IMPACT OF THE RUSSIAN - UKRAINIAN CONFLICT ON ROMANIAN INFLATION

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Abstract
The objective of the paper was to study the effects of the Russian –Ukrainian conflict on Romanian inflation using the energy shock's pass-through effect to inflation in Europe after the invasion. A monthly time series dataset is used for econometric analysis, and the data was collected from EUROSTAT, IMF and BNR databases. Using a Cochrane–Orcutt AR (1) regression with iterated estimates that control for autocorrelated error terms, we measured how variations in the price of coal, gas, and oil affected the harmonized consumer price index (HCPI). Our results suggest that oil price increases will lead to an increase in HIPC in Romania. Gas prices had an inverse relationship with HIPC in the analyzed period. The data however did not suggest a relation between coal price and inflation, in the studied period. The energy shock that occurred in Europe accounted in higher prices for gasoline, heating, and electricity on the short run, but there is no evidence that this inflationary pressure will affect long run household inflation.

Keywords: *Energy Shock, Gas Price, Oil Price, Inflation, Romania*

JEL Classification: E31, P24, Q41

1.Introduction

In this paper we address the question: is the inflationary pressure in Europe caused by the Russian aggression on Ukraine, or is it just an association and not causation between the two? It is not the first time that Russia threatens to use gas exports as an economic weapon. In 2009 Gazprom announced that they intend to cut off gas exports to Ukraine and the EU if debts are not settled. Now, the highly improbable happened when the full-scale invasion started in February 2022. The potential impact of an energy interruption from Russia it is not just potential anymore, nor just a worst-case scenario, it is the reality of today (Sharples & Judge 2014).

The European dependency on Russian gas can be considered an Achilles heel of the European Union, the percent of gas imports reported to the gross inland consumption was approximately 65.8% in 2012 (Sharples & Judge 2014), of which more than 36.5% was provided by Russia via its Nord Streamline to Germany, through Belarus to Poland and via Ukraine to Hungary, Romania, Poland, and Slovakia.

The objective of this paper is to study the effects of the Ukrainian war on Romanian inflation via the pass-through of price increases in energy commodities to the harmonized consumer price index. A monthly time series dataset is used for econometric analysis and the data was collected from EUROSTAT, IMF and BNR databases. The applied data set starts from January 2012 and ends in January 2023, and it includes the prices of oil, gas, coal and three control variables were added as well. The first two are monetary variables, broad money supply and interest rates, and the third is a dummy variable designed to control for the COVID-19 pandemic.

Romania was the third country in the EU in 2017 after Denmark and the United Kingdom with a 61% ratio of net imports to gross inland energy consumption according to Eurostat. This fact puts Romania in the low-dependency oil group of countries, next to Norway, the United Kingdom and Denmark. Roughly over 77.8% of energy needs were produced from indigenous resources in 2012, and the rest of 22.2% accounted of imports. Romania imported all its natural gas needs via Ukraine from Russia in 2013 and this is reflected among all EU members that depend entirely in Russian gas imports. (Sharples & Judge 2014).

Regarding crude oil as one of the key factors of economic growth it is particularly influential in the economies of emerging countries that cannot easily stabilize themselves after an energy shock. Moreover, numerous studies have demonstrated the importance of oil price in determining the consumer price index. Oil is considered a main input for many production processes, but it is also a direct input in every consumer product. A study by Sek, Teo & Wong (2015) pointed out that the effect of an oil price shock is different among two country groups denoted as high dependency countries vs low dependency countries. For countries that are highly dependent, the consequences of a shock in crude oil prices are indirect, meaning that the price change will transfer through the production input to higher consumer prices in final products. Also, for the low dependency group, an oil price shock will have a direct inflationary impact through export price changes. According to Sek, Teo & Wong (2015) "the relationship between oil price and inflation may vary over time". Romania produced roughly 3.41 million tons of oil and petroleum products in 2020 and imported about 6.26 million tons in the same year, according to an energy snapshot made by the European Commission for Romania in 2020. Regarding natural gas, 7.39 million tons were produced from indigenous resources in 2020 and 1.73 million tons were imported. To emphasizes the scale of which Romania depends on Russian fossil fuels please refer to Table 1.

