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Russian aggression against Ukraine and the changes in European Union countries' macroeconomic situation: Do energy intensity and energy dependence matter?

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Abstract

The study aims to assess whether there are significant differences among EU member states regarding the Russo-Ukrainian-conflict-driven changes in macroeconomic indicators and whether these differences are linked to the country's energy vulnerability. Applying *k*-means clustering, three country groups are distinguished, similar with regard to their energy intensity, energy dependence (including dependence on Russian gas), and household budgets' exposure to energy prices. Based on the Kruskal-Wallis and Wilcoxon pairwise comparison tests, the study reveals statistically significant differences among the distinguished country clusters in the level of inflation and interest rates at the time of this conflict as well as differences in the 2022 forecasts' changes for GDP, inflation, budget balance and unemployment. The results indicate that EU economies characterised by the most significant energy vulnerability economically suffer the most in the aftermath of the Russian invasion of Ukraine.

Keywords

- energy intensity
- energy dependence
- natural gas
- Russian aggression against Ukraine
- European Union member states
- macroeconomic indicators
- clustering

JEL codes: Q43, E31, E43, E01, H62, E24

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Introduction

A country's economic development cannot take place without the use of energy. Access to energy is one of the most critical aspects of the socio-economic and environmental well-being and sustainable development of modern countries as almost all mainstream goods are produced, delivered and used only with energy involvement (Chalvatzis, 2009; Chalvatzis & Ioannidis, 2017). Almost every country globally strives to achieve energy security a goal that can be defined and interpreted in various ways. Commonly it refers to reliable and affordable access to sufficient energy supplies (Colgan et al., 2023; Szulecki & Westphal, 2018). Fossil fuels as one of the most popular energy sources still occupy a dominant position in the heart of many economies, including developed countries (Leng Wong et al., 2013; Martins et al., 2018). European Union countries are substantially dependent on Russian energy suppliers, including natural gas. A country's development is vitally based on energy (Caetano et al., 2017; Martins et al., 2019; Sugiawan & Managi, 2019). The Russian aggression against Ukraine propelled energy security to the forefront of the European policy agenda (Giuli & Oberthür, 2023).

The paper examines whether the changes in European Union member states' economic indicators are linked to the Russo-Ukrainian military conflict. In contrast to the studies mentioned above the study is not only focused on the conflict-driven changes in macroeconomic indicators but also links these changes with the magnitude of countries' energy vulnerability. To the authors' knowledge it is the first study that groups all EU countries considering their energy intensity, energy dependence (mainly linked to Russian natural gas supplies), and household budget exposure to energy prices and then verifies whether the distinguished EU country groups differ significantly in terms of changes in leading macroeconomic indicators in the aftermath of this military conflict. The study is novel and relevant regarding the current significant challenges countries face.

The paper is organised as follows: Section 1 provides a review of the relevant scientific literature. Section 2 details the methodology, objectives of the study, research hypotheses, material descriptions and the research methods used. The next Section presents empirical findings, followed by a discussion. The paper ends with conclusions.

1. Literature review

Energy security based on guaranteed access to adequate supplies of energy carriers belongs to universal national objectives (Ericson, 2009). International Energy Agency defines energy security as the availability of a regular supply of energy at an affordable price taking into account physical, socioeconomic and environmental dimensions, both in long-term and short-term perspectives (Costantini et al., 2007). Energy security has become one of the primary concerns of countries worldwide, e.g., due to limited energy sources, limitations in energy supply and fluctuations in energy prices (Zhu et al., 2020). Energy security also belongs to priority challenges for all the European Union countries as access to energy carriers is crucial for each EU member's sustainable development (Bluszcz, 2017). Natural gas belongs to fossil fuels energy sources of electricity production for economic sectors of the countries worldwide. It is linked to lower CO_2 emission as compared to other fossil fuels energy sources (Azam et al., 2021). Moderate natural gas consumption contribute to the decarbonisation pathway and energy security over the complete transition toward a low-carbon economy based on renewables (Aguilera & Aguilera, 2020; Sadik-Zada & Gatto, 2021). Russia is one of the largest natural gas producers and exporters worldwide substantially affecting natural gas markets (Kutcherov et al., 2020). European markets have been the primary destination for the export of Russian natural gas (BP, 2019). Notably the increased European Union countries' import dependence on natural gas supply has often been highlighted (Flouri et al., 2015).

