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An Econometric Model for the Oil Dependence of the Russian Economy

Theodosios Perifanis[1], Athanasios Dagoumas[2]*

[1]Energy and Environmental Policy Laboratory, University of Piraeus, Pireus, PC 18532, Greece, [2]Energy and Environmental Policy Laboratory, University of Piraeus, Pireus, PC 18532, Greece. *Email: dagoumas@unipi.gr

ABSTRACT

There is lot of discussion on the level of the oil dependence of the Russian economy, as well as on whether the Russian Federation presents signs of the Dutch disease or even if already suffers by it. In this paper, we develop econometric models for examining the oil dependence of the Russian economy. We construct two vector autoregressions and then we proceed with vector error correction models. The models consider macroeconomic factors, such as industrial production index, unemployment, gross domestic product and Government expenditure, as well as oil factors, such crude oil price and Russian oil production. We employ impulse response functions to catch the interactions among variables. We find strong evidence on the oil dependence of the Russian economy; however, we do not find firm established proof of the Dutch disease.

Keywords: Russia, Oil, Cointegration
JEL Classifications: Q43, C01, P48

1. INTRODUCTION AND LITERATURE REVIEW

The price of crude oil is an important determinant of the global economy, affecting strongly the balance sheets and the economic growth of both oil producing and consuming countries. In case of oil producing countries, high oil prices, high produced volumes or a combination of them, leads to augmented revenues. Russian Federation, being one of the top oil producers over the last years, strongly depends on the crude oil prices (COPW), especially taken into consideration the profitability of its whole hydrocarbon sector, linked to the crude oil spot prices. Gaidar (2007) claimed that oil price is to account for the collapse of the Soviet Union, while the economic transition was strongly facilitated by the hydrocarbon revenues. This strong dependence of the Russian economy can be easily depicted in the sharp decrease of COPW in 2014, which has led the Russian economy into recession until the last quarter of 2016. Amidst the low-price environment of 2014-2016, the Russian Government responded with flexible exchange rate policy, expenditure curtailment and bank recapitalisation. Inflation was reduced, due to state consumption decrease, from 15.6% in 2015 to 7.1% in 2016. Fixed capital investment also followed a decreasing course of 1.2% in 2016, compared to 2015. Since OPEC deal on the oil production curtailment was reached at the end of the year, the primary deficit grew from 1.7% of gross domestic product (GDP) to 2.7%. The aforementioned economic developments were mitigated through vast expenditure cuts, especially in investment budget and the social sector. The Government had again to cover, in greater extent, the pension fund, contributing 2.4% of GDP from 2.1%.

The oil revenues are extremely important for the Russian economy, as they consisted the 7.6% of its GDP for the first quarter of 2017[1]. The longstanding dependence of the Russian economy from the hydrocarbon revenues, imposes important research questions related to quantifying the oil dependency of the Russian economy. The magnitude and the signs of the oil dependency, could be interpreted as a sign of the Dutch disease. Through Dutch disease, one sector of the economy consists most of the exports or inflows of the economy. The inflows lead to the real exchange appreciation and high inflation. Capital and workforce

1 WORLD BANK GROUP, May 2017, From Recession to Recovery, http://pubdocs.worldbank.org/en/383241495487103815/RER-37-May26-FINAL-with-summary.pdf.

is concentrated to this particular sector, leaving the rest of the economy underdeveloped. When a windfall comes to the main component of the economy, then the undiversified economy is left with high prices, manufacturing underdevelopment, high unemployment and deficits, and extended non-trade able goods sector.

