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The Effects of the ECB's Unconventional Monetary Policy on the Non-Euro Area EU Member States

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Abstract:

The paper examines the unconventional monetary policy programs and measures, implemented by the European Central Bank (ECB). The research is focused on covering their effects on the non-Euro Area Member States of the European Union (EU). The main purpose of the paper is to conduct an econometric study on the effects of the ECB's non-standard measures on the government bond yields of the countries, part of the EU, but outside the Eurozone, through the interest rate channel of the monetary policy transmission mechanism.

The study is dedicated to the empirical study on the dynamics and the relations between the key interest rates and the government bond yields of Bulgaria, Denmark, United Kingdom, Poland, Romania, Croatia, Czech Republic and Sweden. The observed period spreads from January 2010 to December 2016, with the use of monthly data.

The aggregated results from the constructed econometric models for the non-Euro area EU Member States show that between 95% and 98,5% of the changes in the government bond yield can be explained by the changes in the levels of the Euro Over Night Index Average(EONIA) - an interest rate factor, and by the time – the second factor in the model.

The results also show that at EONIA fixed rates the yield on the long-term government bonds can vary from -0,025 percentage points to -0,068 percentage points monthly.

Conclusions and proposals are made, concerning the interest rates in the Eurozone and in the EU, in the context of the unconventional monetary policy, conducted by the ECB – one of the world's major central banks.

Keywords: *Unconventional monetary policy, quantitative easing, central banks, negative interest rates, econometric modeling*

JEL Classification Codes: *E40, E52, E58, F30, G15, F42, C5*

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1. Introduction

The paper covers the effects of the unconventional monetary policy programs and measures, implemented by the European Central Bank (ECB), on the non-Euro area EU Member States. The main purpose of the paper is to conduct an econometric study on the effects of the ECB's non-standard measures on the government bond yields of the countries, part of the EU, but outside the Eurozone, through the interest rate channel of the monetary policy transmission mechanism. The object is the unconventional monetary policy of the ECB. The subject is the change of central banks' base interest rates and its influence on government bond yields in the non-Euro area EU Member States. The research covers 9 countries and the 2010-2016 period.

The main thesis of the proposed paper is that the unconventional monetary policy affects the government bond yields, with a moderate transmission effect through the interest rate channel. The main scientific area of the paper is monetary theory and monetary policy. The scope extends to the field of international finance, including international financial organizations, currency exchange regimes, international financial markets. The methodology, applied in the analysis, includes:

• Conducting an empirical study regarding the base interest rates in the Euro area and the government bond yields of the countries outside the single currency union, but part of the EU;
• Comparative analysis, used for outlining the similarities and differences between the effects on the government bond yields from the base interest rates changes;
• Applying a systematic approach in analyzing the interest rates and government bond yields of the non-Euro area EU Member States;
• Conducting an econometric modeling by using EViews statistical software for the empirical assessment of the impact of the interest rates transmission channel on the government bond yields of the analysed countries. The econometric model has the following view:

$$Y_t = \beta_0 + \beta_1 X_t + \beta_2 t + \varepsilon_t + \varepsilon_{t-1} + \varepsilon_{t-2}$$

where
Y_t (dependent variable) is the yield on long-term government bonds,
X_t is the independent variable for the base interest rates,
t is for the time as another independent variable,
ε_t is for the residual component.
The assumed risk of error is $\alpha = 0,05$.
• The use of the least squares method, conducting an autocorrelations test and assessment of the model;
• Applying of critical analysis about the effects from the unconventional monetary policy, implemented by the ECB.

2. Empirical study for identifying and assessing the impact of key interest rates changes on the government bond yields in the non-Euro area EU Member States

This section is dedicated to the empirical analysis of the dynamics and the relations between the key interest rates and the bond yields, issued by the governments of the EU Member States, which are non-Euro area members – Bulgaria, Denmark, the United Kingdom, Poland, Romania, Croatia, the Czech Republic and Sweden. Accordingly, all nine non-Euro area EU Member States are covered in the analysis. The observation period is from January 2010 to December 2016, with the use of monthly data (towards the end of the respective month), respectively – the length of the time series is 84 terms. The yield on the long-term government securities of the non-Euro area EU Member States in the developed econometric model is presented as the dependent variable Y_t, and the factor variables are EONIA, denoted by X_t, and the time t.

As it is known from the statistical literature, the use of the correlation analysis for studying the relationships between the time series, the so-called “false correlation” may arise. It arises from the fact that two-time series may have a similar development trend and a third-party factor may affect the government bond yields and the key interest rates, while between them there is no such a strong link as the ratio of correlation shows (for more information see Velitchkova (1981)[4], Mishev and Goev (2010)[5]). Therefore, to avoid the occurrence of a false correlation, in the econometric model for the relationship between the yield on government securities and the key interest rates, the time is included as an additional factor (Thalassinos *et al.*, 2015a; 2015b; Cristea and Thalassinos, 2016; Thalassinos and Dafnos, 2015). The least squares method was used for modeling, autocorrelation testing was done, and assessment of the models for the respective countries, too. Information about the assessment of the models, done by the least squares method, and about the autocorrelation coefficients and autocorrelograms of the residual component is given country by country. General conclusions for the non-Euro area EU Member States are also presented in this section.