The Russia–Ukraine war has been raging since February 2014, i.e. the eruption of the dispute over the official status of Crimea and Donbas between the conflicting parties. Since the outbreak of a full-scale Russian invasion of Ukraine on February 24, 2022, tensions between the neighbours have exploded (Umar et al., 2022). The Russian invasion of Ukraine has brought about the worst military conflict in Europe since the Balkan wars (Astrov et al., 2022). Krickovic (2015) claims that the escalation of the conflict between Ukraine and Russia in 2014 has increased the European Union's security concerns about the future development of the energy supply from Russia. Nevertheless, the share of Russian energy carriers, including oil and natural gas, varies significantly across the EU (BP, 2021; Korosteleva, 2022). Energy security risk has surged particularly in Central and Eastern European countries which are mostly supplied by Russia (Mišík & Nosko, 2017). Reducing Russian natural gas dependency remains a critical challenge for the European Union economies (Korosteleva, 2022). The EU economies will need to diversify their energy sourcing to lessen dependency on Russian energy supplies (Khudaykulova et al., 2022). Hosseini (2022) argues that the current crisis, i.e. the Russia–Ukraine conflict has brought the dependability of non-renewable energy sources into question prompting considerations of what steps can be undertaken by authorities to quickly lessen the dependence on fossil fuels for those countries that are most susceptible as importers. In his opinion a global shift towards realizing net-zero goals will gradually reduce the usage and importation of fossil fuels.Before the conflict in Ukraine escalated European consumers were burdened by sharply increasing natural gas and electricity costs, jeopardizing the primary aspect of energy security, i.e. its affordability. The invasion intensified concerns about the accessibility of fossil fuels with mounting apprehension that Russia might leverage control over supply and costs to force political compromises and counter Western economic sanctions (Szulecki & Overland, 2023; Van de Graaf & Colgan, 2017).

The paper deals with energy intensity and energy dependence on Russian natural gas. The literature indicates that energy vulnerability and dependency on Russian energy carriers is country-specific. Thus the study's group of countries that are similar considering energy indicators. The Russian invasion of Ukraine in 2022 highlights the country's energy dependence on fossil fuels and energy supply from Russia. War brought about the rapid growth of uncertainty, declines in stock exchange values, rising commodity prices, supply chain blockages and a general worsening of countries' economic situations. The situation is complex as countries have not yet recovered from the COVID-19 pandemic and have now had to deal with another geopolitical-economic challenge, the recent 2022 Russian attack on Ukraine (Mbah & Wasum, 2022).

Boungou and Yatie (2022) reveal that the stock markets' reaction in countries geographically close to the Russo-Ukrainian conflict has been the most visible and adverse. Czech et al. (2023) demonstrate that, on the first day and subsequent days of the Russian aggression against Ukraine in 2022, stock market indices in countries with the strongest trade ties with Russia and Ukraine reacted the most adversely. Yousaf et al. (2022) observe the significant and adverse reaction of stock markets due to the Russian invasion of Ukraine on the event day and post-event days, particularly in Poland, Hungary and Turkey. Federle et al. (2022) find that the change in stock market prices in a four-week window around the start of the conflict is linked to a country's distance from Ukraine.

Ruiz Estrada (2022) claims that the adverse impact of the Russian invasion of Ukraine on inflation and unemployment is substantial but measuring such impact with any degree of certainty stays a challenge. Nevertheless, this military conflict has led to global inflation rooted in a rise in energy and food prices (Kilian & Murphy, 2014; Ozili, 2022). Dräger et al. (2022) find that the Russian invasion boosted short-run inflation expectations for 2022 and substantially changed recommendations for monetary policy. The Russian war in Ukraine and the subsequent trade restrictions have triggered rising inflation in European Union countries (Prohorovs, 2022).

Inflation represented a primary concern post COVID-19 and has gained even more momentum following the outbreak of the Russian invasion of Ukraine. One of the most vital channels through which inflation may affect the financial aspects of households and firms' functioning is higher interest rates (Aharon & Qadan, 2022). Liadze et al. (2022) indicate that the military conflict imposes further monetary policy tightening, i.e. ca. interest rates increase by one percentage point in 2022 in the United States and more than 1.2 percentage points in the Euro area.