However, the Dutch disease is not something easily detected, nor distinguished by other economical phenomena. Pegg (2010), finds that even if Dutch disease is suspected, the non-coupling of wages growth with productivity, infrastructure underdevelopment and income inequality are to be blamed for Botswana's ill performing economy. Sosunov and Zamulin (2006) propose that rouble's appreciation can be attributed to the oil export revenues' growth, but does not cast shadows to the balance of payments. Rajan and Subramanian (2009) propose that economies, in order for developing countries to avoid the Dutch disease, and unfavourable exchange rates, should receive aid up to their absorptive capacity. Ahrend et al. (2006) conclude that it is the rouble's appreciation to be considered as the main hinder behind Russian's industry weak growth. Brahmbhatt et al. (2010) conclude that inflation targeting is a successful policy but poses the threat of exchange appreciation, when commodity prices increase. Egert (2012) studies almost all former Soviet countries, both for short and long-run, and finds that high oil prices or the increase of oil prices leads to both nominal and real exchange rate to appreciate, thus making in the long term all the other sectors less competitive, leading to negative impact on economic growth. Habib and Kalamova (2007) find the rouble is an oil currency, as its real exchange rate has a trend similar to oil price even with productivity differential inclusion. Tabata (2013) makes a step further and argues that Dutch disease is present in Russian economy, but its impact was not severe, due to four reasons: (1) The non-competitive manufacturing was eliminated during the 90s leaving the completive one to survive, (2) oil price increases led to augmented household demand for domestically produced products, (3) low energy costs for Russian industrial sector gave competitive advantage against imports, (4) Central bank intervention, which protected domestic production.

On the contrary, a lot of research focus on the transition process, most if not all, post-soviet countries followed. They argue that is not the Dutch disease that it is present, but several other symptoms of the transition that are similar. Countries like the Russian Federation had to adapt to the new economic system and impose reforms. Recession was something also anticipated from this kind of transition. Beck et al. (2007) conclude that there are mixed signs, as oil and gas sector were still relatively small, and maintained a developed industrial and human capital base. They also argue that the Russian Federation proceeded to some extent to economy's de-coupling from oil price. Oomes and Kalcheva (2007) find also mixed signs, while all four symptoms of the disease i.e. exchange rate appreciation, manufacturing sector and employment growth relative slow down, and increased share of services in the economy appear. They also conclude that all can be attributed to other factors, such as de-industrialisation and economy's transition. Dobrynskaya and Turkisch (2010), examining the Russian economy over the period 1999-2007, although they find symptoms of the Dutch disease, conclude that the Russian economy increased its industrial production. Moreover, rouble's appreciation can be partly attributed to Balassa-Samuelson effect. Egert (2012) concludes that oil price appreciation does pass to nominal and real exchange rates of the post-Soviet countries but with a lag of 1-2 years. Additionally, he concludes that oil exports had a negative effect, during the economic transition, but contribute positively during the last years. Kerkelg (2004) suggests that subsidies make the most of the distortion system which corresponds to 6.2% of the Russian GDP.

Usui (1998) compares Indonesia and Mexico in terms of their public policy and on whether they succeeded to avoid the Dutch disease. Usui (1998) concludes that Indonesia used many instruments with due diligence helping its economy, while Mexico succumbed to many mistakes. Basdevant (2000) argues that the improvement of private investment does not solely rely on public investment, but also on fight against capital flight and structural reforms. Beine et al. (2014) prove that immigration programmes can be a mitigation instrument to the Dutch disease.

The literature on the Dutch disease is growing rapidly, where several researchers consider the exchange rate as the primary sign of the Dutch disease. Although there is a vast literature on the subject, there are few studies on the Russian Federation. This is the focus of our paper, aiming to examine the Russian economy's dependency on oil and to provide insights on the existence of the Dutch disease. More specifically, we develop two econometric models to examine two macroeconomic figures: The GDP and the Government expenditure. We estimate the GDP correlation with economic fundamental factors, such as industrial production index (IPI), COPW, unemployment and Government expenditure. We then estimate the Government expenditure correlation with oil factors, such COPW and Russian oil production. Those models provide evidence on the dependency of the Russian economy on oil, as well as provide signs on the existence of Dutch disease.

