THE INFLATIONARY IMPACT OF ENERGY PRICES. THE COVID-19 PANDEMIC AND RUSSIA-UKRAINE CONFLICT PERSPECTIVE

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Abstract
This paper investigates the evolution of the Harmonized Consumer Price Index (HICP) in light of the evolution of the price of electricity and gas, given the economic shocks generated by the COVID-19 pandemic and the Russian aggression on Ukraine, in the European Union and Romania by deploying the Vector Autoregressive model. The results obtained, especially the ones from the variance decomposition and historical variance decomposition show that inflation was generally lower in the first year of pandemics and constantly increased in the second year, while a more significant contribution to inflation was found present since the start of the war in Ukraine relative to electricity and natural gas price. The overall results show that the electricity price has a greater contribution to the HICP evolution than the natural gas price and for Romania, it is found the HICP evolution is more dependent on the evolution of electricity price at the European Union level rather than the national one, whereas in relation to the natural gas price it is noticed that the national one is more relevant.

Keywords
crisis, COVID-19 pandemic, Russia-Ukraine conflict, energy prices, VAR model.

JEL Classification
G01, C19, C01

Introduction

The present study aims to analyze to connectedness of the electricity and gas prices to the Harmonized Consumer Price Index (HICP) total and seven sub-categories at the European Union (27 countries level) and Romania level in times of economic tensions that were generated, first, in the medical system as a result of the COVID-19 virus that spread worldwide and was declared by the World Health Organization (2020) as being a pandemic on 11th of March 2020 and the second, a military one as a result of Russia's aggression in Ukraine.

The research hypothesis of the study focuses on the existence of a correlation between electricity and gas prices and inflation, considering that commodities like energy are at

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the centre of the economy. Given that HICP is a measurement of goods and services prices for household's changes over time and that electricity and gas price evolution is also reflected in goods and services final prices, it is expected for a causal relationship to be found among these variables.

To achieve the objective of the study I will deploy the Vector Autoregressive model, a model that is often used to identify over time how the relationship between several indicators shifts as well the Granger causality test under VAR to clearly assess the causal relationships between variables.

The novelty character of the article is that it provides insight into how consumer inflation, including for goods of strict necessity such as food, evolved during the COVID-19 pandemic and the war in Ukraine in relations to commodity price evolution at the European Union and Romania level.

The COVID-19 pandemic and the ongoing war in Ukraine have had a significant impact on the European economy, including the Harmonized Consumer Price Index (HICP). The evolution of energy, natural gas and fuel prices has been a major driver of inflation in Europe, with supply chain disruptions, geopolitical tensions, and changes in consumer behaviour all contributing to price volatility.

Warnings were issued by Lagarde, President of the European Central Bank (ECB) who draw attention to the link between energy prices and inflation by stating that „*Half of total inflation in the euro area today is due to energy prices, which are making up the lost ground from 2020.*" ECB (2021), aspects which were also emphasized by Tobias and Gopinath (2021) who draw attention to the impact of the pandemic on global inflation and note that rising energy prices have been a key driver of inflation in many countries and highlighted the potential for supply chain disruptions to further push up prices, particularly for energy-intensive goods. What we can take from these remarks, is that energy and inflation are strongly correlated and measures to counteract the rise in energy prices could lead to a decrease in inflation.

The war in Ukraine has had a significant impact on the European economy, particularly in terms of energy prices. According to the European Commission (2022a), more than 40% of the natural gas consumed in the EU is imported from Russia and energy represented 62% of EU total imports from Russia. With Ukraine acting as a key transit country for this gas, the conflict in Ukraine has led to disruptions in gas supplies, with both, Russia and Ukraine, restricting or cutting off gas flows to Europe at various times. As a result, in February 2022 according to the European Commission (2022b) the energy inflation was 32%, while the inflation in the euro area increased with 0.8 percentage points, due to energy and food prices, in comparison to the level recorded in January of 5.1%, while an expectancy of further price pressures is acknowledged as a result of substantial increase in the price of energy and unprocessed foods.

Energy is an essential commodity in modern societies, and the price of energy (electricity and gas) can have significant effects on the economy and society. On the other hand, the Harmonized Consumer Price Index (HICP) is a widely used measure of inflation in the European Union (EU) countries and given that Bollard (2020) notes that war can be founded in different ways, including by inflation, I believe that the analysis

of the relationship between these indices can provide insight about where the economy is standing.

The paper is further organized as follows: the first part reviews concepts in the literature related to inflation and as well the relationship between energy and inflation. The second section presents details regarding the sample selection, data and research methodology used, and the third the results obtained regarding the connectedness of electricity and gas prices to the HICP, where the electricity price is found to be a better measurement for inflationary measurement than gas price.

1. Review of the scientific literature

Inflation and its evolution, what influences it, how can we predict certain changes and the effects of the COVID-19 pandemic are some of the main topics discussed and debated by the academia and authors have tried to measure the consumer uncertainty about future inflation, by analyzing different data sets.

The impossibility of predicting a future outcome is found to affect inflation by Binder (2017) who analyzed the impact of uncertainty on inflation by using the Michigan Survey of Consumers (MSC) and the Federal Reserve Bank of New York Survey of Consumer Expectations (SCE) to create an uncertainty model to determine the response of inflation to consumer uncertainty and discovered that the uncertainty is lowest among consumer with high-income and higher education and heightened when inflation is very high or very low. Similarly, Armantier et al. (2021) analyzed the inflation evolution based on New York Fed's Survey of Consumer Expectations in the first six months of the Covid-19 pandemic by deploying a data panel model and discover in the medium-term horizon a substantial and immediate increase in inflation uncertainty and inflation disagreement and more in the short-term horizon, results that may be influenced by the fact that the measure taken to contain the pandemic that led to lower or stop production and a decrease in the consumption of certain goods and services. Sharp increase in household uncertainty resulting from a particular event is found that it can have detrimental consequences for the economy by Dietrich et al. (2022). However, these studies are somewhat subjective as they take into account a human component that can quickly shift and in my opinion cannot be used to analyze inflation expectations on the long term without taking into account other economic variables.

Armantier et al. (2020) measured the inflation expectations in times of COVID-19 based on representative USA household heads and concluded that the inflation expectations of households have not displayed a consistent trend in either an upward or downward direction following the onset of the COVID-19 pandemic and that the data highlights exceptional surges in both individual inflation uncertainty and inflation disagreements among respondents, aspects which suggest that human behaviour or way of living are subjective and can be very different among households making it hard to obtain results that aren't contrary.

On the other hand, household behaviour cannot be fully ignored given its consumption component. Abosedra et al. (2021) revealed that the consumer sentiment shock during the COVID-19 era led to a considerable alteration in consumer spending behaviour from the analysis of consumer sentiment and consumption, with this effect persisting for nearly a year, which in the authors opinion suggests that consumers appear to retain a

lasting memory of the influence of sentiment during the COVID-19 period, in contrast to the pre-COVID-19 period.

I identified studies that present the inflation evolution as a result of pandemics and wars, including the recent ones and proof of higher inflation during and even following such events. Chankova and Daly (2021) analyze inflation after the 12 largest wars and pandemics measured by deaths and conclude that wars result in higher inflation and bond yields, whereas pandemics do not, although following significant pandemics inflation has tended to remain weak. The authors also point out that it is important to exercise caution when trying to apply lessons from wars and pandemics that took place in vastly dissimilar conditions and in the distant past, as each event is unique in its own way. Also, Bonam and Smădu (2021) find that longer lasting and more severe pandemics lead to more pronounced and persistent adverse effects on trend inflation and pandemics negatively affect the inflation trend, while wars have always been followed by persistent increases in underlying inflation.

Bobeică and Hartwig (2022) who have noticed that during the initial stage of the pandemic, inflation in the euro area was generally lower than expected, but later on, it ended up being significantly higher than anticipated and also emphasized on the fact that the pandemic-induced inflationary patterns have been perplexing, as evident from the significant changes in the short-term inflation forecasts of expert analysts. Similar behavior was identified by Buelens and Zdarek (2022) find the inflation in the Euro area hard to be predicted and exceeded expectations and as well the fact that supply disruptions imply that high inflation volatility will be likely seen even after the pandemic is under control and are likely to reappear as a result of the war in Ukraine and push up prices for a period of time.

