-integrated if they satisfy the condition that there exist at least (k-1) co-integrating equations i.e. stationary linear combinations of individually non-stationary variables. (Maddala and Kim, 1998).

After the model is estimated several diagnostic tests has to be done so that all needed corrections, or even different estimators can be employed if necessary. These diagnostic tests are used to check for the specification of the model, as well as for the possible problems of heteroscedasticity, autocorrelation and multicolinearity in the estimated regression model. For that purpose we employed Ramsey RESET and JB tests to check for specification, White Heteroscedasticity test, Breusch-Godfrey Serial Correlation LM test and correlation martix.

3. EMPIRICAL RESULTS

Stationary test

Most economic time series are far from stationary when expessed in their original measure units. Non-stationary can have important consequences for regression models and inference. That is why Unit-root tests shoul be performed on all used time series before the model specification.The Augmented Dickey Fuller (ADF) or Phillips Perron (PP) unit root test for stationary were performed with the following results.

Table 1: Unit root tests

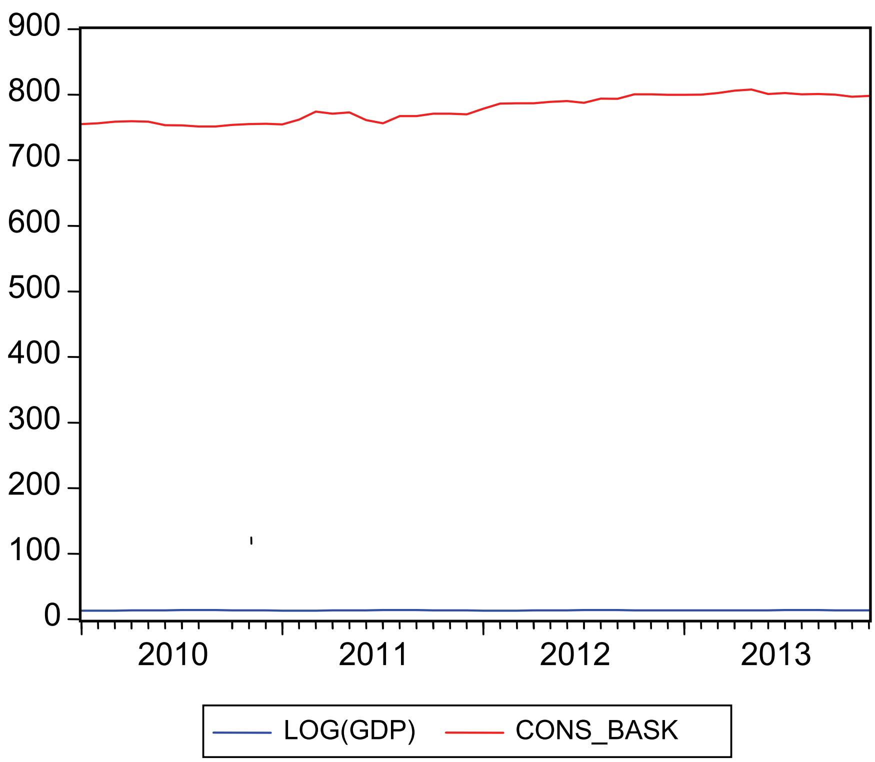
Variable	ADF test statistic	p-values	PP test statistic	p-values	Order
CPI	-1.133729	0.06947			I(0)
UNEMP			-3.895493	0.0042	I(0)
LOG(GDP)	-1.313193	0.6135			I(1)
D(LOG(GDP))	-13.54689	0.0000			I(0)
CONS_BASK	-0.907978	0.7771			I(1)
D(CONS_BASK)	-6.522120	0.0000			I(0)
IMP_EXP			-5.254857	0.0001	I(0)

Test results show that series inflation, unemployment and import-to-export ratio are stationary in absolute form, while series GDP rate and minimal consumer basket are stationary on first difference. That is why we opted to calculate changes in GDP rate and consumer basket and use the change instead of level variables, i.e., D(LOG(GDP)) and D(CONS_BASK), respectively.

Co-integration test

Two series, GDP and minimum consumer basket, are found to be non-stationary and it is necessary to test whether they are co-integrated. The Johansen test is used to test the hypthesis about the rank of the co-integrating relationships that exist among the variables. Figure 1 indicates that GDP rate and minimum consumer basket follow the similar paths while having direct relationship.