Bulgaria

The factor for the interest rates in the constructed econometric model for Bulgaria is the Base Interest Rate. The model was assessed by the least squares method and the results[6] are as follows:

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[4]Veltchkova, N., *Statistical methods for studying and forecasting the development of socio-economic phenomena*, Science and Art, S., 1981.

[5]Mishev, G., V. Goev, *Statistical analysis of time series*, Avangard Prima, S., 2010.

[6]For more information, refer toTrifonova, S., Atanasov, At., Kolev, Sv., *The Unconventional Monetary Policy of the World’s Leading Central Banks and its Effects on Developed and*

Table 1. *Results from the econometric model for Bulgaria*

Dependent Variable: BULGARIA_BONDS
Method: ARMA Generalized Least Squares (Gauss-Newton)
Sample: 2010M01 2016M12
Included observations: 84
Convergence achieved after 8 iterations
Coefficient covariance computed using outer product of gradients
d.f. adjustment for standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.388083	0.258881	20.81300	0.0000
BULGARIA_IR	3.709416	0.808293	4.589198	0.0000
T	-0.041934	0.004435	-9.454457	0.0000
AR(1)	0.806398	0.067933	11.87049	0.0000

R-squared	0.985160	Mean dependent var	3.920476
Adjusted R-squared	0.984604	S.D. dependent var	1.365434
S.E. of regression	0.169424	Akaike info criterion	-0.653869
Sum squared resid	2.296361	Schwarz criterion	-0.538115
Log likelihood	31.46248	Hannan-Quinn criter.	-0.607337
F-statistic	1770.333	Durbin-Watson stat	1.930811
Prob(F-statistic)	0.000000		

The results from the developed econometric model for Bulgaria show that the model is adequate. This is confirmed by the F-test–Prob (F-statistic) < α, where α = 0,05. The model has a very high explanatory power - $R^2 = 0,985$. This means that 98,5% of the interest rate changes of the long-term Bulgarian government bonds can be explained by changes in those factors. In addition, the two factors have a statistically significant impact since the level of significance (prob.) is lower than the assumed risk of error α.

The assessed model has the following analytical view:

$$\widehat{Y}_t = 5{,}39 + 3{,}7.X_t - 0{,}04.t + 0{,}8.\varepsilon_{t-1}$$

Since the parameters in front of the factors can be considered as statistically significant, they can be interpreted. From the obtained results, the following two conclusions can be made:

1. By increasing the Base Interest rate in Bulgaria by 0,1 percentage points (p.p.), the yield on the long-term bonds, issued by the Bulgarian government, ceteris paribus, will rise by 0,37 p.p.
2. At fixed levels of the Base Interest Rate each month the interest rate on the long-term securities of the Bulgarian government is expected to decrease by 0,04 p.p.

In order to ensure the quality of the obtained results, the model was tested for the presence of autocorrelation in the residuals as well as for the type of residuals distribution.

Figure 1. *Autocorrelogram of the residual component* ε_t

Sample: 2010M01 2016M12
Included observations: 84
Q-statistic probabilities adjusted for 1 ARMA term

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob...
		1	0.033	0.033	0.0937	
		2	0.037	0.036	0.2158	0.642
		3	0.150	0.148	2.2278	0.328
		4	0.054	0.045	2.4886	0.477
		5	-0.18...	-0.20...	5.5878	0.232
		6	-0.03...	-0.05...	5.7317	0.333
		7	-0.10...	-0.10...	6.7128	0.348
		8	-0.12...	-0.06...	8.2343	0.312
		9	-0.14...	-0.10...	10.214	0.250
		1...	0.134	0.160	11.973	0.215
		1...	-0.27...	-0.27...	19.406	0.035
		1...	0.019	0.044	19.441	0.054

As it can be seen from Figure 1, the autocorrelation coefficients in the residual component have low values and they are not statistically significant. The conducted tests warranted the assumption that the constructed econometric model was correct, and the results were credible.

Romania

The econometric model for Romania is assessed by the least squares method and the results are as follows:

Table 2. *Results from the econometric model for Romania*

Dependent Variable: ROMANIA_BONDS
Method: ARMA Generalized Least Squares (Gauss-Newton)
Sample: 2010M01 2016M12
Included observations: 84
Convergence achieved after 11 iterations
Coefficient covariance computed using outer product of gradients
d.f. adjustment for standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	8.398432	0.422345	19.88526	0.0000
EU_EONIA	-0.119665	0.383730	-0.311847	0.7560
T	-0.067108	0.008111	-8.274133	0.0000
AR(1)	1.181392	0.110215	10.71902	0.0000
AR(2)	-0.344058	0.110606	-3.110651	0.0026