2. DESCRIPTION OF THE EMPIRICAL METHODOLOGY

We estimate Russian Federation's dependence on oil and the sectoral importance over its macroeconomic fundamentals. In this research, we develop two econometric models for examining two variables: GDP real index (GDPRI) and Government expenditure (EXP). We estimate GDPRI correlation with IPI, Government expenditure (EXP), COPW and unemployment (UNEMP). Consequently, we estimate Government Expenditure (EXP) correlation to COPW index (COPIW), Russian oil production (PRussia) and GDPRI. All variables are in natural logarithms, implying that their coefficients are also their elasticities. So, for the long run relationship we have:

$$\ln GDPRI = \ln IPI + \ln EXP + \ln COPW + \ln UNEMP \quad (1)$$

$$\ln EXP = \ln COPIW + \ln PRussia + \ln GDPRI \quad (2)$$

The variables were adjusted as there was strong seasonality presence. We use quarterly data from the 1st of January 1995 to

31st of December 2014. Our source is the International Monetary Fund for the macroeconomic benchmarks and Energy Information Administration for the Russian oil production.

In our research, we first test whether there is a long run relationship between the variables i.e., cointegration. In our empirical analysis, we examine both for the long and short run relationship of our models. This is conducted by applying cointegration techniques (Johansen test) for the long run and vector error correction model (VECM) for the short run. In order to complete our analysis, we use impulse response functions.

In order to apply Johansen procedure for the long-run, one must conduct stationarity tests. In case our data are non-stationary, I (0) at levels, then they are tested whether their first difference is. The Johansen procedure is applied to non-stationary data, to control if a long-run relationship exists between them. We use the Augmented Dickey Fuller, Phillips-Perron and KPSS tests. All of our data are non-stationary but that of expenditure (Appendix Table A1).

3. EMPIRICAL APPLICATION

The analysis examines Russia's dependence and its magnitude on oil. In order to proceed we construct two vector autoregressions (VARs) and then we proceed with VECMs. Non-stationarity, as it happens with our variables, can result to spurious models with little explanatory ability. Johansen's procedure examines the long run relationship between time series. If a long run relationship exists between variables, then non-stationarity is surpassed. We decided to construct our VAR models with two lags as this would ensure they are white noise i.e. Gaussian Errors. In addition, both VAR models include a constant. They were examined whether polynomial roots existed outside the unit circle. For both of them, the hypothesis that there was a unit root outside the circle was rejected.

Appendix Tables A2 and A3 presents that there is one cointegrating equation for each model i.e., there is a long-run relationship between them. Both Trace and Eigen values agree for both models, that there is one cointegrating vector. We set our equation to zero, in order to present long-run relationship. As it expected their normalized cointegrating coefficients have the correct signs for our first model.

$$GDPRI = \underset{(0.08807)}{0.5438}IPI + \underset{(0.00902)}{0.1102}EXP + \underset{(0.01995)}{0.0315}COPW + \underset{(0.02976)}{0.0153}UNEMP$$

The GDPRI is positively related to its dependent variables, as it increases to the increase of IPI, expenditure and COPW. What is not easily explainable is that unemployment has a positive impact on GDP but it is statistically insignificant. The last does not compromise the explanatory ability of the equation. Our variables are in natural logarithms thus, their coefficients are their respective elasticities. An 1% increase of IPI would increase the GDPRI by 0.54%, and state expenditure would contribute 0.11% if increased by the same magnitude. COPW increase would also positive contribute to a 0.03% increase of the GDPRI. The coefficients are in compliance with our assumption.

In our second model:

$$EXP = \underset{(0.15353)}{0.3808}COPW + \underset{(0.51265)}{0.1003}Prussia + \underset{(0.79015)}{2.3038}GDPR$$

We realise the positive relationship of COPW to state expenditure. The respective elasticity is 0.38 meaning that a 1% increase in crude prices would increase expenditure by 0.38%. Russian oil production sign is in compliance with theory, but is statistically insignificant. An increase of GDPRI by 1%, contributes to 2.30% Government expenditure increase.