Astrov et al. (2022) claim that there is so much uncertainty and so many contingencies that forecasting of macroeconomic effects of this military conflict for EU countries is challenging. Nevertheless, the short-term economic and financial effects are substantially negative. The unprovoked Russian aggression against Ukraine represents a considerable cost equivalent to 1% of global GDP in 2022. However, Europe (mainly European Union), due to its tight trade links with Russia and Ukraine and its dependence on Russian energy carriers is expected to shrink by more than 1% in 2022, and the developing European economies (including Ukraine) are expected to shrink by even 30% (Liadze et al., 2022). According to the spring 2022 World Bank forecast (World Bank, 2022), a conflict-driven worldwide recession and possible stagflation are expected. Such a negative macroeconomic phenomenon has not been observed since 1970.

The conflict is expected to increase public expenditure on defence particularly in the European Union countries. Moreover, the war creates an enormous problem of refugees in Europe leading to growing public spending for refugees mainly in Ukraine-neighbouring countries such as Poland (Liadze et al., 2022). This conflict is expected to worsen the difficult post--COVID-19 fiscal situation. Irtyshcheva et al. (2022) observe increased pressure on some countries' public finances. The slowdown in economic growth and even the expected recession will undoubtedly contribute to the deterioration of the labour market, i.e. an increase in the unemployment rate (Ruiz Estrada, 2022).

2. Materials and methods

The study aims to identify the groups of EU countries which are similar considering the indicators reflecting their energy intensity, energy dependence on Russian gas and household budget exposure to energy prices. Additionally, the paper aims to check whether the identified groups of EU member states differ significantly in relation to the selected macroeconomic indicators in the aftermath of the Russian invasion of Ukraine.

To cluster EU countries according to their energy intensity, energy dependence on Russian gas and household budget exposure to energy prices, the k-means clustering developed by Linde et al. (1980) is applied. The k-means procedure aims to find the closest distance of points from the cluster's centre (Ding & He, 2004). The k-means clustering has various benefits including straightforward implementation, easy interpretation and is capable of computing. The optimal number of clusters is identified based on the Silhouette coefficient (Tibshirani et al., 2001).

Given a dataset $C = \{x_1, ..., x_n\}$ with n samples and m features. The k-means clustering aims to minimise the following function:

$$F(U, Z) = \sum_{h=1}^{k} \sum_{i=1}^{n} \sum_{j=1}^{m} u_{ih} \times c(x_{ij}, z_{hj}) \tag{1}$$

where k represents the number of clusters; $U = [u_{ih}]$ is an $n \times k$ partition matrix that satisfies $u_{ih} \in \{0, 1\}$ and $\sum_{h=1}^{k} u_{ih} = 1 (1 \le i \le n; 1 \le h \le k)$; $Z = \{Z_h, h = 1, \dots k\}$ is a set of cluster centres in which Z_h consists of m values $(z_1^h, z_2^h, \dots, z_m^h)$, each is the mean of a feature j in cluster Z_h and is defined as $z_j^h = \frac{\sum_{x_i \in Z_h} x_{ij}}{|Z_h|}$; while $c(\cdot,\cdot)$ is the squared Euclidean between two feature values.

In the study n refers to EU member states and equals 27—the number of all European Union countries, while m equals six and represents clustering variables, i.e. indicators reflecting the country's energy intensity, energy dependence on Russian gas and household budget exposure to energy prices (equation 1). The variables are standardised before clustering to make them comparable between the EU countries.

All energy indicators applied in the clustering come from the Vulnerability matrix developed by European Commission and are presented in the European Economic Forecast Spring 2022 (European Commission, 2022). The energy part of the matrix includes the following indicators:

- total energy intensity—the ratio of total energy to gross value added (GVA), i.e. global value chains of products purchased by residents for final use;
- total gas intensity—the ratio of total gas to gross value added (GVA), i.e. global value chains of products purchased by residents for final use;
- total Russian gas intensity—the ratio of total Russian gas to gross value added (GVA), i.e. global value chains of products purchased by residents for final use;
- ratio of Russian gas in total available gas—the extent to which EU countries rely on Russian gas. Total available gas is measured as import + domestic production – export + stock changes;

- energy weight in the HICP consumption basket—the ratio of spending on energy to the total expenditures of households;
- contribution of energy to annual HICP inflation—the ratio of changes in energy prices to the changes in the prices of consumer goods and services acquired by households.