R-squared	0.975566	Mean dependent var	5.430595
Adjusted R-squared	0.974328	S.D. dependent var	1.651617
S.E. of regression	0.264628	Akaike info criterion	0.257330
Sum squared resid	5.532231	Schwarz criterion	0.402022
Log likelihood	-5.807861	Hannan-Quinn criter.	0.315495
F-statistic	788.5335	Durbin-Watson stat	2.198622
Continues			
Prob(F-statistic)	0.000000		

The following conclusions can be drawn from the results:

First of all, it can be assumed that the developed econometric model is adequate. This is confirmed by the F-test–Prob (F-statistic) < α, where α = 0,05. In addition, the model has a very high explanatory power - R^2 = 0,97. This means that 97% of the interest rate changes of the long-term securities issued by the Romanian government can be explained by changes in the two factors – EONIA and the time. In addition, time has a statistically significant impact since the level of significance (prob.) is quite lower than the assumed risk of error α, but the EONIA has no impact. The next step is to test for serial autocorrelation, i.e. whether autocorrelation exists in the residual component ε_t. This was done by the calculation of the autocorrelation coefficients and by the construction of the autocorrelogramof ε_t. The results are presented in Figure 2.

Figure 2. *Autocorrelogram of the residual component* ε_t

Sample: 2010M01 2016M12
Included observations: 84
Q-statistic probabilities adjusted for 2 ARMA terms

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob...
		1	-0.09...	-0.09...	0.8475	
		2	-0.00...	-0.01...	0.8527	
		3	0.039	0.037	0.9885	0.320
		4	0.155	0.164	3.1486	0.207
		5	-0.15...	-0.13...	5.4488	0.142
		6	0.083	0.059	6.0805	0.193
		7	0.055	0.053	6.3603	0.273
		8	0.022	0.023	6.4067	0.379
		9	-0.11...	-0.08...	7.7370	0.356
		1...	0.151	0.096	9.9563	0.268
		1...	-0.07...	-0.06...	10.550	0.308
		1...	-0.06...	-0.06...	10.911	0.364

As it can be seen from Figure 2, the autocorrelation coefficients have small values and are not statistically significant. Since one of the parameters in front of the factors

can be considered statistically significant, it can be interpreted. From the obtained results, the following two conclusions can be made:
1. The levels of EONIA did not have a statically significant impact on the yield on the Romanian long-term government bonds.
2. At fixed rates of EONIA each month the interest rate on the long-term securities of the Romanian government is expected to decrease by 0,067108 p.p.

Denmark
The econometric model for Denmark is assessed by the least squares method and the results are as follows:

Table 3. *Results from the econometric model for Denmark*

Dependent Variable: DENMARK_BONDS
Method: ARMA Generalized Least Squares (Gauss-Newton)
Sample: 2010M01 2016M12
Included observations: 84
Convergence achieved after 8 iterations
Coefficient covariance computed using outer product of gradients
d.f. adjustment for standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.036596	0.302750	10.03006	0.0000
EU_EONIA	0.194972	0.262591	0.742494	0.4600
T	-0.033975	0.005770	-5.888257	0.0000
AR(1)	1.211032	0.106993	11.31883	0.0000
AR(2)	-0.354148	0.106633	-3.321179	0.0014

R-squared	0.968869	Mean dependent var	1.592143
Adjusted R-squared	0.967293	S.D. dependent var	0.964245
S.E. of regression	0.174385	Akaike info criterion	-0.575086
Sum squared resid	2.402399	Schwarz criterion	-0.430394
Log likelihood	29.15361	Hannan-Quinn criter.	-0.516921
F-statistic	614.6675	Durbin-Watson stat	1.985624
Prob(F-statistic)	0.000000		

The following conclusions can be drawn from the results:

The developed econometric model is adequate, confirmed by the F-test–Prob (F-statistic) < α, where α = 0,05. The model has a very high explanatory power - R^2 = 0,97. This means that 97% of the interest rate changes of the long-term securities issued by the Danish government can be explained by changes in the two factors – EONIA and the time. In addition, time has a statistically significant impact since the level of significance (prob.) is quite lower than the assumed risk of error α, but the EONIA has no impact. The next step is to check for serial autocorrelation, i.e. whether autocorrelation exists in the residual component ε_t . This was done by the calculation of the autocorrelation coefficients and by the construction of the autocorrelogramof ε_t . The results are presented in Figure 3.

Figure 3. *Autocorrelogram of the residual component* ε_t

Sample: 2010M01 2016M12
Included observations: 84
Q-statistic probabilities adjusted for 2 ARMA terms

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob...
		1	-0.00...	-0.00...	0.0012	
		2	-0.10...	-0.10...	0.9566	
		3	0.111	0.111	2.0535	0.152
		4	-0.01...	-0.02...	2.0634	0.356
		5	0.027	0.051	2.1286	0.546
		6	-0.05...	-0.07...	2.4259	0.658
		7	0.038	0.054	2.5637	0.767
		8	-0.00...	-0.03...	2.5689	0.861
		9	-0.22...	-0.20...	7.4906	0.380
		1...	0.007	-0.00...	7.4949	0.484
		1...	0.110	0.081	8.6996	0.465
		1...	0.061	0.109	9.0677	0.526

As it can be seen from Figure 3, the autocorrelation coefficients have small values and are not statistically significant. Since one of the parameters in front of the factors can be considered statistically significant, it can be interpreted. From the obtained results, the following two conclusions can be made:

1. The levels of EONIA did not have a statically significant impact on the yield on the Danish long-term government bonds.
2. At fixed rates of EONIA each month the interest rate on the long-term securities of the Danish government is expected to decrease by 0,033975 p.p.