Figure 1: *Non-stationary variables*



The null hyphotesis of the Johansen test states that there is no co-integrating equations. It is rejected if Trace statistic and Max-Eigenvalue are higher than coresponding critical value at 0.05 significance level.

Table 2: *Johansen co-integration test*

Series: LOG(GDP), CONS_BASK

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Max-Eigen Statistic	0.05 Critical Value
None *	0.332668	19.00028	15.49471	18.20106	14.26460
At most 1	0.017604	0.799226	3.841466	0.799226	3.841466

* denotes rejection of the hypothesis at the 0.05 level

The Johansen test indicates that there exist one co-integrating equation at 5% significanse level meaning that there exit a stationary linear combination of non-stationary series GDP rate and minimal consumer basket. This result satisfies the requirement that there must be at list (k-1) number of co-integrating equations for the variables to be integrated. Consequently, carryng out a regression on these variables may not produce a spurious regression.

Estimation of the model

Based on the analysis we specified the model represented by the following equation

$$CPI_t = \alpha + \beta_2 UNEMP_t + \beta_3 D(CONS\_BASK)_t + \beta_4 \mathrm{D(LOG(GDP)}_t + \beta_5 IMP\_EXP_t + \varepsilon_t$$

The OLS estimates of the regression model of inflation in Montenegro are presented in the table 3.

Tabela 3: *OLS Estimates of the regression model*

Dependent Variable: INFLATION (CPI)
Sample (adjusted): 2010M02 2013M12
Included observations: 47 after adjustments

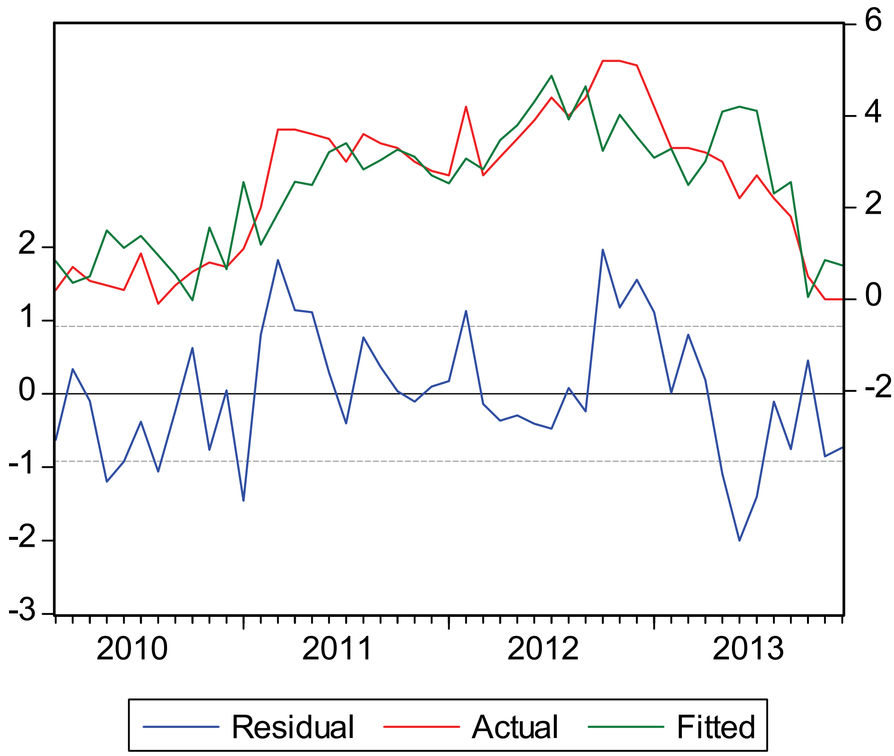
Variable	Coefficient	Std. Error	t-Statistic	p-values
C	37.06151	14.23898	2.602820	0.0127
UNEMP	-0.000 853	0.000107	-7.976519	0.0000
D(CONS_BASK)	0.043082	0.007187	5.994599	0.0000
D(LOG(GDP)	-3.215435	0.881846	-3.646256	0.0007
IMP-to-EXP	10.40189	2.754461	3.776379	0.0005