This evidence suggests that inflation can be a good measurement for economical health and that it is prone to significant increase when events that have an impact on production or distribution chain occur.

In addition, other studies find that certain sectors and categories are more susceptible to higher inflation. Drops recorded in core PCE (personal consumption expenditures) inflation are mainly imputable to the decrease in demand for goods and services due to the COVID-19, which in turn offset any upward inflation pressures due to supply constraints in some sectors and categories of hospital services, restaurant services, physician services, air travel and hotels are found to be more sensitive to COVID-19 by Shapiro (2020). Also, Reinsdorf (2020) finds that different subcategories of the Consumer Price Index (CPI) react differently to the pandemic and the main positive contributors to the gap between the COVID-19 index and the CPI are found to be rising food prices and falling transport prices.

Energy prices have also been researched given that they have an impact on products and service price and inflation itself. The inflation rate for energy resources found by Giri (2021) not only be correlated with headline inflation over the short term, but also over longer periods, and the author noted that the results could raise concerns for central banks regarding the suitability of core inflation as a reliable indicator of headline inflation, while core-inflation is found to be modestly impacted by energy price shocks

and overall inflation is mainly impacted by energy price shocks due to the consumer basket by Kilian and Zhou (2023). Also, Vlieghe (2024) found proof, that after the pandemic, services and core inflation increased gradually for a period of 14 months after positive shocks to energy prices and Bai et al. (2021) think of crude oil prices as having a great influence on the economy given that its evolution can lead to changes in production and consumption, which in end affects the worlds inflation evolution.

In addition, recent research has shown an inverse relationship between inflation and energy and an example is the research of Batten et al. (2024) who conclude that inflation data can help predict price fluctuations and volatility of energy prices.

Neri et al. (2023) found proof of indirect and direct effects on inflation due to energy price shocks in the euro area, respectively a contribution of approximately 60% to headline inflation in 2020Q4 as a result of these energy price shocks. Also, Coutinho and Licchetta (2023) noted that almost half of the inflation evolution in the euro area can be explained by energy price evolution and consider that to mitigate inflationary pressure changes in energy production costs and supply side should be made to reduce the energy dependence, aspects which can be justified by the authors given that at EU level 62% of the energy imported in 2021 was from Russia (European Commission (2022)).

Given that energy prices are one of the main commodities in the production of goods and services, it is expected for it to have a considerable impact on inflation, especially in the context of a surge in energy prices as a result of external stressors. Markowski and Kotliński (2024) found proof of this kind of connection relative to electricity for EU countries during 2022 for five out of 13 inflation categories analyzed, more specifically for *(a)* food and non-alcoholic beverages, *(b)* furnishings, household equipment, and routine household maintenance, *(c)* recreation and culture, *(d)* education and *(e)* restaurants and hotels, based on the Granger causality test under VAR.

However, these studies do not provide insight if energy prices at economic union level, in this case EU (27), have or not a more significant impact on inflation at member state level, in this case Romania, energy prices for that specific member state. Also, the identified studies do not cover a comparison between electricity and gas prices and aspects on which one is a better measure to determine inflation expectations.

2. Research methodology

2.1. Sample selection and data

Given the latest evolutions of inflation and to further analyze its magnitude, I will look at the relationship between HICP (Harmonized Index of Consumer Prices), electricity and gas prices in the European Union (27 countries) and Romania. I will also look at the HICP subcategories (food, clothing, education, health, transportation services, electricity and gas) in order to determine which of them were most affected by fluctuations in electricity and natural gas prices, and which of them has the highest share in HICP for all items.

The period analyzed is Q1 2019 – Q3 2024 and the data source for the electricity and gas EU is Bloomberg expressed in €/MWh, electricity RO is The Operator of Electricity and Natural Gas Market in Romania (OPCOM), gas RO is Romanian Commodities

Exchange, and respectively for the HICP indicator is Eurostat website. For the exchange rate RON/EUR the exchange from Cursbnr.ro was used.
The data consists of monthly observations for indices:

a) Electricity_EU - the average of spot prices at the level of major European countries (Germany, France and Netherlands) expressed in EUR/MWh,
b) Gas_EU - TTF EU gas (European natural gas futures) price expressed in EUR/MWh,
c) HICP - Harmonized Consumer Price Index for European Union (27),
d) HICP EU subcategories – food, clothing, education, health, transportation services, electricity and gas,
e) Electricity_RO - the average monthly price of electricity,
f) Gas_RO - the average monthly price of natural gas,
g) HICP - Harmonized Consumer Price Index for Romania,
h) HICP RO subcategories – food, clothing, education, health, transportation services, electricity and gas.

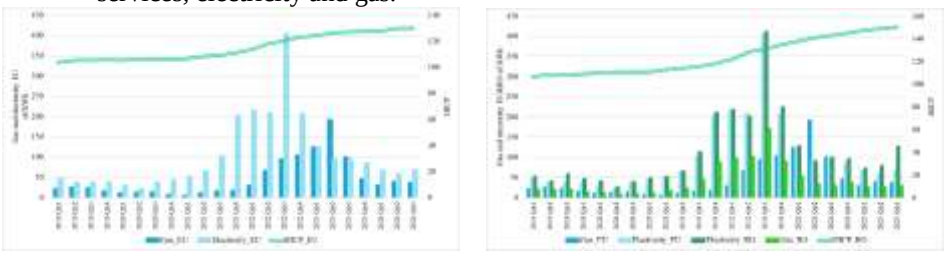


Figure no. 1: Electricity and gas price and HICP evolution in EU (27) and Romania.

Source: *Author's own work based on the information available on EUROSTAT, Bloomberg, OPCOM and Romanian Commodities Exchange.*

The increase in electricity and gas price in EU (Figure no. 1) lead to an increase in HICP in EU variation in the direction of growth. For example, in 2020Q1 a decrease compared to the previous quarter in energy of 24,46%, respectively for gas of 27,51% results in a decrease of HICP EU of 0,29%.
On the other hand, in 2021Q3, respectively 2022Q3 an increase in energy of 54,05%, respectively 93,13% and for gas an increase of 49,34%, respectively 40,74% results in an increase of HICP EU of 0,67%, respectively 2,02%. However, although in 2024Q1 both energy and gas decrease compared to the previous quarter with 20,55%, respectively 32,41%, HICP continued its upward trend recording a 0,41% compared to the previous quarter.
When looking at the increase evolution of HICP total for Romania (Figure no. 1) in Q1 2020 an increase compared to the previous quarter of 1,14% is registered while the price of electricity, respectively natural gas in Romania records a decrease of 12,79%, respectively 9,93%.
On the other hand, the effects of the war in Ukraine become more noticeable in 2020Q4 when an increase in HICP total RO of 0,96% is recorded compared to the previous

quarter, while electricity, respectively natural gas in Romania recorded an increase of 59,33%, respectively 18,05%. Overall, the HICP total records an increase in 2024Q3 compared to 2020Q1 of 36,53%, while electricity RO an increase of 210,34% and gas RO an increase of 127,39%.

2.2. Research methodology

For the empirical analysis, EViews 10 was used to deploy the Vector Autoregressive Model (VAR) for the data series selected, including impulse response, variance decomposition, historical decomposition and Granger Causality under VAR.

The VAR model, and variations of it, is often used by economists to determine the relationship between variables and to determine inflation expectations. Blanchard et al. (1990) deploy the VAR model to examine the correlation between valuation and fundamentals to stock market investments, Friedman et al. (1997) analyze eight European Community countries' stock markets relative to international investments and information by using the VAR model, Bobeică and Hartwig (2022) deploy VAR and standard Gaussian BVAR models to analyze inflation during the pandemic and pre-pandemic period, Lenza and Primiceri (2020) explore the personal consumption expenditures, employment and unemployment after COVID-19 was declared a pandemic by deploying VAR, Dürmeier (2024) deploys VAR to test Japanese Households inflation expectations between Q2 2006 and Q1 2020, while Apergis and Apergis (2025) use TVP-VAR to analyze the impact of uncertainty due to the COVID-19 pandemic on inflation.