Poland

The econometric model for Poland is assessed by the least squares method and the results are as follows:

Table 4. *Results from the econometric model for Poland*

Dependent Variable: POLAND_BONDS
Method: ARMA Generalized Least Squares (Gauss-Newton)
Sample: 2010M01 2016M12
Included observations: 84
Convergence achieved after 5 iterations
Coefficient covariance computed using outer product of gradients
d.f. adjustment for standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.

C	6.123569	0.447961	13.66988	0.0000
EU_EONIA	0.049052	0.279548	0.175470	0.8612
T	-0.041581	0.008978	-4.631185	0.0000
AR(1)	1.305130	0.104794	12.45423	0.0000
AR(2)	-0.393096	0.107721	-3.649220	0.0005

R-squared			
Continues			
	0.979075	Mean dependent var	4.289167
Adjusted R-squared	0.978016	S.D. dependent var	1.282626
S.E. of regression	0.190176	Akaike info criterion	-0.395042
Sum squared resid	2.857190	Schwarz criterion	-0.250350
Log likelihood	21.59175	Hannan-Quinn criter.	-0.336877
F-statistic	924.1060	Durbin-Watson stat	1.962321
Prob(F-statistic)	0.000000		

The following conclusions can be drawn from the results:

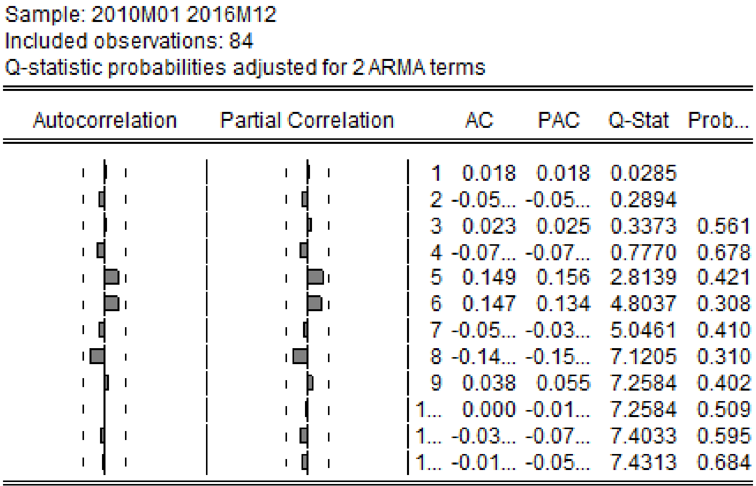
The developed econometric model is adequate, confirmed by the F-test–Prob (F-statistic) < α, where α = 0,05. The model has a very high explanatory power - R^2 = 0,979, meaning that 97,9% of the interest rate changes of the long-term securities issued by the Polish government can be explained by changes in the two factors – EONIA and the time. In addition, time has a statistically significant impact since the level of significance (prob.) is quite lower than the assumed risk of error α, but the EONIA has no impact.

The next step is to test for serial autocorrelation, i.e. whether autocorrelation exists in the residual component ε_t. This was done by the calculation of the autocorrelation coefficients and by the construction of the autocorrelogramof ε_t. The results are presented in Figure 4.

As it can be seen from Figure 4, the autocorrelation coefficients have small values and are not statistically significant. Since one of the parameters in front of the factors can be considered statistically significant, it can be interpreted. From the obtained results, the following two conclusions can be made:

1. The levels of EONIA did not have a statically significant impact on the yield on the Polish long-term government bonds.
2. At fixed rates of EONIA each month the interest rate on the long-term securities of the Polish government is expected to decrease by 0,041581 p.p.

Figure 4. *Autocorrelogram of the residual component* ε_t


Sample: 2010M01 2016M12
Included observations: 84
Q-statistic probabilities adjusted for 2 ARMA terms

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob...
		1	0.018	0.018	0.0285	
		2	-0.05...	-0.05...	0.2894	
		3	0.023	0.025	0.3373	0.561
		4	-0.07...	-0.07...	0.7770	0.678
		5	0.149	0.156	2.8139	0.421
		6	0.147	0.134	4.8037	0.308
		7	-0.05...	-0.03...	5.0461	0.410
		8	-0.14...	-0.15...	7.1205	0.310
		9	0.038	0.055	7.2584	0.402
		1...	0.000	-0.01...	7.2584	0.509
		1...	-0.03...	-0.07...	7.4033	0.595
		1...	-0.01...	-0.05...	7.4313	0.684

Hungary

The econometric model for Hungary is assessed by the least squares method and the results are as follows:

Table 5. *Results from the econometric model for Hungary*

Dependent Variable: HUNGARY_BONDS
Method: ARMA Generalized Least Squares (Gauss-Newton)
Sample: 2010M01 2016M12
Included observations: 84
Convergence achieved after 15 iterations
Coefficient covariance computed using outer product of gradients
d.f. adjustment for standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	8.663883	0.948475	9.134538	0.0000
EU_EONIA	-0.872861	0.507380	-1.720329	0.0892
T	-0.068021	0.017442	-3.899808	0.0002
AR(1)	0.941326	0.039778	23.66474	0.0000

R-squared	0.969652	Mean dependent var	5.730833
Adjusted R-squared	0.968514	S.D. dependent var	1.925606
S.E. of regression	0.341684	Akaike info criterion	0.762449
Sum squared resid	9.339838	Schwarz criterion	0.878202
Log likelihood	-28.02286	Hannan-Quinn criter.	0.808981
F-statistic	852.0370	Durbin-Watson stat	1.781281
Prob(F-statistic)	0.000000		

The following conclusions can be drawn from the results:

The developed econometric model is adequate, confirmed by the F-test–Prob (F-statistic) < α, where α = 0,05. The model has a very high explanatory power - R^2 = 0,97, meaning that 97% of the interest rate changes of the long-term securities issued by the Hungarian government can be explained by changes in the two factors – EONIA and the time. In addition, time has a statistically significant impact since the level of significance (prob.) is quite lower than the assumed risk of error α, but the EONIA has no impact.

The next step is to check for serial autocorrelation, i.e. whether autocorrelation exists in the residual component ε_t. This was done by the calculation of the autocorrelation coefficients and by the construction of the autocorrelogramof ε_t. The results are presented in Figure 5.

Figure 5. *Autocorrelogram of the residual component* ε_t

Sample: 2010M01 2016M12
Included observations: 84
Q-statistic probabilities adjusted for 1 ARMA term

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob...
		1	0.105	0.105	0.9571	
		2	-0.07...	-0.08...	1.4540	0.228
		3	0.035	0.053	1.5609	0.458
		4	-0.10...	-0.12...	2.6147	0.455
		5	0.227	0.272	7.3082	0.120
		6	0.187	0.104	10.540	0.061
		7	-0.03...	-0.01...	10.673	0.099
		8	-0.08...	-0.10...	11.371	0.123
		9	-0.03...	0.028	11.498	0.175
		1...	-0.08...	-0.13...	12.250	0.200
		1...	-0.10...	-0.17...	13.415	0.201
		1...	0.057	0.048	13.742	0.248

As it can be seen from Figure 5, the autocorrelation coefficients have small values and are not statistically significant. Since one of the parameters in front of the factors can be considered statistically significant, it can be interpreted. From the obtained results, the following two conclusions can be made:

1. The levels of EONIA did not have a statically significant impact on the yield on the Hungarian long-term government bonds.
2. At fixed rates of EONIA each month the interest rate on the long-term securities of the Hungariangovernment is expected to decrease by 0,068021 p.p.

Croatia

The econometric model for Croatia is assessed by the least squares method and the results are as follows:

Table 6. *Results from the econometric model for Croatia*

Dependent Variable: CROATIA_BONDS
Method: ARMA Generalized Least Squares (Gauss-Newton)
Sample: 2010M01 2016M12
Included observations: 84
Convergence achieved after 14 iterations
Coefficient covariance computed using outer product of gradients
d.f. adjustment for standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.685129	0.531525	12.57726	0.0000
EU_EONIA	0.192076	0.381282	0.503763	0.6158
T	-0.042687	0.010200	-4.184951	0.0001
AR(1)	1.167629	0.110585	10.55866	0.0000
AR(2)	-0.269587	0.109158	-2.469699	0.0157

Continues

R-squared	0.966101	Mean dependent var	4.960238
Adjusted R-squared	0.964385	S.D. dependent var	1.348881
S.E. of regression	0.254560	Akaike info criterion	0.183175
Sum squared resid	5.119273	Schwarz criterion	0.327867
Log likelihood	-2.693368	Hannan-Quinn criter.	0.241340
F-statistic	562.8683	Durbin-Watson stat	2.030212
Prob(F-statistic)	0.000000		

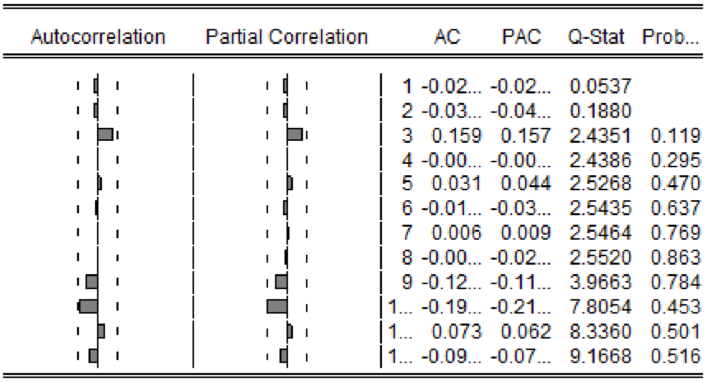
The following conclusions can be drawn from the results:

The developed econometric model is adequate, confirmed by the F-test–Prob (F-statistic) < α, where α = 0,05. The model has a very high explanatory power - R^2 = 0,97, meaning that 97% of the interest rate changes of the long-term securities issued by the Croatian government can be explained by changes in the two factors – EONIA and the time. In addition, time has a statistically significant impact since the level of significance (prob.) is quite lower than the assumed risk of error α, but the EONIA has no impact. The next step is to check for serial autocorrelation, i.e. whether autocorrelation exists in the residual component ε_t . This was done by the calculation of the autocorrelation coefficients and by the construction of the autocorrelogramof ε_t . The results are presented in Figure 6.