Table 1. Dependency on Russian Fossil Fuels (2020)

	Gas	**Oil**	**Coal**
EU27	44%	26%	54%
RO	45%	32%	99%

Source: EUROSTAT https://ec.europa.eu/eurostat

The paper is structured as follows: section 2 Literature review, section 3 Methodology and data, section 4 Results and discussion and Conclusion.

2.Literature review

There are many different studies that emphasize the implications of an oil shock on inflation among different countries and each study reported as expected, different results. In the case of oil as it's a direct input for production and consumer products we can assume that a change in oil price will transfer into consumer price index (CPI), but this premise is not entirely right or wrong. The linkage between oil price and CPI varies over time. The consequences of a shock in oil prices can be seen during the 1970s and 1990s, a period in which oil price went from 3 dollars per barrel in 1973 to nearly 40 dollars per barrel in 1979 (Sek, Teo & Wong 2015). In that time, the consumer price index in the United States also doubled. According to the Bureau of Labour Statistics, CPI in US went from 41.10 in 1972 to 86.30 in 1980. The strong correlation between oil price and inflation during the '70s disappeared after the mid '80s. Evans & Fisher (2011) conducted a study that found no significant evidence of a pass-through of oil price changes to inflation. Similarly, Chen & Wen (2011) found the same results in the period between 1985 and 2011, concluding that crude oil price variations have no impact on the inflation trend but that the effects are just transitory. Hooker (2002) studied the effect of oil price on inflation over two different periods, first period from 1962 to 1980 and 1981 to 2000. What Hooker (2002) pointed out is that in the first period inflation was significantly affected by oil price changes, but the correlation between oil and inflation in the second period has faded. Among the studies who reported limited effects of an oil price shock on CPI are the following Hooker (2002), Gregorio, Landerretche & Neilson (2007) and Arango (2014). Alvarez, Hurtado, Sánchez & Thomas (2011) studied oil price variations in the Eurozone and Spain using a DSGE model and observed that the inflationary effects of oil price changes in the Spanish economy and euro area are limited. Kilian & Zhou (2022) showed that the concern of high inflation on the long term because of oil price changes is overstated and found no evidence that gasoline prices have changed household inflation in the long run, but rather a gasoline price shock is sizable only in the short term. The declining relationship between oil and inflation was explained in detail by Blanchard and Gali (2007) and Alvarex (2009) pointed out that weakening inflationary effects of crude oil are due to higher energy efficiency during production processes. Kilian (2014) provided a comprehensive discussion on the topic concluding that changes in oil prices create inflationary pressures that lead to higher prices in consumer goods, also higher oil prices can be transmitted through cost channels wherein higher oil prices induce higher production costs (Sek, Teo & Wong 2015). Mbah & Wasum (2022) pointed out that the Russian-Ukrainian war is impacting the global economy by creating inflationary pressures in the EU and USA, as well as Canada through rising prices of oil, gas and food. Russian gas is particularly important for the European Union energy needs, as the EU imports more than 36% of all gas from Russia. Baqaee, Moll, Landais & Martin (2022) concluded that a stop in energy imports from Russia, especially an embargo on natural gas will impact Germany by reducing the gross national income anywhere from 0.3% up to 3%. Also, the same study concluded that there may be greater consequences for: Lithuania, Bulgaria, Slovakia. Finland and Czech Republic that may see declines in national income of about 1% to 5%. Another study conducted on the Spanish economy by López, Párraga and Santabárbara (2022) concluded that natural gas significantly affected the Spanish economy and the euro zone, by surging gas prices which doubled since January 2022, the pass-through effect to consumer prices is significant and can be quantified as direct and indirect. The direct effects of a natural gas price change are a result of higher prices that household's pay for gas. The indirect effects stem from higher prices of production as in the case of oil.

3.Methodology and Data

For the empirical analysis we used a monthly time series dataset collected from EUROSTAT, IMF and BNR databases. The studied period was from January 2012 to January 2023. All indicators and their specific measuring units can be found in Table 2.