Given the previous studies of variable relationship that used the VAR model, I find this model suitable to the objectives of this paper which are to determine the connectedness of consumer inflation and energy, respectively gas prices.

For the VAR Granger Causality test, I have established two hypotheses:

- Hypothesis 1 (H1) - An increase in electricity, respectively gas price leads to an increase in HICP (total and subcategories) for a level of significance greater than 5% and
- Hypothesis 2 (H2) - The electricity, respectively gas price evolution adversely influences the HICP (total and subcategories) for a level of significance below 5%.

3. Results and discussion

In order to have data uniformity the log-transformation was applied for all indicators and based on the Augmented Dickey Fuller for a 5% level of significance the first difference on the log-transformed data was applied.

Moving further, I deployed the VAR model after testing the VAR Lag order, which was chosen, based on the Akaike Information Criterion, with few exceptions for Romania geographical region. The summarized results are presented in Table no. 1 below.

Table no. 1: Summarized results for VAR Lag order Criteria

HICP indicator	VAR Lag order Criteria	HICP indicator	VAR Lag order Criteria EU	VAR Lag order Criteria RO
All items EU	12	All items RO	12	10
Food EU	12	Food RO	12	11

Clothing EU	11	Clothing RO	12	12
Education EU	12	Education RO	12	12
Health EU	11	Health RO	11	10 (LR)*
Transportation Services EU	12	Transportation Services RO	9	0**
Electricity EU	12	Electricity RO	12	10 (LR)*
Gas EU	12	Gas RO	12	11

* Provided that the results shown Lag 0, the LR criterion was chosen provided by the fact that a Lag 10 result was obtained

** Given that all criteria shown Lag 0, I decided to continue with the analysis for a Lag of 12

Source: Authors' own work using EViews 10 software.

In order to establish the stability of the model I deployed the Inverse Roots of AR characteristic Polynomial, in order to identify if, and if so, how many of the inverse roots lie inside the unit circle (have magnitudes less than one). The results obtained, show that for both selected regions for HICP total (Figure no. 2) and as well for all the sub-categories the majority of the inverse roots are inside the unit circle and a few in its immediate vicinity, I will consider the model to be stable enough for further analysis.

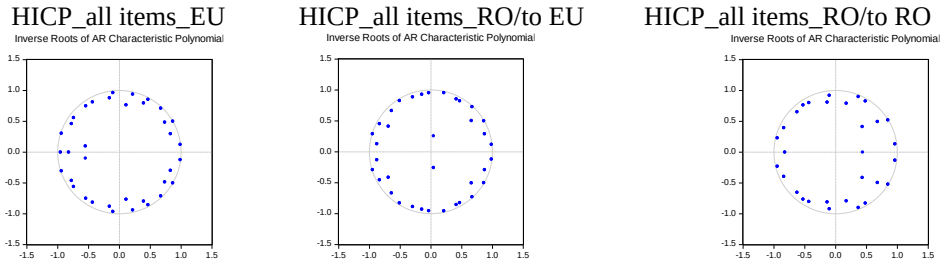


Figure no. 2: VAR model stability - Inverse Roots Graph.

Source: Author's own work using EViews 10 software.

Further on I deployed the Impulse Response in order to determine the direction and magnitude of the effects of a shock on each variable over time, based on the *(a)* increase or decrease of the variable after the shock, *(b)* slope of the lines and *(c)* persistence of the effects of the shock on each variable.

If the response of a variable to a shock is positive, then we can infer that the variable increases after the shock, and if the response is negative, then we can infer that the variable decreases after the shock. Second, the slope of the lines in the impulse response graph indicates the speed of the adjustment of each variable to the shock. If the line is steep, then the variable adjusts quickly to the shock, while a flatter line indicates a slower adjustment process. Third, the persistence of the effects of the shock on each variable can be inferred from the length of the response in the impulse response graph. If the response of a variable to the shock dies out quickly, then we can infer that the

effect of the shock is not very persistent. If the response is long-lasting, then we can infer that the effect of the shock persists for a longer period.
When it comes to the HICP_total_EU, it can be noticed from the results obtain (Figure no. 3), that overall, it follows the same trend as the electricity_EU and gas_EU, an increase, respectively a decrease of electricity and gas lead to an evolution of HICP in line with them, however, the slope is greater and more abrupt related to electricity than to gas as well as the persistence.
Also, the response of HICP_total_EU related to electricity_EU and natural gas_EU is similar to the one recorded by the sub-categories of HICP, the slopes are smoother and have constant growth and the persistence isn't as strong, with the exception of HICP sub-categories food, health and electricity, however for all sub-categories the volatility episodes are more frequent. Similar results were obtained for inflation related to the food category by Markowski and Kotliński (2024).
The graphical representations of HICP_EU subcategories impulse response to electricity_EU and gas_EU can be found in Appendix no. 1.

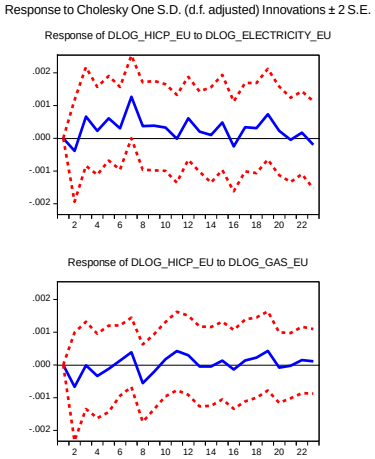


Figure no. 3: Impulse Response of HICP_EU to electricity and gas prices in the EU.

Source: Author's work using EViews 10 software.

On the other hand, although HICP_total_RO follows the same trend as the electricity and natural gas prices in the EU and RO, an increase, respectively a decrease in these prices leads to an evolution of HICP in line with them.
The periods when a negative shock is found present is as follows:

a) relative to gas_EU in the 2019 Q4, 2020 Q3, a prolonged one in 2021 Q1-Q2 as well again in 2022 Q1-Q2 when the war in Ukraine started, 2022 Q4, followed again by a prolonged negative shock between 2023 Q1 – 2023 Q4 however not as significant as the other two previously mentioned and ending with another negative shock on 2024 Q3;

b) related to gas_RO the slopes have a lower intensity till 2020 Q2 compared to the gas EU, however they are more significant, frequent and the effect is more prolonged starting with 2020 Q3 compared to gas_EU. A first prolonged negative shock is found present between end of 2019 Q2-2019 Q4, after which a sharp decrease in 2020 Q2, 2021 Q1-2021 Q2, followed by a short negative impact in 2022 Q1, a prolonged one end of 2022 Q2-2022 Q4, followed by negative shocks in end of 2022 Q2-2023 Q1, mid 2023 Q3-mid 2023 Q4, mid 2024 Q1-mid2024 Q2;

c) relative to electricity_EU there are nine negative shocks recorded, of which the most significant ones are between 2020 Q4-2021 Q2 followed immediately by one between mid 2021 Q3-mid2021 Q4;

d) relative electricity_RO there are 10 negative shocks recorded, of which the most significant ones are between mid 2019 Q4 – end of 2020 Q2, followed by a significant negative effect in 2020 Q4 – mid 2021 Q1 with small variation in the sense of increase and decrease till mid 2022 Q2, with another drop between 2022 Q4 – mid 2023 Q4.

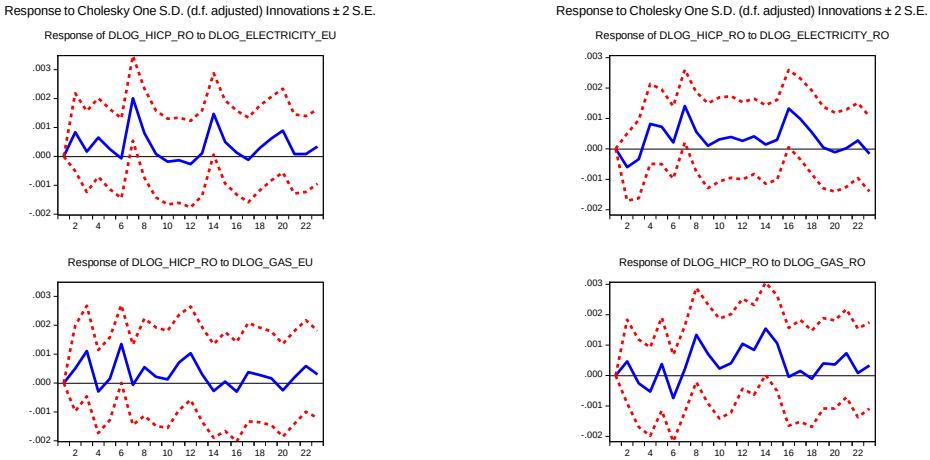


Figure no. 4: Impulse Response of HICP_RO to electricity and gas prices in EU and RO.