What should be noticed is that the period is quite extended from 1995 to 2014. During this period, Russia has undergone massive changes from a post-Soviet economy to its current character. The models examine this relationship through the whole period at an aggregate, as examining different subperiods might mostly lead to manipulations.

Since we have the long-run elasticities, we proceed to the short-run dynamics which are captured by the respective VECMs. Appendix Tables A4 and A5 present the short run elasticities. We added a lagged term for each dependent variable.

Our GDPRI model fits data at an excellent scale as R^2 and adjusted R^2 are over 80%. All our elasticities are statistically important but that of the unemployment. The IPI leads to an increase for the real GDP by 0.47%, if it is increased by 1%. The state expenditure also leads to an increase of the GDP by 0.048%, if it is increased by 1%. The COPW elasticity is almost identical to the long-run (0.03) elasticity. The lagged GDPRI is also statistically important with 0.177 as elasticity. The error correction term (ECT) is significant with a correct sign (−0.2389). The ECT term is the speed of adjustment towards the long run curve i.e. if we are off the curve, the first year's adjustment will be 23.89% towards the curve.

In general, our short-run elasticities are lower than the long-run ones. This complies again with the theory, as changes in an economy, in the short-run have fewer and at lower pace impacts.

For our second model, we have different results. Most of our variables are insignificant, as only the correction term, trend and Russian production are significant in the short-run, implying that price fluctuations do not affect, or Russian Federation does not quickly adapt to them. GDPRI is also insignificant implying the slow or the no adaptation to state expenditure. GDPRI is a slow-moving variable, which needs a lot of time and it is not day-to-day estimated to affect expenditure. The Russian production is important and with a high coefficient (3.66). The magnitude of the coefficient implies that increasing production temporary has large scale impact on expenditure, thus oil production increase is a tool for increasing the expenditure, only for short periods. This is presented by the short-run coefficient which is higher than the long-run implying also that the production cannot be sustained at high levels for long periods, or be permanently increased. Trend is also significant and close to zero. The ECT is significant and an adjustment of 33% will be effected in the 1st year.

In general, the long and short-term coefficients are in compliance with theory, as short-run ones are lower than long-run. Except for the Russian production coefficient presenting the production limitations in the long-run.

Our so far analysis of elasticities does not reveal the interaction between our variables, as it only sheds light between the relationship of one variable against a group of others, leaving possible interactions between variables' pairs non-estimated. On order to catch this kind of interactions, we employ impulse response functions.

The IRFs from the unrestricted VAR are presented in Appendix Tables B6 and B7 the diagrams report one variable's response to another's standard deviation (SD) shock. The impulse response functions are estimated for 12 periods ahead i.e., 3 years. We use a short period of time ahead since an even more extended period would not add to the analysis, nor would be scientifically reliable.

From the first row and Appendix Table B6 we have the GDPRI response to a SD shock of IPI. The response is as theory predicts positive and fades out in future. The peak of GDPRI increase comes two quarters later than the SD shock of the production index, and it is <0.01%.

State expenditure is also additive, but its addition come at later stages. A GDPRI has a positive response, if expenditure is expanded, but needs seven quarters for its impact to be fully absorbed by the economy. The result is in compliance with the results of the short-run dynamics, since industrial production's coefficient is much higher than expenditure's one.

Russia dependence on COPW is presented by the GDPRI's response to a SD shock of COPW. The response is initially positive and reaches its peak two quarters later, but from the fourth quarter and onwards we have a negative response. Oil dependence initially adds to the output but the positive effects last only for few quarters.

The Russian Industry is heavily focused on oil price. A price shock would have again the same course of the GDPRI, implying that the majority of the industry in concentrated in the oil sector, and thus affects GDP later. The peak is again two quarters later than the SD shock of crude price, and turns negative from the fourth quarter and onwards.