Then based on the clustering results it is assessed whether the distinguished country groups differ significantly in relation to the selected macroeconomic indicators in the aftermath of the Russian invasion of Ukraine. In the analysis seven macroeconomic indicators are selected. A detailed description of the selected indicators is as follows:

- stock prices change—a stock market reaction to the Russian invasion of Ukraine outbreak on 24 February 2022. It is estimated as the change of the country's leading stock market index between 23 February 2022 and 7 March. 7 March reflects the highest level of stock market uncertainty in the aftermath of the war outbreak measured by the S&P option implied volatility index (VIX). Data come from Refinitiv Datastream;
- inflation—the maximum level of HICP inflation (Y/Y) from March-August 2022, i.e. the first half of the year of the Russian invasion of Ukraine. Monthly data on inflation come from Eurostat;
- interest rates—interest rates for long-term government bonds in EU member states. Data come from Eurostat and the European Central Bank (ECB);
- GDP forecast change refers to the change in the projected 2022 GDP growth rate between autumn 2021 and spring 2022 forecasts. The change is calculated as a difference between the value from autumn 2021 and spring 2022 and is measured in percentage points. The positive value indicates an increase in the forecasted 2022 GDP growth rate (improvement of the macroeconomic situation) while the negative value indicates a decrease in the projected 2022 GDP growth rate (deterioration of the macroeconomic situation);
- inflation forecast change refers to the change in the projected average 2022 HICP inflation rate between autumn 2021 and spring 2022 forecasts. The change is calculated as a difference between the value from autumn 2021 and spring 2022 and is measured in percentage points. The positive value indicates an increase in the forecasted 2022 inflation rate, while the negative value indicates a decrease in the projected 2022 inflation rate;
- budget balance forecast change refers to the change in the projected 2022 budget balance between autumn 2021 and spring 2022 forecasts. The change is calculated as a difference between the value from autumn 2021 and spring 2022 and is measured in percentage points. The positive value indicates an increase in the forecasted 2022 budget bal-

ance (improvement of the forecasted fiscal situation), while the negative value indicates a decrease in the projected 2022 budget balance (deterioration of the predicted fiscal situation);

- unemployment forecast change refers to the change in the projected average 2022 unemployment rate between autumn 2021 and spring 2022 forecasts. The change is calculated as a difference between the value from autumn 2021 and spring 2022 and is measured in percentage points. The positive value indicates an increase in the forecasted 2022 unemployment rate (deterioration of the forecasted situation in the labour market), while the negative value indicates a decrease in the projected 2022 unemployment rate (improvement of the forecasted situation in the labour market). Data on the forecasted change in the value of macroeconomic indicators in 2022 come from two European Commission reports:
  - European Economic Forecast Autumn 2021 Economic Forecast: From recovery to expansion, amid headwinds (European Commission, 2021),
  - European Economic Forecast Spring 2022 Economic Forecast: Russian invasion tests EU economic resilience (European Commission, 2022).

Both reports have been developed and published by the European Commission. Economic forecasts are prepared and published quarterly (spring, summer, autumn, winter) for each European member state and for the EU as a whole. The autumn 2021 forecast was prepared in the declining phase of the COVID-19 pandemic and projected that despite existing obstacles the EU economies would experience prolonged and robust expansion over the post-pandemic time. The spring 2022 forecast was prepared just after the outbreak of the Russian aggression against Ukraine and projected that this military conflict would substantially affect EU economies posing new challenges facing the EU, i.e. further upward pressures on commodity prices, increasing supply disruptions and growing uncertainty.

The study checks the existence of significant differences among clusters by applying the Kruskal-Wallis test (Kruskal, 1952a, b) and the Wilcoxon rank-sum pairwise comparison test (Wilcoxon, 1992) with the p-values adjustment using the Benjamini and Hochberg method (Benjamini & Hochberg, 1995). In the Kruskal-Wallis test country groups represent the independent qualitative variable while the selected macroeconomic indicator is the dependent variable.