Source: Author's own work using EViews 10 software.

Also, the response of HICP_total_RO related to electricity and natural gas in EU is similar to the one recorded by the sub-categories of HICP, the slopes are smoother and have a constant growth and the persistence isn't as strong, with exception of HICP sub-categories food and electricity, however for all sub-categories the volatility episodes are more frequent. A similar situation is found present for HICP sub-categories for Romania related to electricity_RO and gas_RO, however in this case the exception if found present for food and health subcategories of HICP.

The graphical representations of HICP_RO subcategories impulse response to electricity and gas prices in the EU and RO can be found in Appendix no. 2.
Based on the impulse response results, the first aspect to be noted is that HICP for both EU and Romania is more sensible related to electricity than to gas prices with visible responses at the beginning of the COVID-19 pandemic in 2020 Q2 and Q3, respectively at the beginning of the war in 2022 Q1 and Q2, aspects which emphasize the results of Bonam and Smădu (2021) related to pandemics and Coutinho and Licchetta (2023) related to inflation evolution in the euro area as result of energy price evolution.
In order to determine how much of the proportion of the variation in HICP can be attributed to electricity and gas over time I deployed the variance decomposition.

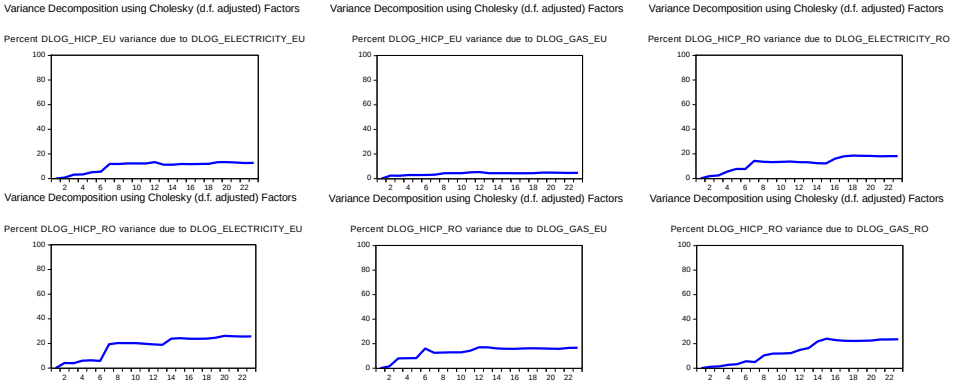


Figure no. 5: Variance Decomposition of HICP_EU and HICP_RO.
Source: Author's own work using EViews 10 software.

Most of the variation of HICP_total_EU and HICP_total_RO is explained by electricity_EU with levels up to 12,79%, respectively 25,72%, while the one explained by gas_ EU is up to 4,69%, respectively 16,33%. The variation of HICP_total_RO explained by electricity_RO is up to 18,33%, respectively related to gas_RO 23,5%, meaning that the evolution of HICP_total_RO is more dependent on the evolution at the electricity prices at EU level rather than the national one, while the contrary is found for gas prices.
As it can be seen (Table no. 2 and 3) the total variance of HICP_total and its sub-categories in both EU and RO, explained by energy_EU record an increase in 2020, the year when the COVID-19 virus spread around the world and was declared a pandemic, causing a sanitary crisis. The explained variance continued to increase reaching its peak in 2023 for HICP_food_EU, respectively HICP_food_RO related to both energy_ EU and gas_ EU, with exception of HICP_food_EU related to the evolution of gas_EU when the peak of the variation was reached in 2022, matters that could be explained by the start of the war in Ukraine.
However, the rest of the sub-categories of HICP in EU and Romania recorded their highest variance explained by the evolution of energy_EU and gas_EU in 2024, fact that could be explained by the continued pressure exacerbated on the economy by the two

crises, the one represented by the pandemic and the one in Ukraine which is still ongoing.

The HICP sub-categories variation related to the electricity and natural gas price evolution are summarized below, in average values per year, in the Table no. 2 and 3 below.

Table no. 2: Summarized results of variance decomposition for HICP EU

Variable	Year	HICP Total EU	HICP Food EU	HICP Clothing EU	HICP Education EU	HICP Health EU	HICP Transp. Services EU	HICP Electri-city EU	HICP Gas EU
Electri-city EU	2019	2,43	2,57	5,41	11,78	8,01	5,63	4,53	18,06
	2020	8,59	9,57	13,61	18,99	22,59	24,59	11,54	22,18
	2021	12,52	16,76	16,42	22,97	25,69	31,41	14,26	26,63
	2022	11,52	19,55	17,22	22,84	25,41	30,18	18,9	26,23
	2023	12,61	**23,43**	20,09	23,71	28,63	35,91	19,31	26,55
	2024	**12,79**	22,13	**20,26**	**24,45**	**33,33**	**38,83**	**20,68**	**28,06**
Gas EU	2019	2,43	4,27	1,52	5,9	2,04	15,34	1,12	5,12
	2020	3,37	5,64	8,03	11,27	7,12	18,17	3,6	9,97
	2021	4,84	8,54	10,96	10,47	12,27	**22,12**	5,43	10,75
	2022	4,43	**9,31**	11,4	10,94	12,66	21,15	6,23	10,56
	2023	4,64	7,08	**11,97**	13,83	13,67	21,28	**6,77**	12,17
	2024	**4,69**	6,83	12	**14,03**	**15,04**	**20,91**	6,5	**12,38**

Source: Author's own work using EViews 10 software.

The highest average weight in a year for the variation for HICP sub-categories in EU related to electricity_EU is recorded in 2023 for food with a value of 23,43%, respectively in 2024 for clothing 20,26%, education 24,45%, health 33,33%, transportation services 38,83%, electricity 20,68 % and gas 28,06%.

Also, for the same sub-categories related to gas_EU it can be noticed (Figure no. 2) that the weight registers a significant shift, recording the greatest variance level between 2022 and 2024 with a level up to 9,31% for food, 11,97% for clothing, 14,03% for education, 15,05% for health, 20,91% for transportation services, 6,77% for electricity and 12,38% for gas. The HICP sub-categories in EU most affected by the evolution of the electricity_EU and gas_ EU are transportation services and health.

When it comes to weight for the variation for HICP sub-categories in Romania related to electricity_EU, a level up to 37,04% is recorded for health, 35,82% for clothing and 27,88% for education, while for the rest de upper value of variation is approximately 18%. Related to gas_EU the variance level is lower compared to electricity_EU, with

the greatest values recorded in 2024 for all sub-categories with exception of food in 2023, and the greatest values for health with a percentage of 16,7% and clothing with 14,43%, respectively approximately 15% for electricity and gas.

The greatest variance values (average) relative to electricity_EU are recorded in 2024 for all HICP categories, with exception of food. For the year 2024 the top four values are recorded for transportation services (38,83%), health (33,33%), gas (28,06%) and education (24,45%), similar to the findings of Neri et al. (2023) for headline inflation relative to energy price shocks during 2022 Q4.

Overall, at EU level, the variance of HICP due to electricity and gas prices emphasize the results obtained previously for the impulse response function, as well provide insight on the fact that electricity prices are a better measure for inflation expectations. A similar result regarding correlation between energy resources inflation with headline inflation over longer time periods of time by Giri (2021), which means that electricity prices could be used to evaluate headline inflation expectations. The results provide proof that the evolution of HICP sub-categories in EU is more dependent on the evolution of electricity_EU rather than gas_EU.