As it can be seen from Figure 6, the autocorrelation coefficients have small values and are not statistically significant. Since one of the parameters in front of the factors can be considered statistically significant, it can be interpreted. From the obtained results, the following two conclusions can be made:

1. The levels of EONIA did not have a statically significant impact on the yield on the Croatian long-term government bonds.
2. At fixed rates of EONIA each month the interest rate on the long-term securities of the Croatian government is expected to decrease by 0,042687 p.p.

Figure 6. *Autocorrelogram of the residual component* ε_t



Sample: 2010M01 2016M12
Included observations: 84
Q-statistic probabilities adjusted for 2 ARMA terms

	AC	PAC	Q-Stat	Prob...
1	-0.02...	-0.02...	0.0537	
2	-0.03...	-0.04...	0.1880	
3	0.159	0.157	2.4351	0.119
4	-0.00...	-0.00...	2.4386	0.295
5	0.031	0.044	2.5268	0.470
6	-0.01...	-0.03...	2.5435	0.637
7	0.006	0.009	2.5464	0.769
8	-0.00...	-0.02...	2.5520	0.863
9	-0.12...	-0.11...	3.9663	0.784
1...	-0.19...	-0.21...	7.8054	0.453
1...	0.073	0.062	8.3360	0.501
1...	-0.09...	-0.07...	9.1668	0.516

Czech Republic

The econometric model for the Czech Republic is assessed by the least squares method and the results are as follows:

Table 7. *Results from the econometric model for the Czech Republic*

Dependent Variable: CZECHREPUBLIC_BONDS
Method: ARMA Generalized Least Squares (Gauss-Newton)
Sample: 2010M01 2016M12
Included observations: 84
Convergence achieved after 7 iterations
Coefficient covariance computed using outer product of gradients
d.f. adjustment for standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.237365	0.246216	17.20997	0.0000
EU_EONIA	0.194921	0.251564	0.774834	0.4408
T	-0.049697	0.004656	-10.67384	0.0000
AR(1)	1.207703	0.102476	11.78519	0.0000
AR(2)	-0.424593	0.104513	-4.062574	0.0001

R-squared	0.983109	Mean dependent var	2.151905
Adjusted R-squared	0.982253	S.D. dependent var	1.348561
S.E. of regression	0.179651	Akaike info criterion	-0.518093
Sum squared resid	2.549680	Schwarz criterion	-0.373401

Log likelihood	26.75989	Hannan-Quinn criter.	-0.459928
F-statistic	1149.483	Durbin-Watson stat	1.779348
Prob(F-statistic)	0.000000		

The following conclusions can be drawn from the results:

The developed econometric model is adequate, confirmed by the F-test–Prob (F-statistic) < α, where α = 0,05. The model has a very high explanatory power - R^2 = 0,98, meaning that 98% of the interest rate changes of the long-term securities issued by the Czech government can be explained by changes in the two factors –EONIA and the time. In addition, time has a statistically significant impact since the level of significance (prob.) is quite lower than the assumed risk of error α, but the EONIA has no impact. The next step is to check for serial autocorrelation, i.e. whether autocorrelation exists in the residual component ε_t . This was done by the calculation of the autocorrelation coefficients and by the construction of the autocorrelogramof ε_t . The results are presented in Figure 7.

Figure 7. *Autocorrelogram of the residual component* ε_t

Sample: 2010M01 2016M12
Included observations: 84
Q-statistic probabilities adjusted for 2 ARMA terms

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob...
		1	0.110	0.110	1.0523	
		2	-0.22...	-0.24...	5.5241	
		3	-0.01...	0.043	5.5512	0.018
		4	0.197	0.150	9.0651	0.011
		5	0.061	0.020	9.4095	0.024
		6	0.017	0.090	9.4374	0.051
		7	0.002	0.004	9.4378	0.093
		8	-0.17...	-0.20...	12.380	0.054
		9	-0.06...	-0.03...	12.789	0.077
		1...	0.030	-0.06...	12.877	0.116
		1...	0.012	-0.01...	12.890	0.168
		1...	-0.15...	-0.09...	15.272	0.122

As it can be seen from Figure 7, the autocorrelation coefficients have small values and are not statistically significant. Since one of the parameters in front of the factors can be considered statistically significant, it can be interpreted. From the obtained results, the following two conclusions can be made:

1. The levels of EONIA did not have a statically significant impact on the yield on the Czech long-term government bonds.
2. At fixed rates of EONIA each month the interest rate on the long-term securities of the Czech government is expected to decrease by 0,049697 p.p.