Expenditure has an almost instant positive response to COPW and two quarters later the Russian Federation increases its expenditure at the highest level. One SD increases expenditure by 0.04%. Since then gradually fades away to reach zero levels.

Additionally, expenditure by state increases after a SD of GDP. This is in compliance as state firsts expects a positive output in order to augment its expenditure. Expenditure's dependence is presented, if examined as a response to price fluctuations. Expenditure reacts positively to a SD of price. The positive relationship expands for eight quarters to reach zero level. The expenditure has zero variation to unemployment and expanding bounds of confidence. More importantly its statistical significance was not proved in our models.

From our second model and Appendix Table B6 we have the response of expenditure to one SD of Russian production. The response is positive and remains positive i.e., expenditure increases when production increases. This is another proof of Russian dependence to oil. There is an increase until the second quarter and since then remains positive. Crude's oil price response to Russian production is quite interesting as a production increase decreases crude price and after the fourth quarter becomes positive, an implication of that price is the result of the produced volumes. This implication is also present in our short run dynamics where Russian production could not be maintained at high levels for long periods.

Russian production has a negative sign reaction to one SD shock of COPW i.e., production decreases when price increases. From third quarter, onwards the confidence bounds become extremely wide compromising production's response to price fluctuations. The character of the response presents, that the Russian Federation manages its resource as scarce and attempts to maximize its revenues.

Since Russian production is mainly focused in oil, a GDPRI increase would again have a negative impact on it due to the scarcity of the resource. This is verified by impulse response functions, but the confidence bounds become very wide from the third quarter. The positive relationship between GDP and Russian production is again verified by the GDPRI response to the one SD shock of Russian production. It is positive and confidence bounds remain within satisfactory widths.

4. CONCLUSION

There is lot of discussion on the level of the oil dependency of the Russian economy, as well as on whether the Russian Federation presents signs of the Dutch disease or even if already suffers from it. In theory when a country has one overdeveloped sector concentrates its resources there, not diversifying itself. This kind of inflow, either from exports or capital inflow appreciates the exchange rate and increases inflation. When the downturn comes the concentrated economy stubbles.

Since many researchers consider the exchange rate as the main sign, we tried to divert with our two models, trying to engulf this kind of dependency for total output and Government expenditure. This kind of approach is even more sensitive, as even if the Dutch disease is not present, then high oil dependency can be detected. GDP in the long run is dependent on crude price but it is also dependent on other economic fundamentals. In the short-run GDP is more sensitive to all other economic drivers. Crude price is statistically significant and low (inelastic) and almost identical to the long-run elasticity.

But GDP is also dependent on state expenditure. When we examine expenditure in the long-run, then crude price is significant and inelastic. Oil volumes are not significant for the long-run expenditure. Oil dependency might be explained by the elastic coefficient of GDP. Oil dependency might be implied, even if crude price is not significant for GDP, from expenditure. In the short-run, expenditure is only dependent on oil production. The significance of oil in the short-run and not in the long run implies the technological and production limitations i.e., production volumes can change only for short periods.

Finally, we consider that even if we do not find firm established proof of the Dutch disease, we do find for oil dependency. This might be the reason behind the rapid response of the Russian Central Bank which followed a flexible exchange policy and curtailed expenditure. This kind of policy and the rebound of oil price might distant us from the conclusion that the Dutch disease exists in Russian Federation. Moreover, our analysis does not provide any firm signs on the existence of Dutch disease in the Russian economy. What is present is a high dependency on oil revenues as there exists a high correlation.