Table no. 3: Summarized results of Variance decomposition for HICP RO

Variable	Year	HICP Total RO	HICP Food RO	HICP Clothing RO	HICP Education RO	HICP Health RO	HICP Transp. Services RO	HICP Electri-city RO	HICP Gas RO
Electricity EU	2019	4,67	3,72	2,02	2,56	7,56	1,86	8,96	3,27
	2020	12,92	5,77	5,31	11,81	13,81	3,68	13,54	5,33
	2021	19,86	10,5	11,73	16,84	18,91	6,34	14,7	6,17
	2022	22,71	14,36	23,72	22,61	25,34	9,21	15,8	10,64
	2023	24,6	**17,92**	30,37	26,91	35,92	9,93	16,56	13,75
	2024	**25,72**	17,51	**35,82**	**27,88**	**37,04**	**10,85**	**16,77**	**14,63**
Gas EU	2019	5,87	**11,06**	2,25	4,53	0,68	0,51	5,07	5,12
	2020	12,4	10,5	6,25	11,75	5,81	0,68	10,53	8,38
	2021	14,26	9,02	12,34	16,65	10,39	1,44	12,94	12,27
	2022	16,18	9,39	13,65	12,14	11,44	2,87	14,41	14,01
	2023	16,1	8,86	13,84	15,33	11,1	3,53	14,97	15,12
	2024	**16,33**	8,43	**14,43**	**16,7**	**12,41**	**12,41**	**15,02**	**15,53**
Electricity RO	2019	3,3	9,75	11,98	14,07	0,68	0,51	4,78	0,81
	2020	10,84	19	18,62	16,71	4,08	2,71	6,24	5,08
	2021	13,44	21,05	21,58	**20,54**	7,82	6,11	8,07	6,49
	2022	13,47	**23,56**	22,79	16,1	9,28	6,5	10,15	12,92
	2023	**18,33**	19,89	**23,44**	15,99	12,11	7,95	10,33	16,28
	2024	18,13	18,42	22,84	16,13	**12,31**	**9,01**	**10,48**	**16,31**
Gas RO	2019	1,76	8,13	13,47	3,66	2,42	1,76	6,7	5,92
	2020	6,08	13,47	18,38	6,88	5,02	6,08	15,89	11,03

	2021	12,75	21,12	19,05	9,65	8,28	12,75	19,59	17,32
	2022	21,29	29,44	22,77	10,51	14,23	21,29	21,93	19,72
	2023	**22,37**	29,79	25,7	14,03	16,42	**22,37**	**24,43**	20,21
	2024	23,5	**31,27**	**27,84**	**17,15**	**16,75**	13,84	24,06	**22,02**

Source: Author's own work using EViews 10 software.

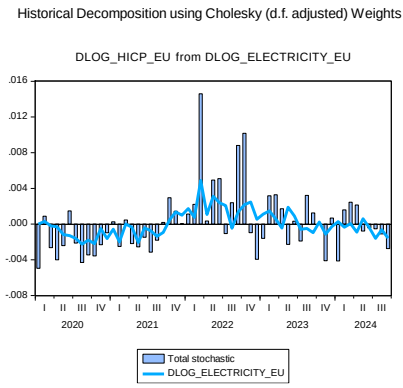
On the other hand, for the HICP subcategories in Romania the evolution is more dependent on electricity at the EU level rather than the national one, while for gas the vice-versa is valid. However, when we take into consideration the results obtained for the variance related to the national market, it can be noticed that gas_RO has a greater impact than electricity_RO, and even gas_EU starting with 2022, an aspect which could be explained by Romania's dependence on imported gas and as well its proximity to the war.

The variance decomposition results obtained provide proof of longer lasting effects of electricity prices on inflation, especially as a result of war, similar to the findings of Chankova and Daly (2021) and Bonam and Smădu (2021), respectively confirm the assumptions of Buelens and Zdarek (2022).

Overall, the results of variance decomposition of HICP total and subcategories due to electricity and gas prices for both European Union and Romania provide proof that the inflation variation in the first year of pandemics recorded values that were between two and five times greater than 2019, especially relative to electricity prices, which is contrary to the findings of Bobeică and Hartwig (2022) who noticed a lower than expected inflation in the euro area during the initial stage of the pandemic. Also, it can be noticed, that in general, the amount of variance of HICP total and subcategories that can be explained by energy and gas price evolution, has an ascending trend that extends for more than the 14 months identified by Vlieghe (2024) for core and services inflation after the start of the pandemic period.

The contribution of electricity_EU and gas_EU (independent variable) to the total variation in the HICP for all items and all sub-categories for EU (dependent variable) as well as the contribution of electricity and gas in EU and RO (independent variable) to the total variation in the HICP for all items and all sub-categories for Romania (dependent variable) starts to become noticeable with 2021 (as a result of the ongoing pandemic) and a greater variation is noticed starting with 2022, which coincides also with the start of the war in Ukraine.

From all HICP subcategories analyzed, it can be observed that food, education and gas have the greatest contribution from electricity_EU and gas_EU to their variation, while HICP health and transportation are very volatile. The historical variance decomposition graph (Figure no. 6 and Figure no. 7) will allow us to observe the contribution of each independent variable to the total variation in the dependent variable and how it has changed over time and which variables have had the greatest impact on the dependent variable at different points in time.



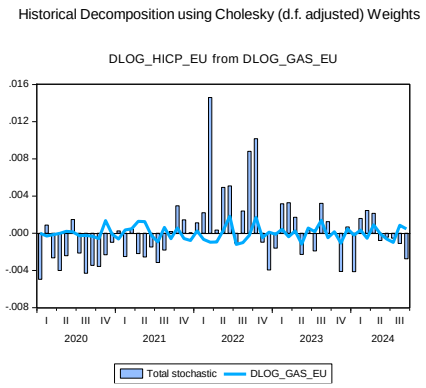
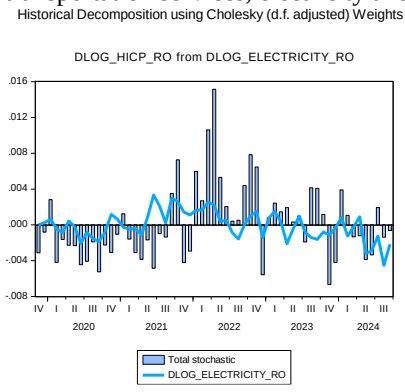


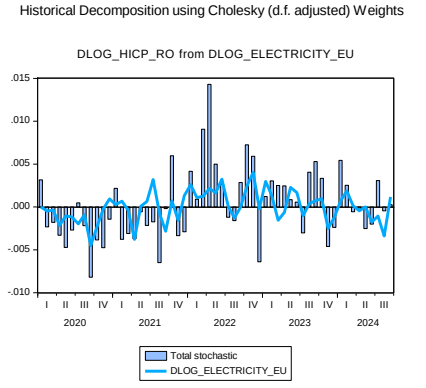
Figure no. 6: Historical Variance of HICP_EU to electricity and gas prices in EU.

Source: Author's own work using EViews 10 software.

For HICP_food_RO it can be said that overall, the contribution from electricity and gas in both EU and Romania to its variation follows the same pattern over time, however in amplitude the contribution of electricity_EU and gas_EU to HICP_food_RO is higher than the contribution on electricity_EU and gas_EU to HICP_food_EU. The sub-categories of HICP that are the most sensitive to the evolution of electricity and gas prices in both EU and Romania are electricity, gas, and transportation services, followed by education, health, clothing and food.

The results of the historical variance decomposition reflect the fact that of all HICP subcategories analyzed, the most sensitive to the evolution of the electricity and gas prices are the HICP categories that are very strictly related to them, meaning transportation services, electricity and gas.