R-squared	0.694509	Mean dependent var	2.480851
Adjusted R-squared	0.665414	S.D. dependent var	1.590821
S.E. of regression	0.920185	Akaike info criterion	2.771804
Sum squared resid	35.56309	Schwarz criterion	2.968628
Log likelihood	-60.13739	F-statistic	23.87086
Durbin-Watson stat	2.071316	Prob(F-statistic)	0.000000

From the estimated model, it is obvious that all coeficients came out with the right and expected signs; all exogeneous variables are statisticaly significant at less than 1% significance level. More over, the estimated F-statistic proves whole model to be a significant one, i.e. joint influence of the explanatory variables on the variation of inflation (70%) is highly significant.

From the Actual-Fitted- Residuals graph it can be seen whether the model is successfull in estimating the actual inflation.

Figure 2: *Actual-Fitted- Residuals of the model*



The figure suggests that in the most of the studied months the correlation real life – model is high.

Diagnostic tests

The **specification** of the regression is tested by Ramsey RESET test and Jarque Bera test.

Ramsey RESET (REgression Specification Error Test) is a general test for the model specification error regarding omitted relevant variable, incorrect functional form and correlation between explanatory variable and error. In any of this cases misspecification causes biased and nonconsistent OLS estimates.

Table 4: Ramsey RESET test

F-statistic	3.783319	Probability	0.031272
Log likelihood ratio	8.142853	Probability	0.017053

Test Equation:
Dependent Variable: INFLATION (CPI)
Sample: 2010M02 2013M12
Included observations: 47

Variable	Coefficient	Std. Error	t-Statistic	Prob.

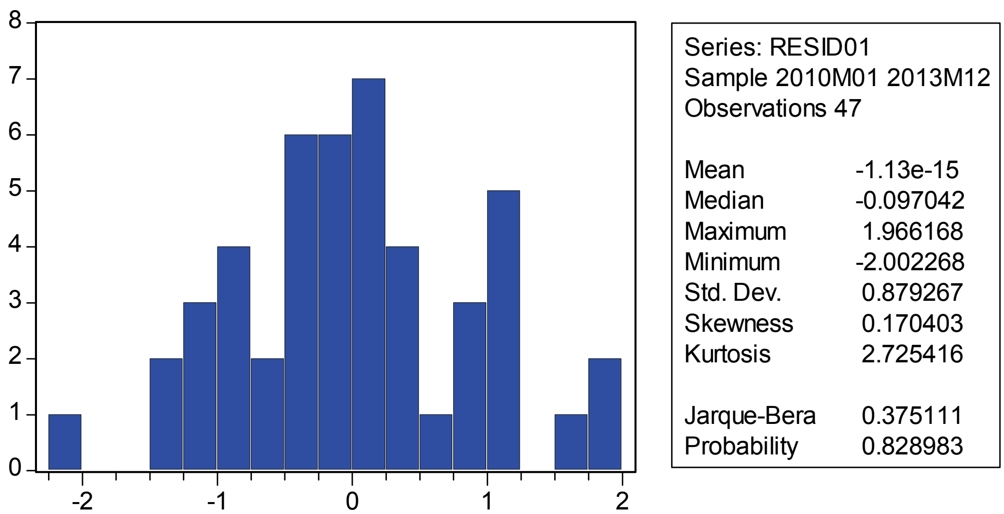
C	-5.219326	34.37772	-0.151823	0.8801
UNEMP	0.000230	0.000834	0.276153	0.7839
D(CONS_BASK)	-0.014151	0.044039	-0.321329	0.7496
D(LOG(GDP)	0.704493	3.043618	0.231466	0.8181
IMP-to-EXP	-4.557235	10.13808	-0.449517	0.6555
FITTED^2	0.828453	0.458743	1.805921	0.0785

R-squared	0.743105	Mean dependent var	2.480851
Adjusted R-squared	0.704570	S.D. dependent var	1.590821
S.E. of regression	0.864666	Akaike info criterion	2.683658
Sum squared resid	29.90591	Schwarz criterion	2.959212
Log likelihood	-56.06596	F-statistic	19.28423
Durbin-Watson stat	2.069670	Prob(F-statistic)	0.000000

The null hypothesis of the RESET test that model is misspecified can be rejected at 5% significant level. According to RESET test the model specification is a correct one.