Table 2: Name of the indicators and measuring units

Harmonized index of consumer prices (HICP)	Monthly data collected from EUROSTAT database
Price of Crude Oil	Monthly data expressed in $/UK Brent from IMF database
Price of Natural Gas	Monthly data expressed in $/Netherlands TFF from IMF database
Price of Coal	Monthly data expressed in $/Australian Exports from IMF database
Broad Money Supply (M3)	Monthly data expressed in thousand RON from BNR database
Interest Rates (BNR)	Monthly data expressed in % from BNR database
COVID-19	0 = before 2020 and 1 = after 2020

Source: All data was collected from EUROSTAT, IMF and BNR databases and analyzed in Stata 17

This analysis has been separated into two periods. First period, before the invasion of Ukraine that consists of January 2012 to January 2022. The second period is just after the war broke out from February 2022 until January 2023. In this way we can easily see the energy shock that occurred after the invasion and economic sanctions. As Sek, Teo & Wong (2015) pointed out, "the relationship between oil price and inflation may vary over different periods". In this study we want to see if that is also true for natural gas and coal as the main sources of energy in Romanian economy.

Table 3: Descriptive Statistics

	N	Mean	Median	SD	Skewness	Kurtosis	Min	Max
HICP	134	106.067	101.165	10.162	1.493	4.589	93.97	137.95
Crude Oil	134	74.868	67.660	25.754	.263	1.791	26.85	124.7

	N	Mean	Median	SD	Skewness	Kurtosis	Min	Max
Natural Gas	134	11.02	7.865	10.571	2.896	12.918	1.46	69.98
Coal	134	119.448	89.875	95.5	2.465	8.044	51.38	467.78
M3	134	3.565e+8	32703859	1.20e+08	.621	2.127	2.16e+08	6.12e+08
Interest Rates	134	2.877	2.500	1.475	1.001	2.764	1.25	6.75
COVID-19	134	.284	0.000	.452	.96	1.922	0	1

Source: Own computing using Stata 17 software

From Table 3 we can see that the data needs to be normalized before elaborating the econometric model and conducting the proposed analysis. The observations do not follow a normal distribution, HICP for example features a more leptokurtic type, same for natural gas and coal. All three indicators feature a leptokurtic distribution, meaning that there are outliers that are situated at a considerable distance from the mean of the sample. Interest rates and M3 follow a more platykurtic distribution meaning there are fewer outliers in the dataset.

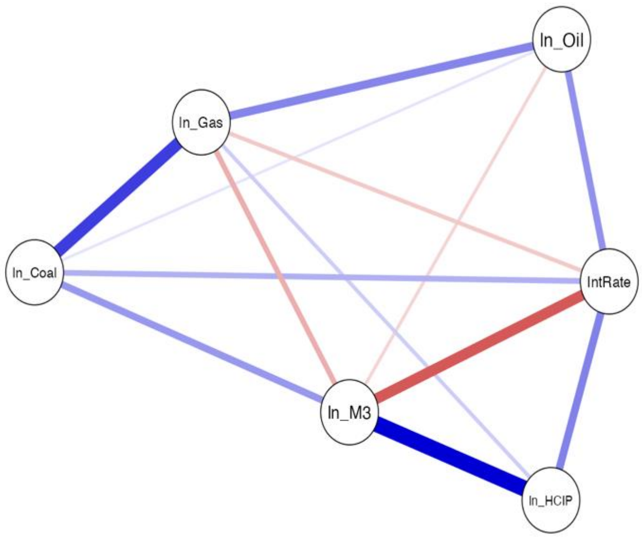
Table 4: Pairwise correlation matrix for all indicators

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) HICP	1.000						
(2) Price of Coal	0.743***	1.000					
(3) Price of Gas	0.444***	0.814***	1.000				
(4) Price of Oil	0.060	0.494***	0.719***	1.000			
(5) Broad Money	0.905***	0.575***	0.181**	-0.225***	1.000		
(6) Interest Rates	0.055	0.369***	0.490***	0.711***	-0.295***	1.000	
(7) COVID19	0.835***	0.506***	0.274***	-0.080	0.825***	-0.099	1.000

Source: Own computation using Stata 17 software

*** represents 1% level of significance, ** represents 5% level of significance

In Table 4 we computed a pairwise correlation matrix to easily see the type of relationships between our variables. Broad money has the strongest relationship with HICP from all the indicators included in our analysis, and this fact was to be expected. We used this correlation matrix presented in Table 4 to further conduct a network analysis of our indicators using the JASP software.



Source: Own computing using JASP software

Figure 1: Network analysis plot

From Figure 1 we can see very easily the relationship between our indicators. Broad money supply still has the strongest correlation with HICP. We can also see that interest rates and broad money supply influence each other strong, same for prices of gas and coal, and thus we expect to face an autocorrelation problem during our econometric analysis.