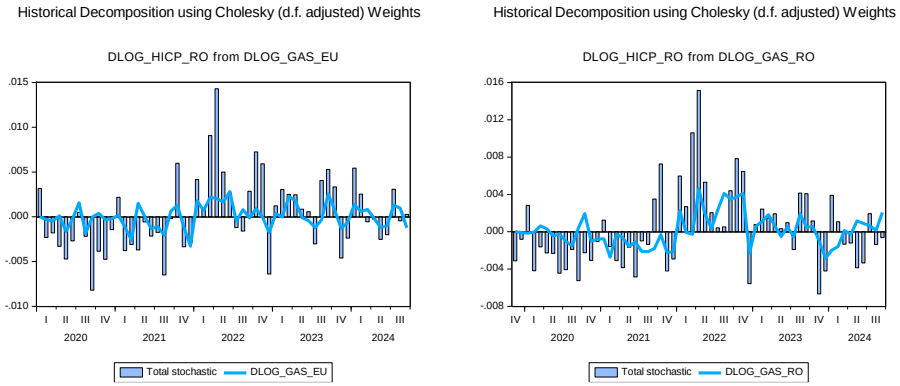


Figure no. 7: Historical Variance Decomposition of HICP_RO to electricity and gas prices in EU and RO.

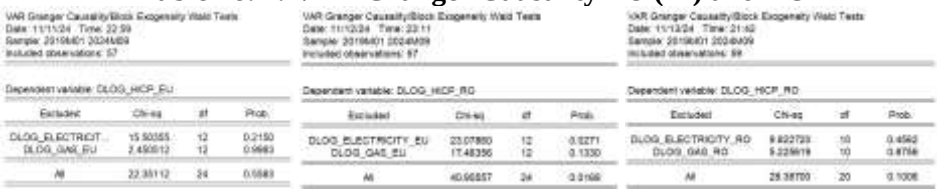
Source: Author's own work using EViews 10 software.

The graphical representations of HICP subcategories in EU and RO for historical variance decomposition to electricity and gas prices in the EU and RO can be found in Appendix no. 3 and 4.

Based on the two hypotheses established at the beginning of the analysis, Hypothesis 1 (H1) - An increase, respectively decrease in Electricity, respectively Gas price lead to an increase, respectively decrease in HICP for a level of significance greater than 5%, which will be marked with Y(yes) in Table no. 4 below, and Hypothesis 2 (H2) - The HEPI evolution adversely influences the HICP for a level of significance below 5% which will be marked with N(no) in the table below.

It can be noticed (Table no. 4) that for HICP_total_EU a causality relation is found related to both electricity and natural gas in EU and an increase or decrease in these prices leading to an increase or decrease in HICP, as well as for HICP_total_RO a causality relation is found related to electricity_RO and gas in both EU and RO.

Table no. 4: VAR Granger Causality EU (27) and RO



Source: Author's own work using EViews 10 software.

When it comes to the sub-categories of HICP EU related to electricity_EU for all subcategories causality relations are found present an increase, respectively a decrease leading as well to an increase respectively a decrease of HICP, with the exception of

health, transportation services and gas, while on the other hand the exceptions related to the price of natural gas EU is found for HICP_health_EU.
For all HICP sub-categories for Romania, causality relations are found present related to both electricity_EU and gas_EU, with exceptions of health related to gas_EU, respectively for HICP_food related to electricity_RO.

Table no. 5: Summarized results for Granger causality

HICP indicator	electricity price EU	gas price EU	electricity price RO	gas price RO
Food EU	Y(38,50%)	Y(88,26%)	N/A	N/A
Clothing EU	Y(56,41%)	Y(20,40%)	N/A	N/A
Education EU	Y(6,27%)	Y(27,54%)	N/A	N/A
Health EU	N(0,39%)	N(0,03%)	N/A	N/A
Transportation Services EU	N(1,07%)	Y(49,34%)	N/A	N/A
Electricity EU	Y(39,97%)	Y(93,21%)	N/A	N/A
Gas EU	N(0,77%)	Y(14,13%)	N/A	N/A
Food RO	Y(55,62%)	Y(29,69%)	N(4,58%)	Y(18,92%)
Clothing RO	Y(47,70%)	Y(12,38%)	Y(8,15%)	Y(15,38%)
Education RO	Y(57,87%)	Y(5,88%)*	Y(64,93%)	Y(93,69%)
Health RO	Y(5,13%)*	N(1,35%)	Y(75,27%)	Y(84,36%)
Transportation Services RO	Y(93,08%)	Y(97,21%)	Y(96,91%)	Y(98,08%)
Electricity RO	Y(74,77%)	Y(57,02%)	Y(14,94%)	Y(25,61%)
Gas RO	Y(61,51%)	Y(28,47%)	Y(60,66%)	Y(25,18%)

*near the 5% threshold
Source: Author's own work using EViews 10 software.

The causality relation between HICP food and education is found present relative to electricity price EU, similar to the findings of Markowski and Kotliński (2024) during 2022, aspects which reflect that causality extend over a longer period, which in end emphasize that electricity prices are a good measurement for inflation related to food. Also, given that European Commission (2022b) identified that energy and food prices are found to lead to an increase of inflation in the euro area reflect a domino effect.
Additionaly, the granger results provide proof of supplementary inflation categories that are correlated with electricity compared to the ones identified by Markowski and Kotliński (2024) for EU countries, which means that also other inflation categories could be correlated with electricity prices, especially if it's an important part of its manufacturing or offering as a service.
Given that supply constraints are found to lead to upward inflation pressures by Shapiro (2020), in conjunction with the fact that supply constraints also influence electricity prices, it can be inferred that electricity prices could also create an upward inflation pressure to the sectors hospital services, restaurant services, physician services, air travel and hotels, identified by Shapiro (2020).

Conclusions

The purpose of this article was to analyze the evolution of the HICP index given the tensions that the economy has faced lately from an energy perspective since the start of the pandemics and Russia's aggression on Ukraine. While the COVID-19 pandemic had a significant impact on production of goods, especially food and still strives to return to pre-pandemic levels, as well as supply chain disruptions, adding on the bans on Russian imports which put a toll on energy prices in terms of growth which will further exacerbate the effect on food and transportation costs and prices that the pandemic already triggered as well as the fact that Russia and Ukraine account for almost one third of all wheat exports, it is still unknown how much time will be necessary for the economy to stabilize and for sure these events will have long lasting effects.

Using the data set for HICP (total, food, clothing, education, health, transportation services, electricity and gas), respectively electricity and gas prices for both the European Union and Romania, I investigated the correlation between these variables for almost five years that covers both pandemic and war. The main finding is that electricity prices have a more significant and longer-lasting effect on HICP no matter the category or region than compared to gas prices, respectively inflation in Romania is more sensible to the evolution of electricity and gas prices in the EU than the national ones, especially when it comes to HICP food. The results obtained from the VAR model - impulse response analysis show a positive correlation of the HICP index with electricity and natural gas prices, in general an increase in electricity and natural gas prices generates an increase in the HICP index and a stronger reaction is recorded for the HICP in RO to the electricity and gas in EU is very similar to the one at a national level, however more volatile relative to electricity and natural gas price EU, especially when it comes to HICP sub-categories for which the slope of the lines in the impulse response graph are steeper. Also, the VAR Granger causality provides proof that of all the sub-categories for HICP in EU and RO, a causal relation is found related to both electricity and gas in EU and RO, an increase or decrease in one of them generating an increase or decrease of HICP. Similar findings were observed by Reinsdorf (2020) who analyzed 83 economies from all geographical regions throughout a one year period, pre and during the COVID-19 pandemic (May 2019 – May 2020), and identified that when the economy faces shocks an increase in the consumer price index is recorded, and the author identified that for the analyzed period food prices rose faster than the overall consumer price index, as well as Gentiloni who expressed his concern regarding the significant increases in unprocessed food and energy prices that will in end have an important impact in the economic health due to the additional pressure on prices European Commission (2022b) and Buelens and Zdarek (2022) whom noted that supply disruptions caused by the pandemics lead to high inflation volatility, a phenomenon that according to the authors is likely to reappear as a result of the war in Ukraine.

The variance decomposition results provide important insight when it comes to how much of the increase in electricity and natural gas price, especially as a result of the war in Ukraine, has contributed to the increase of HICP and I observed that overall, the electricity price has a greater contribution to the increase in HICP than the natural gas price. Overall, it can be said that the increase in electricity and gas prices lead to

volatility in the HICP index, aspects emphasized by Tobias and Gopinath (2021) who draw attention to the fact that the COVID-19 pandemic had an impact on global inflation but also draw attention to the fact that rising energy prices have been a key driver of inflation in many countries, as well by Lagarde whom stated that approximately half of the inflation in the euro area is caused by the increase in energy prices ECB (2021).