Jarque-Bera test (JB) test is used to check the specification of the model by testing normality assumption of the model residuals. This test first computes skewness and kurtosis measures of OLS residuals. For a normally distributed variable, s=0 and k=3. The JB test of normality is a test of a joint hypothesis that s and k are 0 and 3, respectivly, in which case the JB statistic value is expected to be 0 (Gujaraty, 2004).

Figure 3: *Jarque Bera test*



In figure 3 the residuals from the estimated regression model seem to be symetrically distributed. Application of JB test under the null hypothesis that the residuals are normally distributed shows that JB statistic is 0.375 and its probability is 83%. Hence, the hypothesis that the residuals are normally distributed can not be rejected both at 5% and 1% significant level. JB test indicates that the model specification is a correct one.

White Heteroscedasticity test is employed under the null hypothesis that errors in regression model have constant variance regardless of the X_i value, i.e. stochastic errors are homoscedastic.

Table 5: *White Heteroscedasticity test*

F-statistic	1.148044	Probability	0.355056
Obs*R-squared	9.148469	Probability	0.329927

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Sample: 2010M02 2013M12
Included observations: 47

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	676.6744	1171.447	0.577640	0.5669
UNEMP	0.002382	0.003490	0.682620	0.4990
UNEMP ^2	-4.02E-08	5.53E-08	-0.727837	0.4712
D(CONSUM_BASK)	-1.863047	1.139831	-1.634494	0.1104
D(CONSUM_BASK) ^2	0.001207	0.000732	1.647636	0.1077
D(LOG(GDP))	2.273095	145.0021	0.015676	0.9876
D(LOG(GDP))^2	-0.122719	5.317273	-0.023079	0.9817
IMP_EXP	-9.219247	15.12609	-0.609493	0.5458
IMP_EXP ^2	26.13625	27.86993	0.937794	0.3543

R-squared	0.194648	Mean dependent var	0.756662
Adjusted R-squared	0.025101	S.D. dependent var	1.004659
S.E. of regression	0.991970	Akaike info criterion	2.992169
Sum squared resid	37.39215	Schwarz criterion	3.346453
Log likelihood	-61.31597	F-statistic	1.148044
Durbin-Watson stat	1.793241	Prob(F-statistic)	0.355056

According to the results of the White Heteroscedasticity test the null hypothesis can not be rejected. Hence, it can be concluded that there is no problem of heteroscedasticity in the model.

Breusch-Godfrey Serial Correlation LM test is applied to check wheter there is a problem of errors autocorelation in the regression model.

Table 6: *Breusch-Godfrey Serial Correlation LM Test*

F-statistic	1.529103	Probability	0.168181
Obs*R-squared	17.83718	Probability	0.120724

Results of the test indicate that there is no serial autocorrelation in the model. This result was expected since estimated value of DW statistic is close to 2.

Finally, the correlation matrix of all explanatory variables is computed in order to check for the *multicolinearity* ***among the explanatory variables.***

Table 7: *Correlation coefficients natrix in the regression model*

	D(CONSUM_BASK)	D(LOG(GDP))	UNEMP	IMP_EXP
D(CONSUM_BASK)	1.000000	0.010602	0.058631	0.247404
D(LOG(GDP))	0.010602	1.000000	-0.494622	-0.094548
UNEMP	0.058631	-0.494622	1.000000	0.267255
IMP_EXP	0.247404	-0.094548	0.267255	1.000000

All the correlation coefficients are lower than 0.50 leading to conclusion that multi-colinearity is not a problem in the estimated regression model.

The employed diagnostic tests revealed that the problems of misspecification, heteroscedasticity, autocorelation and multicolinearity are not detected in the model. Therefore, the specification of the regression model need not be changed nor transformed; estimated regression coeficients are BLUE.

4. CONCLUSION

The goal of this paper was to estimate the regresion model of inflation in Montenegro. The estimated model is an empirical evidence of the Philips curve i.e. theoretical trade-off between unemployment and inflation in a short run. The estimated values of regression coeficients are in accordance with theory. An increase in unemployment results in a decrese in inflation, while a rise in minimum consumer basket results in inflation rise. On the other side, rise of the GDP rate has negative effect on inflation causing it to fall, while the increase in import-to-export ratio results in inflation increase.

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