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APPENDIX A

Appendix Table A1: Stationarity tests

Level	ADF	Phillips-Perron	KPSS	First difference	ADF	Phillips-Perron	KPSS	Order of integration
GDPRI	−0.7443	−0.963	1.20	D (GDPRI)	−4.081	−14.375	0.072	I (1)
IPI	−1.028	−1.099	1.089	D (IPI)	−4.393	−14.710	0.126	I (1)
EXP	−3.529[a]	−3.372[b]	1.237	D (EXP)	−8.287	−8.327	0.584	I (0)
COPW	−1.604	−1.657	1.034	D (COPW)	−7.469	−7.303	0.175	I (1)
UNEMP	−1.615	−1.618	0.847	D (UNEMP)	−2.576	−10.722	0.337	I (1)
COPIW	−1.397	−1.164	−5.746	D (COPIW)	−6.116	−1.164	−1.167	I (1)
PRUSSIA	−1.032	−0.434	−1.152	D (PRUSSIA)	−2.110	−6.320	−0.209	I (1)

The null hypothesis of the ADF test is a variable and has a unit root and the null hypothesis for the KPSS test is a variable and is stationary. The first difference of the series is indicated by Δ. [a]Indicates rejection of the null hypothesis at all levels (1%, 5% and 10%). [b]Indicates rejection of the null hypothesis at 5% and 10%. [c]Indicates rejection of the null hypothesis at 10%. GDPRI: gross domestic product real index, IPI: Industrial production index

Appendix Table A2: Johansen's maximum likelihood method test for cointegration relationship for the GDPRI model

Null hypothesis H_0	Alternative hypothesis, H_1	Eigen value	0.05 critical value
Maximum eigenvalues			
r=0	r=1	43.98	33.87
r71	r=2	20.80	27.58
Trace statistics			
r=0	r=0	86.48	69.81
r10	r10	42.50	47.85

Trace indicates 1 CE at 0.05 level. **MacKinnon-Haug-Michelis (1999) P values. GDPRI: Gross domestic product real index

Appendix Table A3: Johansen's maximum likelihood method test for cointegration relationship for the Government expenditure model

Null hypothesis H_0	Alternative hypothesis, H_1	Eigen value	0.05 critical value
Maximum eigenvalues			
r=0	r=1	39.92	30.81
r11	r=2	19.18	24.25
Trace statistics			
r=0	r=0	69.15	55.24
r40	r40	29.22	35.01

Trace indicates 1 CE at 0.05 level. **MacKinnon-Haug-Michelis (1999) P values

Appendix Table A4: VECM and short-run elasticities for the GDPRI model

Variables	Coefficients	Standard error
C	0.0005	0.0011
D (IPI)	0.4780	0.0468
D (EXP)	0.0486	0.0121
D (COPW)	0.0301	0.0079
D (UNEMP)	0.0300	0.0162
D (GDPRI [-1])	0.1771	0.0565
ECT	−0.2389	0.0479
R^2	0.8273	
Adj R^2	0.8127	
Durbin Watson	2.0542	
BG LM test	0.5433 (0.5048)	
Arch test	0.9892 (0.9890)	
Jarque Bera	18.03 (0.0002)	

GDPRI: Gross domestic product real index, IPI: Industrial production index, VECM: Vector error correction model, ECT: Error correction term