To compute our regression model, all data was transformed using natural log to reduce the skewness and to remediate the different distributions among indicators. As we are working with time series data, before running our regression we tested for stationarity using the Augmented – Dicky Fuller test of which $\mathrm{H_0: data\ has\ unit-root}$. Our p value in all cases were less than 0.01 in which case we reject the null hypothesis of a unit root concluding that our data is non-stationary at level but, is stationary at first-difference level.

First, we run an OLS regression that can be written as following:

$$y_i = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \varepsilon_i \tag{1}$$

where y_i is our dependent variable, α is the constant in our model, β_1, $\beta_2 \ldots \beta_6$ are the regressors, $X_{1,} X_2 \ldots X_6$ are our independent variables and ε_i represents the error term.

We run the Breusch-Pagan Test for heteroskedasticity under the null hypothesis of constant variance. Our p-value was greater than 0.5 in which case we accepted the null and conclude that the error terms within our model are normally distributed. After running the Breusch-Pagan Test for heteroskedasticity we checked for autocorrelation between the residuals using the Breusch-Godfrey LM test for autocorrelation. The null hypothesis of the Breusch-Godfrey LM test for autocorrelation is that there is no autocorrelation between the residuals in the model. Our p-value of the test was less than 0.05, rejecting the null, we accepted the alternative hypothesis and conclude that the residuals in our model are autocorrelated.

Classic regression estimations like OLS or GLS cannot be interpreted if the error is autocorrelated with the other variables included. Therefore, a special method of regression analysis that corrects the autocorrelated errors needs to be used. The first option would be an AR (1) model because of the autoregressive nature of time series data with the premise that current observations pull their values from previous observations and from their stochastic nature. A classic AR(p) model of order p can be written as follows:

$$X_t = \sum_{i=1}^{p} \varphi_i X_{t-1} + \varepsilon_t \tag{2}$$

Where X_t is the outcome of the autoregressive process of order p; $\varphi_i \ldots \varphi_p$ are the parameters of the model, and $\{\varepsilon_t\}$ represents the white noise. To correct the autocorrelation of residuals in our initial model, we used the Prais – Winsten estimation derived from the AR (1) model, thus constructing a Prais – Winsten regression model with adjusted autocorrelation.

The Prais – Winsten estimation can be written in the following way:

$$y_i = X_{1t}\beta_1 + \ldots + X_{6t}\beta_6 + \mu_t \tag{3}$$

where the errors satisfy: $\mu_t = \rho\mu_{t-1} + \varepsilon_t$, and the error term denoted as ε_t is independently and identically distributed as $N(0, \sigma^2)$. The matrix of covariance noted with Ψ of the error term μ_t, can be written in the following form:

$$\Psi = \frac{1}{1-\rho^2}\begin{bmatrix} 1 & \rho & \rho^2 & \dots & \rho^{T-1} \\ \rho & 1 & \rho & \dots & \rho^{T-2} \\ \rho^2 & \rho & 1 & \dots & \rho^{T-3} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \rho^{T-1} & \rho^{T-2} & \rho^{T-3} & \dots & 1 \end{bmatrix} \quad (4)$$

Thus, our final linear model will have the following form:

$$\log(Hicp)_t = \log(POil)_t\,\beta_1 + \log(PGas)_t\,\beta_2 + \log(PCoal)_t\beta_3 + \log(M3)_t\beta_4 + \log(IntR)_t\beta_5 + COVID\,\beta_6 + \mu_t \quad (5)$$

where the error satisfies $\mu_t = \rho_{dw}\mu_{t-1} + \varepsilon_t$ and where $\rho_{dw} = \left(\frac{1-DW}{2}\right)$, dw is the Durbin – Watson d statistic. Finally, we apply the Cochrane-Orcutt transformation for observations $t = 2, \dots, n$ in the following way:

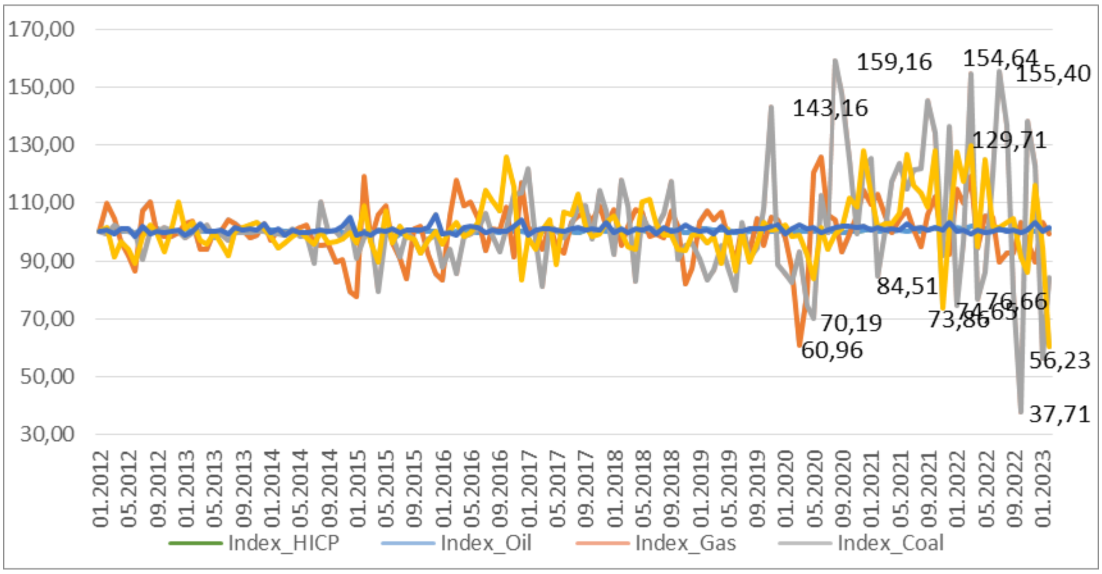
$$y_t - p_{dw}y_{t-1} = \alpha(x_t - p_{dw}x_{t-1}) + \beta(z_t - p_{dw}z_{t-1}) + \delta(1 - p_{dw}) + \upsilon_t. \quad (6)$$

4.Results and discussions

As mentioned above, to conduct an opposite analysis that quantifies the impact of the war on inflation, we divided the time period into two parts. The first period consists from January 2012 until January 2022, and the second period consists from February 2022 until January 2023. To follow the evolution of our indicators among these two periods, we determined the chain-base index for each of them with the following formula:

$$P_{n-1,n} = \frac{P_n}{P_{n-1}}\ x\ 100 \quad (7)$$

where P_n represents the price in the current year and P_{n-1} is the price in the preceding year. After computing the formula for all indicators, we created a line graph to observe the changes in our data for the periods analyzed.



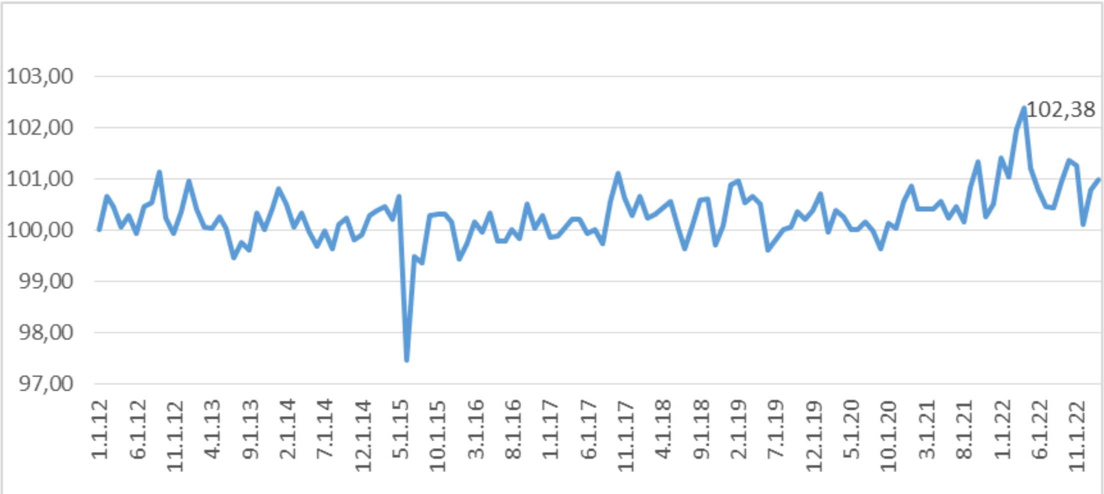
Source: Own computing using data extracted from IMF and BNR databases.