When it comes to the historical variance decomposition results obtained, it can be said that electricity and gas prices started to have a noticeable contribution to the HICP variation even since the first year of the pandemic and constantly increased in the second year of the pandemic, while a more significant contribution since the start of the war in Ukraine, with a greater contribution to HICP transportation services, electricity and gas, results which emphasize again the similarities with the findings of Buelens and Zdarek (2022), as well as with Chankova and Daly (2021) whom concluded that wars lead to a higher inflation than pandemics and Bobeică and Hartwig (2022) whom stated that during the initial stage of the pandemic, inflation was generally lower than expected, but later on, it ended up being significantly higher than anticipated. Given that the results provide proof that an increase in electricity and natural gas prices lead to an increase in inflation during both crises, of which a more significant one as a result of the war in Ukraine, policy makers need to take into consideration commodity prices, such as electricity and gas, given that they are a main component of the production of goods and services which in time of economic tension can undergo significant fluctuation. Measures such as timely price capping the price for goods of strict necessity and commodity prices that have a significant impact of businesses such as electricity and price, securing energy reserves and adoption of renewable energy solutions could help to limit inflation growth.

With regard to the limitations of this article, I appreciate that statistical data on the price of electricity and gas for industry would be more relevant in explaining the evolution of the HICP indices analyzed, given that the goods and services in the economy are influenced by the production, transportation and other related costs which often involve the consumption of electricity and gas, however I did not identify any open-sources with monthly frequency for these series. Also, the research can be extended by analyzing the impact of electricity and gas prices in EU at other member states level and as well in relation to Romania, to better understand the dependence of member states to the EU, respectively of Romania to other member states.

Regarding future research directions I will extend this current research by adding on its other variables that reflect the economies state, such as GBP and its components and exchange rate. My overall goal remains the same to identify through empirical analysis if we are confronting a new economic crisis by also comparing the evolution times of COVID pandemics and Russia's aggression on Ukraine to the Global financial crisis.

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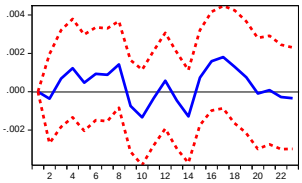
Appendix no. 1 - Impulse Response of HICP_EU subcategories to electricity and gas prices in EU.

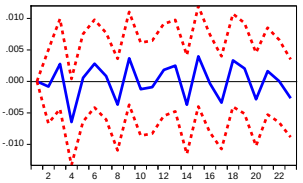
Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.

Response of DLOG_HICP_FOOD_EU to DLOG_ELECTRICITY_EU

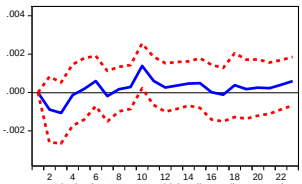


Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.

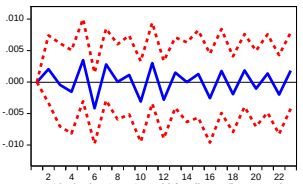
Response of DLOG_HICP_CLOTHING_EU to DLOG_ELECTRICITY_EU



Response of DLOG_HICP_FOOD_EU to DLOG_GAS_EU

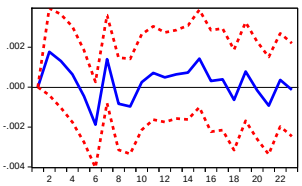


Response of DLOG_HICP_CLOTHING_EU to DLOG_GAS_EU



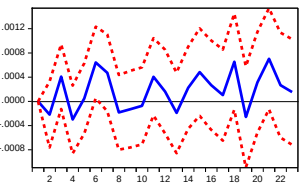
Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.

Response of DLOG_HICP_EDUCATION_EU to DLOG_ELECTRICITY_EU

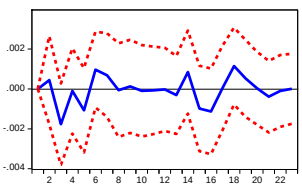


Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.

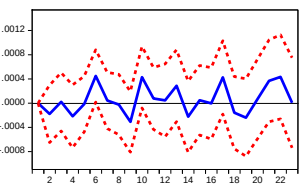
Response of DLOG_HICP_HEALTH_EU to DLOG_ELECTRICITY_EU

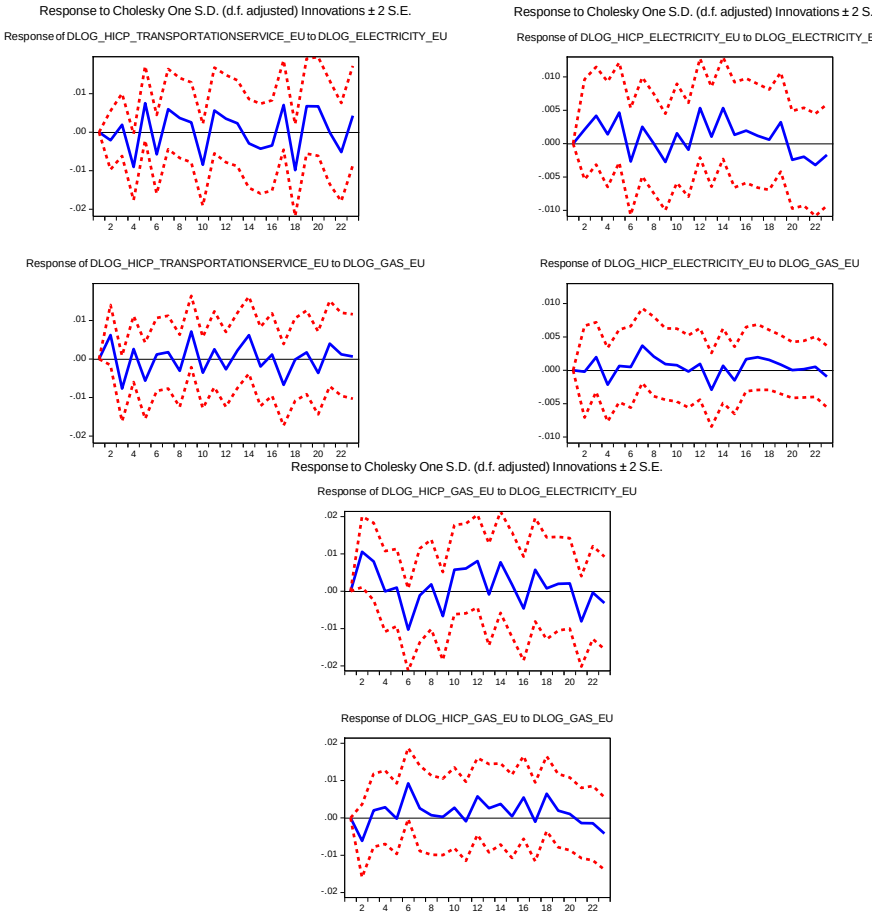


Response of DLOG_HICP_EDUCATION_EU to DLOG_GAS_EU



Response of DLOG_HICP_HEALTH_EU to DLOG_GAS_EU



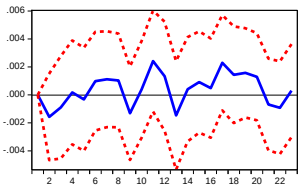


Source: Author's own work using EViews 10 software.

Appendix no. 2 - Impulse Response of HICP_RO subcategories to electricity and gas prices in EU and RO.

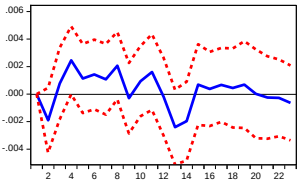
Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.

Response of DLOG_HICP_FOOD_RO to DLOG_ELECTRICITY_EU

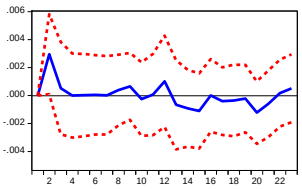


Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.