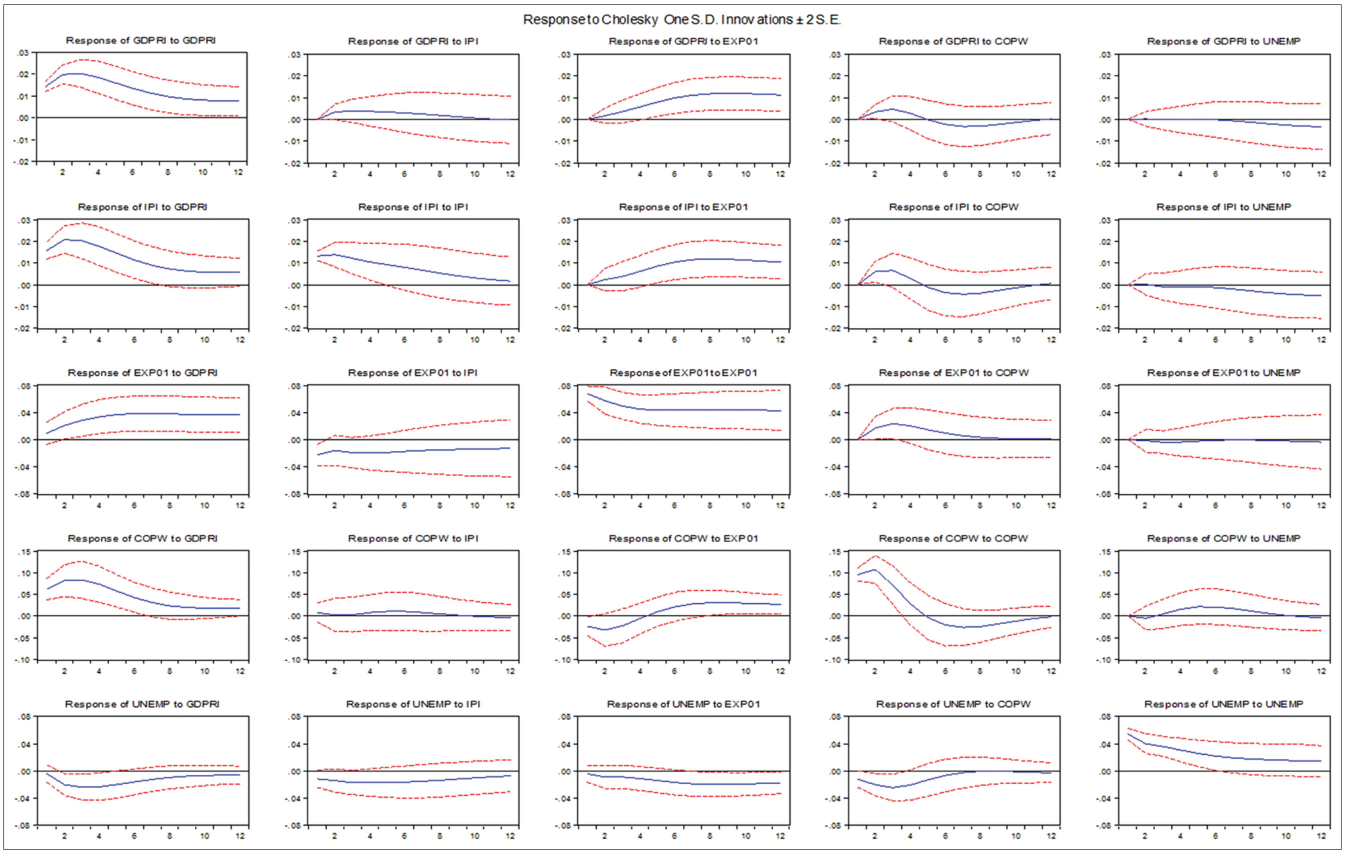
Appendix Table A5: VECM and short-run elasticities for the Government expenditure model

Variables	Coefficients	Standard error
C	0.0622	0.0192
Trend (95Q1)	−0.0008	0.0003
D (COPIW)	−0.0924	0.0638
D (PRUSSIA)	3.6657	0.9234
D (GDPRI)	0.7214	0.4892
D (EXP [−1])	−0.0520	0.0894
ECT	−0.3300	
R^2	0.4363	
Adj R^2	0.3887	
Durbin Watson	2.0240	
BG LM test	0.9274 (0.9184)	
Arch test	0.4673 (0.4608)	
Jarque Bera	29.4955 (0.0000)	

VECM: Vector error correction model, ECT: Error correction term

APPENDIX B

Appendix Table B6: Impulse response functions of the VAR for the GDPRI model



Appendix Table B7: Impulse response functions of the VAR for the Government expenditure model