Figure 2: Line graph of chain-based indexes for all indicators

As it can be seen from Figure 2, all indicators start to exert high volatility in the period after 2019, and in the beginning of 2020. This extreme volatility among energy commodities and inflation may be based on the COVID-19 pandemic that started in 2020. Immediately after the pandemic hit, prices of energy started to rise exponentially. Another shock can be observed exactly when the Ukrainian war started in February 2022.

A sharp increase in coal and oil prices can be seen in that period. Prices of gas are the most volatile, it increased with 45% in September 2021 from the previous month, again in October of the same year it increased with 34% from September and another big increase happened in December with 35.4% from the previous month. In February 2022, the month of the Russian invasion, price of gas decreased with 4% from the January.

Figure 3 shows the fluctuation of the harmonized index of consumer prices for the same period. We can easily see that in the pandemic period it was relatively stable, but in the period right after the invasion a sudden and albeit brief increase can be seen. Inflation hit its highest value sometime in April 2022, at the same time as prices of energy commodities hit their respective highest values in the same period.



Source: Own computing using data extracted from EUROSTAT

Figure 3: Line graph of chain-based index of HICP

For the econometric analysis we first attempted to estimate a linear regression equation using the ordinary least squares method and tested for heteroskedasticity and autocorrelation using the Breusch – Pagan and Breusch – Godfrey tests.

From the OLS regression output from Table 5 we see that all indicators except crude oil are significant at the 10% level. Although there is a significance, our R^2 = 0.95 in which case we might consider that the error term is autocorrelated.

Table 5: Results of OLS regression

ln_hcip	**Coef.**	**St.Err.**	**t-value**
ln_coal	-0.021^{**}	0.011	-1.99
ln_gas	0.03^{***}	0.006	4.7
ln_oil	-0.012	0.009	-1.23
ln_m3	0.265^{***}	0.017	15.4
InterestRates	0.019^{***}	0.002	9.29
COVID19	0.015^{*}	0.008	1.86
Constant	-0.511	0.316	-1.62

Mean dependent var	4.66
R-squared	0.951
F-test	410.254***
Akaike crit. (AIC)	-654.354
Number of obs	134
Bayesian crit. (BIC)	-634.1

Source: Own computing using Stata 17 software

*** represents 1% level of significance, ** represents 5% level of significance and * represents 10% level of significance

The results for Breusch-Pagan Test for heteroskedasticity and Breusch-Godfrey LM test for autocorrelation are presented in Table 6.

Table 6: Tests for Heteroskedasticity and Autocorrelation

	Breusch-Pagan Test for Heteroskedasticity	**Breusch-Godfrey LM test for autocorrelation**
chi2	0.02	94.57***
H0	Constant Variance	No serial correlation

Source: Own testing and computing using Stata 17 software

*** represents 1% level of significance

The problem of autocorrelation of the error terms determined us to estimate a regression model using the Prais – Winsten estimation derived from the AR (1) model with adjusted autocorrelation. Finally, we apply the Cochrane-Orcutt transformation and estimate the model.

The results are presented in Table 7, all indicators except price of coal are statistically significant. The rest of our indicators are all statistically significant at the 5% level, only the COVID19 dummy variable is significant at 10%, but we consider this just a control variable in our model.

The broad money supply indicator denoted with M3 in our equation, together with the Interest Rates and COVID19 are control variables that we included in our model. The data does suggest that there is a relationship present between the prices of oil and gas, and the HICP in the analyzed period.

Table 7: Results of Cochrane–Orcutt AR (1) regression with iterated estimates

ln_HICP	**Coef.**	**Std. Err.**	**t**
ln_coal	0.0089	0.0070069	1.28
ln_gas	-0.0106***	0.0038498	-2.75
ln_oil	0.02140***	0.0068426	3.13
ln_m3	0.2272***	0.0200168	11.35
ln_IntRates	0.0075**	0.0032593	2.31
COVID19	0.011006	0.0073944	1.49
Obs	133		
rho	0.9988***		
R -squared	0.5527		
F (6, 127)	26.16***		

Source: Own computing using Stata 17 software

*** represents 1% level of significance, ** represents 5% level of significance and * represents 10% level of significance

Between all the indicators, broad money supply has the most influence on inflation in the analyzed period, and this was to be expected because of the high quantity of monetary supply that has been put into circulation after the COVID-19 pandemic restrictions were removed and a great amount of currency flow began. In the analyzed period the data suggests that there was a positive relationship between the price of oil and inflation, and a negative relationship between the price of gas and inflation in Romania. An increase in oil prices by 1% might lead to an increase in the harmonized index of consumer prices with 0.02%, but indeed the increase in HICP because of oil price is a small one.