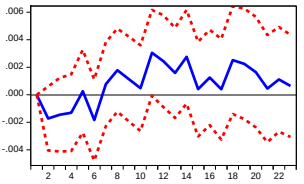
Response of DLOG_HICP_FOOD_RO to DLOG_ELECTRICITY_RO



Response of DLOG_HICP_FOOD_RO to DLOG_GAS_EU

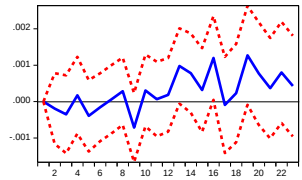


Response of DLOG_HICP_FOOD_RO to DLOG_GAS_RO



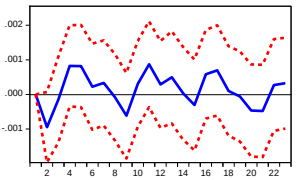
Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.

Response of DLOG_HICP_CLOTHING_RO to DLOG_ELECTRICITY_EU

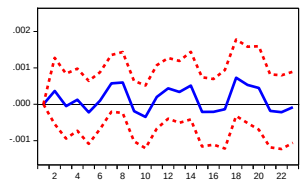


Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.

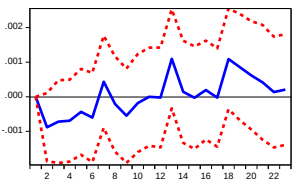
Response of DLOG_HICP_CLOTHING_RO to DLOG_ELECTRICITY_RO



Response of DLOG_HICP_CLOTHING_RO to DLOG_GAS_EU

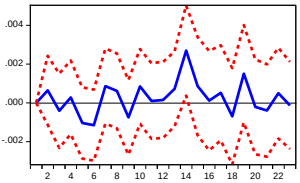


Response of DLOG_HICP_CLOTHING_RO to DLOG_GAS_RO

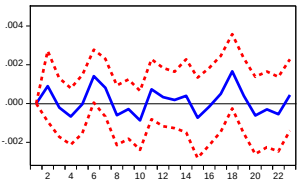


Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.

Response of DLOG_HICP_EDUCATION_RO to DLOG_ELECTRICITY_EU

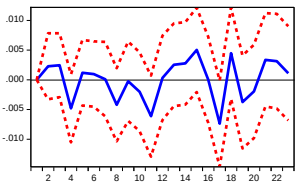


Response of DLOG_HICP_EDUCATION_RO to DLOG_GAS_EU

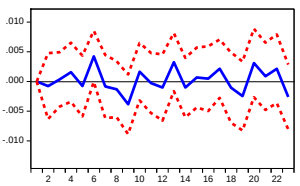


Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.

Response of DLOG_HICP_HEALTH_RO to DLOG_ELECTRICITY_EU

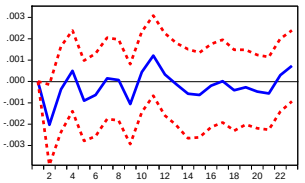


Response of DLOG_HICP_HEALTH_RO to DLOG_GAS_EU

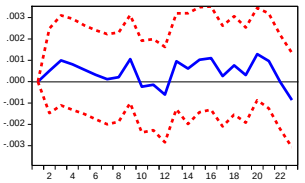


Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.

Response of DLOG_HICP_EDUCATION_RO to DLOG_ELECTRICITY_RO

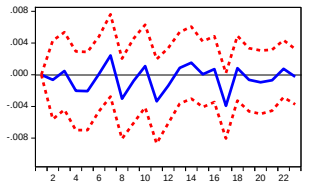


Response of DLOG_HICP_EDUCATION_RO to DLOG_GAS_RO

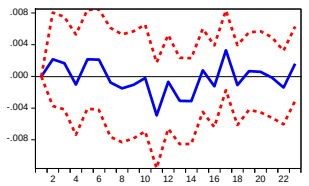


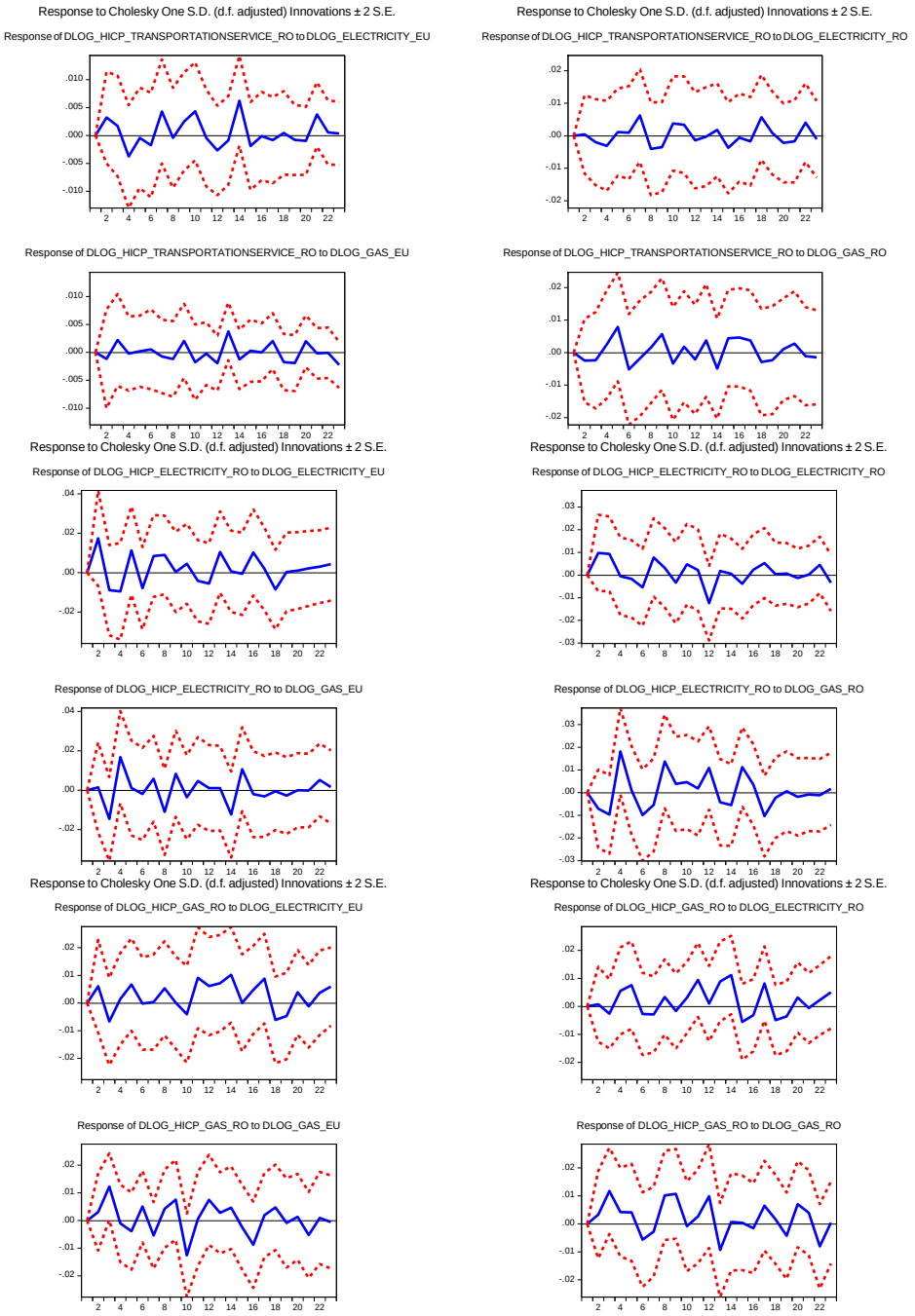
Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.

Response of DLOG_HICP_HEALTH_RO to DLOG_ELECTRICITY_RO



Response of DLOG_HICP_HEALTH_RO to DLOG_GAS_RO





Source: Author's own work using EViews 10 software.

Appendix no. 3 - Historical Variance of HICP_EU subcategories to electricity and gas prices in EU.

Source: Author's own work using EViews 10 software.

Appendix no. 4 - Historical Variance of HICP_RO subcategories to electricity and gas prices in EU and RO.

Source: Author's own work using EViews 10 software.