Sweden

The econometric model for Sweden is assessed by the least squares method and the results are as follows:

Table 8. *Results from the econometric model for Sweden*

Dependent Variable: SWEDEN_BONDS
Method: ARMA Generalized Least Squares (Gauss-Newton)
Sample: 2010M01 2016M12
Included observations: 84
Convergence achieved after 4 iterations
Coefficient covariance computed using outer product of gradients
d.f. adjustment for standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.046721	0.333442	9.137194	0.0000
EU_EONIA Continues	0.140387	0.246326	0.569925	0.5703
T	-0.030479	0.006434	-4.736840	0.0000
AR(1)	1.302354	0.103962	12.52721	0.0000
AR(2)	-0.413376	0.104273	-3.964346	0.0002

R-squared	0.968521	Mean dependent var	1.740952
Adjusted R-squared	0.966927	S.D. dependent var	0.906307
S.E. of regression	0.164821	Akaike info criterion	-0.683267
Sum squared resid	2.146101	Schwarz criterion	-0.538575
Log likelihood	33.69720	Hannan-Quinn criter.	-0.625102
F-statistic	607.6513	Durbin-Watson stat	1.988091
Prob(F-statistic)	0.000000		

The following conclusions can be drawn from the results:

The developed econometric model is adequate, confirmed by the F-test–Prob (F-statistic) < α, where α = 0,05. The model has a very high explanatory power - R^2 = 0,97, meaning that 97% of the interest rate changes of the long-term securities issued by the Swedish government can be explained by changes in the two factors – EONIA and the time. In addition, time has a statistically significant impact since the level of significance (prob.) is quite lower than the assumed risk of error α, but the EONIA has no impact. The next step is to check for serial autocorrelation, i.e. whether autocorrelation exists in the residual component ε_t . This was done by the calculation of the autocorrelation coefficients and by the construction of the autocorrelogramof ε_t . The results are presented in Figure 8.

Figure 8. *Autocorrelogram of the residual component* ε_t

Sample: 2010M01 2016M12
Included observations: 84
Q-statistic probabilities adjusted for 2 ARMA terms

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob...
		1	-0.00...	-0.00...	2.E-05	
		2	-0.11...	-0.11...	1.0835	
		3	0.176	0.178	3.8357	0.050
		4	0.010	-0.00...	3.8454	0.146
		5	-0.06...	-0.02...	4.1868	0.242
		6	0.061	0.033	4.5317	0.339
		7	-0.06...	-0.08...	4.9522	0.422
		8	-0.01...	0.014	4.9737	0.547
		9	-0.11...	-0.15...	6.2515	0.511
		1...	-0.00...	0.030	6.2517	0.619
		1...	0.041	0.017	6.4178	0.697
		1...	0.145	0.197	8.5266	0.578

As it can be seen from Figure 8, the autocorrelation coefficients have small values and are not statistically significant. Since one of the parameters in front of the factors can be considered statistically significant, it can be interpreted. From the obtained results, the following two conclusions can be made:

1. The levels of EONIA did not have a statically significant impact on the yield on the Swedish long-term government bonds.
2. At fixed rates of EONIA each month the interest rate on the long-term securities of the Swedish government is expected to decrease by 0,030479 p.p.

United Kingdom

The model for the UK is assessed by the least squares method and the results are as follows:

Table 9. *Results from the econometric model for United Kingdom*

Dependent Variable: UNITEDKINGDOM_BONDS
Method: ARMA Generalized Least Squares (Gauss-Newton)
Sample: 2010M01 2016M12
Included observations: 84
Convergence achieved after 9 iterations
Coefficient covariance computed using outer product of gradients
d.f. adjustment for standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.247986	0.376381	8.629525	0.0000
EU_EONIA	0.157333	0.254234	0.618849	0.5378
T	-0.025173	0.007281	-3.457350	0.0009

AR(1)	1.354713	0.102349	13.23622	0.0000
AR(2)	-0.457236	0.101043	-4.525151	0.0000

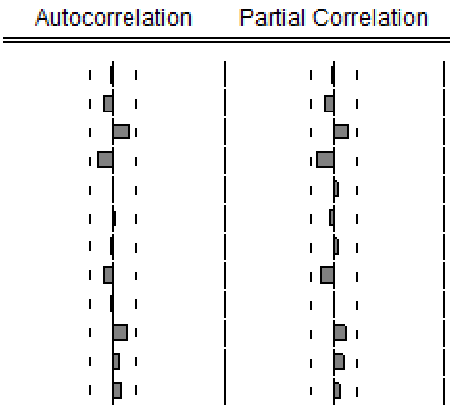
R-squared	0.954403	Mean dependent var	2.159881
Adjusted R-squared	0.952095	S.D. dependent var	0.795356
S.E. of regression	0.174082	Akaike info criterion	-0.571544
Sum squared resid	2.394062	Schwarz criterion	-0.426853
Log likelihood	29.00485	Hannan-Quinn criter.	-0.513379
F-statistic	413.3949	Durbin-Watson stat	1.997748
Prob(F-statistic)	0.000000		