The results obtained in this research are in correlation with ones obtained by Kilian & Zhou (2022) who concluded that there is no indication that rising oil costs have changed long-term household inflation. The same study concluded that the invasion of Ukraine was connected to a sudden, albeit brief, increase in headline inflation.

Similarly, Alvarez et al (2011) found that the inflationary effect of oil price changes is limited. Albeit the belief that high gas prices will move inflation on the long run, the data in the analyzed in this period suggests a contradiction. A change in prices of natural gas might decrease the HICP, but indeed we must note that the decrease might be very small.

Although our data suggests a negative relationship between gas and inflation we need to remind that the relationship between natural gas prices and inflation might change over time, as Sek, Teo & Wong (2015) pointed out, "the relationship between energy prices and inflation may vary over different periods". The transmission mechanism of energy prices to inflation is a complex one indeed, and its effects can be quantified as direct and indirect.

The direct effects that an energy price increase has on inflation derives from the higher energy bills households must pay for the same amount of energy consumed. The indirect effects can be transmitted through different cost channels to the prices of final consumer goods. For example, an increase in energy prices will lead to an increase in production costs among a wide range of economic activities, that in their turn, will need to rise final prices for their consumer goods. Realistically, at the end of the transmission channel, the consumer will be the one who supports the higher prices for the same goods consumed.

An important thing to point out is that between all indicators, the monetary ones exercise the most influence on inflation. The monetary mass that is in circulation has a sizable impact on HICP. The National Bank of Romania together with policy makers need to evaluate future fiscal policy keeping in mind that an increase in monetary supply will lead to a significant increase in headline inflation that will be persistent and will move household inflation in the long run.

5.Conclusions

The main objective of this paper was to study the effects of Russian aggression on Ukraine on Romanian inflation, through the pass-through effect of an energy shock caused by high oil, gas, and coal prices to the harmonized consumer price index.

Our results suggest that oil and gas have a statistically significant impact on HICP in the analyzed period, and at the same time the data did not suggest a relationship between coal price and inflation. The broad money supply indicator denoted with M3 in our equation, has the most influence on inflation in the analyzed period, and this was to be expected because of the high quantity of monetary supply that has been put into circulation after the COVID-19 pandemic restrictions were removed and a great amount of currency flow began.

The strongest relationship can be seen between HICP and the monetary variables included. We feel obliged to mention that this weak relationship between energy commodities and inflation will change over the course of time and needs more attention in the future. The dependency of energy imports, especially ones imported from the Russian Federation, must be reevaluated. The decoupling from Russian energy by the EU states must happen sooner than we think. In the case of Germany for example and the construction of Nord Stream 1, made the Republic of Germany more than 80% dependent on Russia for its energy needs. Thus, making the link between Germany and Russia completely irrational due to the lack of diplomatic relations and the tumultuous past of the two countries.

Policy makers will have to consider all scenarios when reconsidering energy necessities in the future, making it an important task to reduce energy imports. A good part of headline inflation variation is due to changes in monetary and fiscal policy, and we urge the National Bank of Romania together with policy makers, to evaluate future policy keeping in mind that an increase in monetary supply will lead to a significant increase in headline inflation that will be persistent and will move household inflation in the long run.

The results of this study are consistent with ones obtained by Sek et al (2015), Mbah & Wasum (2022), Kilian & Zhou (2022), Alvarez et al (2011), in which all authors concluded that an increase in energy prices will lead to an albeit but brief increase in headline inflation, and that the data does not suggest an increase of inflation in the long run.

The limitation of our study consists in the availability of data and access to other influence factors. Future research on this topic can be extended to a broader time frame of analysis, including historical trends and shocks in the energy market. The topic of being more energy efficient as a country needs more spotlight and future research needs to come up with more energy efficient production processes, thus not needing more energy to be imported, but instead using the same energy input to produce the same output and, why not, even more. The directions of this study may be applied in future research that consists in panel data analysis for more countries and a broader time frame.

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