The null (H_0) and alternative (H_1) hypotheses in the Kruskal-Wallis test are as follows (Hecke, 2012; Ostertagová et al., 2014)

$\mathbf{H_0}$: All k population medians are the same.
$\mathbf{H_1}$: At least two population medians **differ**.

A calculation of the test statistic in the Kruskal-Wallis test is presented below:

$$H = \frac{12}{N(N+1)} \sum_{i=1}^{k} \frac{R_i^2}{n_i} - 3(N+1),\ N = \sum_{i=1}^{k} n_i \tag{2}$$

where R_i is the sum of the ranks calculated for each group i ($i = 1, 2, \ldots, k$), n_i is the size of i group, N is the number of observations in all k groups. H is approximately χ^2 distributed, with the number of degrees of freedom which equals $k - 1$. The coefficient $\frac{12}{N(N+1)}$ is a suitable normalization factor.

3. Results and discussion

European Union countries are highly dependent on Russian energy supplies. Before the Russian aggression against Ukraine in February 2022 Russia's share of Europe's energy supply amounted to 25% of oil and 40% of gas supplies. Figure 1 depicts a plunge in the import of Russian natural gas in the EU in the majority of pipelines in the aftermath of the outbreak of the military conflict and the implementation of economic sanctions against Russia (Statista, 2022). Moreover, according to Statista's report on natural gas in Europe the expected shortfall in natural gas demand due to the shutoff of pipe gas from Russia in 2022 will decrease. Nevertheless, the drop in natural gas consumption will differ among EU member states equalling 7% on average and up to 40% in Czechia, Slovakia and Hungary (Figure 1). Considering this diversity of EU economies there is an assumption that the countries differ in energy vulnerability.

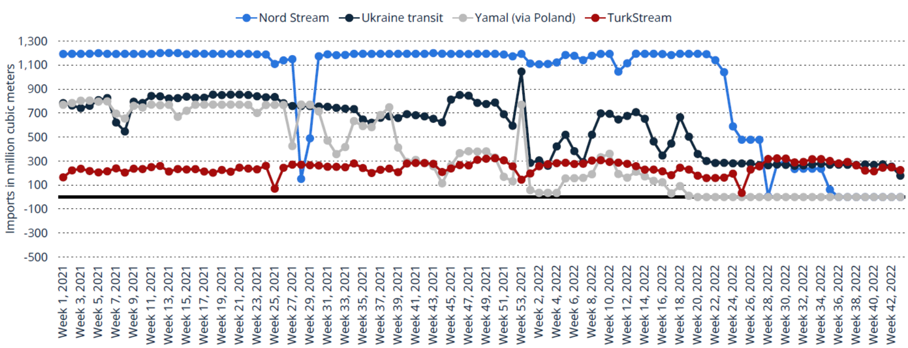

Figure 1. Natural gas import volume from Russia in the European Union in 2021–2022, by exporting route in million cubic meters

Source: (Statista, 2022).

The study groups EU countries according to their energy intensity, energy dependence on Russian gas and household budget exposure to energy prices. The k-means clustering reveals three groups of EU countries. The dendrogram depicts clusters in which countries are combined according to their similarity (Figure 2). Cluster I includes Portugal, Ireland, Sweden, France, Malta, Italy, Germany, Denmark, Austria, Spain, Luxemburg, Netherlands and Belgium. Cluster II contains countries such as Finland, the Czech Republic, Croatia, Slovenia, Poland, Greece, Cyprus and Romania. Cluster III contains Slovakia, Latvia, Bulgaria, Hungary, Lithuania, and Estonia (Figure 2).