The following conclusions can be drawn from the results:

The developed econometric model is adequate, confirmed by the F-test–Prob (F-statistic) < α, where α = 0,05. The model has a very high explanatory power - R^2 = 0,95, meaning that 95% of the interest rate changes of the long-term securities issued by the UK government can be explained by changes in the two factors – EONIA and the time. In addition, time has a statistically significant impact since the level of significance (prob.) is quite lower than the assumed risk of error α, but the EONIA has no impact. The next step is to check for serial autocorrelation, i.e. whether autocorrelation exists in the residual component ε_t. This was done by the calculation of the autocorrelation coefficients and by the construction of the autocorrelogramof ε_t. The results are presented in Figure 9.

Figure 9. *Autocorrelogram of the residual component* ε_t

Sample: 2010M01 2016M12
Included observations: 84
Q-statistic probabilities adjusted for 2 ARMA terms



	AC	PAC	Q-Stat	Prob...
1	-0.01...	-0.01...	0.0164	
2	-0.08...	-0.08...	0.6127	
3	0.132	0.131	2.1738	0.140
4	-0.15...	-0.16...	4.2870	0.117
5	0.007	0.033	4.2921	0.232
6	0.016	-0.03...	4.3169	0.365
7	-0.01...	0.030	4.3448	0.501
8	-0.09...	-0.13...	5.1693	0.522
9	-0.01...	-0.00...	5.1939	0.636
1...	0.125	0.106	6.7245	0.567
1...	0.063	0.094	7.1152	0.625
1...	0.068	0.059	7.5854	0.669

As it can be seen from Figure 9, the autocorrelation coefficients have small values and are not statistically significant. Since one of the parameters in front of the factors can be considered statistically significant, it can be interpreted. From the obtained results, the following two conclusions can be made:

1. The levels of EONIA did not have a statically significant impact on the yield on the UK long-term government bonds.
2. At fixed rates of EONIA each month the interest rate on the long-term securities of the UK government is expected to decrease by 0,025173 p.p.

The aggregated results from the constructed econometric models for the non-Euro area EU Member States showed that between 95% and 98,5% of the changes in the yield of the government bonds can be explained by the changes in the EONIA levels and over time. The results also showed that at EONIA fixed rates the yield on the long-term government bonds can drop from -0,025to -0,068 p.p. monthly. The summarized results are shown in Table 10.

Table 10. *Summarized results from the constructed econometric models for the non-Euro area EU Member States (in no particular order)*

Country/ Criteria	**% from the changes in the government bond yields, explained by the EONIA and the time**	**Statistically significant impact of the Base Interest Rate/EONIA**	**Statistically significant impact of the time**	**At Base Interest Rate/EONIA fixed rates every month the government bond yields are expected to decline by (p.p.)**
Bulgaria	98,5%	YES	YES	-0,042758
United Kingdom	95%	NO	YES	-0,025173
Denmark	97%	NO	YES	-0,033975
Poland	97,9%	NO	YES	-0,041581
Romania	97%	NO	YES	-0,067108
Hungary	97%	NO	YES	-0,068021
Croatia	97%	NO	YES	-0,042687
Czech Republic	98%	NO	YES	-0,049697
Sweden	97%	NO	YES	-0,030479

Source: *own calculations*

3. Conclusion

Given that the pass through of the monetary policy decisions on the real economy takes time, the full effects of the unconventional measures on the macroeconomic conditions have not yet fully materialized. In this regard, Gambacorta, Hofmann and Peersman (2012) conclude that it is challenging to find an appropriate econometric model to analyze the macroeconomic effects of central banks' measures aimed at increasing their balance sheets in times of crisis when the interest rates reach the zero lower bound[7].

However, the adjustment of financial conditions, through which the transmission mechanism of monetary policy operates, gives encouraging signals. For example, as of June 2014, there is a trend of a significant fall in the 10-year sovereign bond yields in the Euro area, while the Euro area banks' lending rates to non-financial corporations are declining. The ECB reported improvement in lending conditions and growth in demand for new loans in all categories, which is in line with expectations for recovery of the credit growth in the Euro area[8].

Regarding the statistical analysis of the impact of key central bank interest rates changes on the government bond yields of the non-Euro area EU Member States the following conclusions can be drawn: in some countries, changes in the key interest rates and the time have a statistically significant impact on the yields on the long-term government securities; in other countries - changes in the key interest rates and the time do not have a huge impact.

For the non-Euro are EU Member States, 1 p.p. increase in the interest rates would lead to a change in yields on the long-term government securities in the range of -0,068 to -0,025 p.p. Only in Bulgaria at fixed levels of the Base Interest Rate, each month the interest rate on the long-term government securities is expected to decrease by 0,04 p.p. In addition, it can be said that in Bulgaria the Base Interest Rate and time have a statistically significant impact.

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