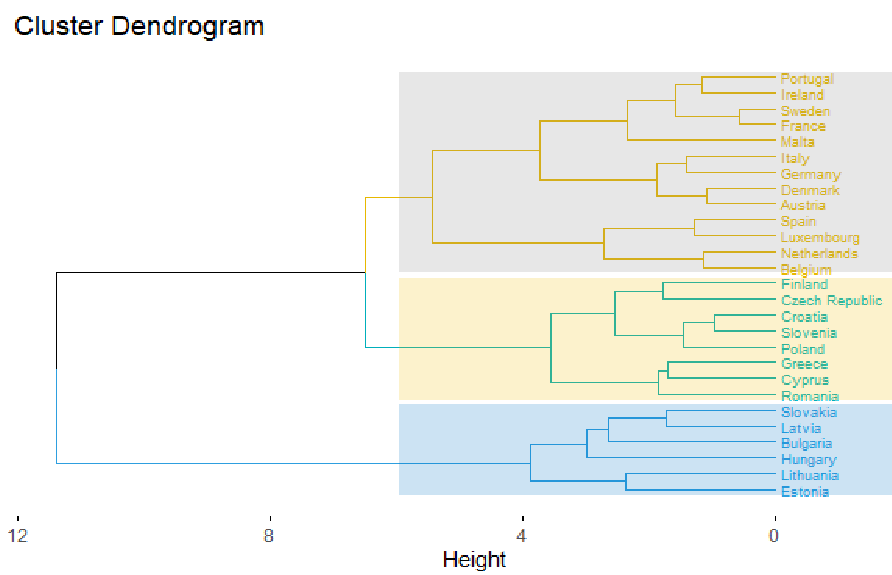

Figure 2. The k-means regional clustering results

Source: own calculations.

Table 1 shows mean and medium values in the distinguished clusters for all six indicators applied in the k-means analysis. Cluster I represents countries with the lowest energy intensity, energy dependence on Russian gas and energy weight in the HICP consumption basket. The average total energy intensity equals 4.45% GVA, of which gas-based energy accounts for approximately 20% (Table 1). Russian gas represents on average about 25% of all gas. The dependence on Russian gas varies in cluster I as in Germany, Austria and Denmark more than half of the natural gas comes from Russia while Ireland and Malta do not use Russian gas at all. Moreover, in EU member states from this cluster energy constitutes less than 10% of the HICP consumption basket and the contribution of energy to annual HICP inflation is close to 3%.

Table 1. Descriptive statistics of cluster features, i.e. energy intensity, energy dependence on Russian gas and household budget exposure to energy prices in the distinguished EU country groups

Indicator	Measure	I	II	III
Total energy intensity	mean	4.45	7.54	9.12
	median	4.40	7.75	8.55
Total gas intensity	mean	0.85	1.12	1.82
	median	0.90	1.15	1.80
Russian gas intensity	mean	0.23	0.55	1.27
	median	0.20	0.55	1.20
Ratio of Russian gas in total available gas	mean	25.78	51.79	82.58
	median	20.00	50.25	80.85
Energy weight in the HICP consumption basket	mean	9.95	11.93	14.12
	median	9.70	11.90	14.25
Contribution of energy to annual HICP inflation	mean	3.19	2.70	3.55
	median	2.80	2.60	3.25

Source: own calculations.

Cluster II contains the countries with on average, about 70% higher energy intensity and about 30% higher gas intensity than cluster I (Table 1). Moreover in this cluster the average ratio of Russian gas to gross available gas equals 50%. In detail, in Finland, the Czech Republic and Slovenia more than 80% of gas comes from Russia. In cluster II energy constitutes almost 12% of the HICP consumption basket (Table 1). Cluster III is characterised by the highest levels of all six indicators related to energy intensity indicators, energy dependence on Russian gas and household budget expo-sure to energy prices. In this country group the average ratio of total energy intensity is more than twice as high as in cluster I. Russian gas as a total of all available gas is as high as 82.58%. Moreover, Hungary and Latvia use only Russian gas. Energy weighs as much as one-seventh of residents' consumption basket while the contribution of energy to annual consumer inflation is about 3.5%. Table 1 data indicate that cluster III includes the European Union member states that seem the most exposed to the Russian invasion of Ukraine's adverse economic effects due to the highest energy intensity and most extraordinary Russian gas dependence.

Table 2 shows selected macroeconomic indicators' mean and medium values in the distinguished clusters. The estimated descriptive statistics indicate that cluster III includes countries that suffer the most in the aftermath of the Russian invasion of Ukraine. The short-term reaction of the stock market to this military conflict in all three clusters is visible and negative. Nevertheless, stock indices drop more in clusters that are more energy-intensive and Russian gas-dependent. The study results correspond to Boungou and Yatié (2022) and Yousaf et al. (2022). They reveal the instant and short-term negative effect of the Russian invasion of Ukraine on stock market prices mainly in countries geographically close to the parties of the conflict.

The average maximum HICP inflation (Y/Y) level in the March-August 2022 period in cluster III is more than twice as high as in cluster I (Table 2). In detail, inflation in cluster III is as high as 19.12%, compared to 12.51% in cluster II and 9.59% in cluster I. However, it should be stressed that the average inflation values in all clusters should be considered high. The highest levels of HICP, greater than 20%, are observed in Estonia, Latvia and Lithuania which are included in cluster III. In contrast France and Malta from cluster I experience the lowest inflation levels.

Surprisingly and despite the highest level of inflation in cluster III the highest level of interest rates is not observed there. However, four out of six cluster III countries, including Estonia, Latvia and Lithuania, belong to the eurozone which makes it impossible to mitigate inflation using a key country's monetary policy instrument, i.e. an increase in interest rates. In turn cluster II which is characterised by the highest interest rates includes as many as four countries that do not use the common European currency.

To picture the economic situation of the EU countries in the aftermath of the Russian invasion of Ukraine the changes in forecasts of macroeconomic indicators for 2022 are analysed. The forecast made in autumn 2021 with the forecast made in spring 2022, i.e. before and after the outbreak of the conflict are compared. Moreover, the analysis of macroeconomic forecasts allows for a better capture of the effect of Russian aggression against Ukraine and separates it from the COVID-19 pandemic effect. The forecast from autumn 2021 considers the coronavirus pandemic's negative impact on EU economies while the forecast from spring 2022 includes the effects of the outbreak of the military conflict .

Table 2 data indicates a deterioration of the economic growth rate forecast in all three analysed clusters from one percentage point in cluster I to more than two percentage points in cluster III. Interestingly there is almost no change in the budget balance forecast between autumn 2021 and spring 2022 in clusters I and II while the European Commission forecasts a substantial deterioration of the fiscal stance in cluster III. The forecast from spring 2022 significantly increases the assumed average annual inflation level for 2022. However, the change in the increase in the price level in countries from group III is greater by more than three percentage points than in group I. Significant changes in the unemployment rate in the analysed clusters are not observed. Compared to the forecast from autumn 2021 the forecast from spring 2022 indicates a deterioration in the labour market in 2022 in groups II and III and a slight improvement in group I.

Table 2. Descriptive statistics of indicators reflecting country's macroeconomic situation in the aftermath of the Russian invasion of Ukraine in the distinguished EU country groups

Indicator	Measure	I	II	III
Stock prices change	mean	–8.64	–11.10	–12.04
	median	–8.09	–11.40	–12.34
Inflation	mean	9.59	12.51	19.12
	median	9.5	12.20	19.85
Interest rates	mean	2.23	4.54	3.02
	median	2.13	3.68	2.47
GDP forecast change	mean	–0.98	–1.75	–2.40
	median	–1.00	–1.80	–2.35
Inflation forecast change	mean	3.78	4.89	6.87
	median	3.50	4.50	6.55
Budget balance forecast change	mean	0.11	–0.05	–1.17
	median	0.10	0.10	–1.20
Unemployment forecast change	mean	–0.28	0.23	0.70
	median	–0.20	0.30	0.75

Source: own calculations.

The descriptive statistics analysis shows that the impact of Russia's invasion of Ukraine hurts the EU economies. Most of the macroeconomic indicators deteriorate. However, the most substantial and adverse economic effects are observed in countries from cluster III and also from cluster II. To visualize and expand descriptive statistics analysis boxplots are applied. Figure 3 depicts boxplots for selected macroeconomic indicators in the distinguished EU country groups. The boxplots serve as a straightforward graphical representation in preliminary data analysis. They illustrate the complete spread of the dataset, offer insights into its extremities and highlight the data's distribution pattern.

The boxplots segment data into quartiles using a box and whiskers. The box covers the middle 50% of data with its edges (hinges) marking the first and third quartiles and its centre line indicating the median. The box's length is the interquartile range (IQR) a measure of spread. Whiskers extend from the quartiles to display the data range reaching up to 1.5 IQRs. Data beyond whiskers are outliers shown as individual points (Nuzzo, 2016). The boxplots visualize the changes in the analysed macroeconomic indicators among the distinguished clusters. The median line indicates the average trend for the group with a higher median suggesting an increase in the given indicator. The

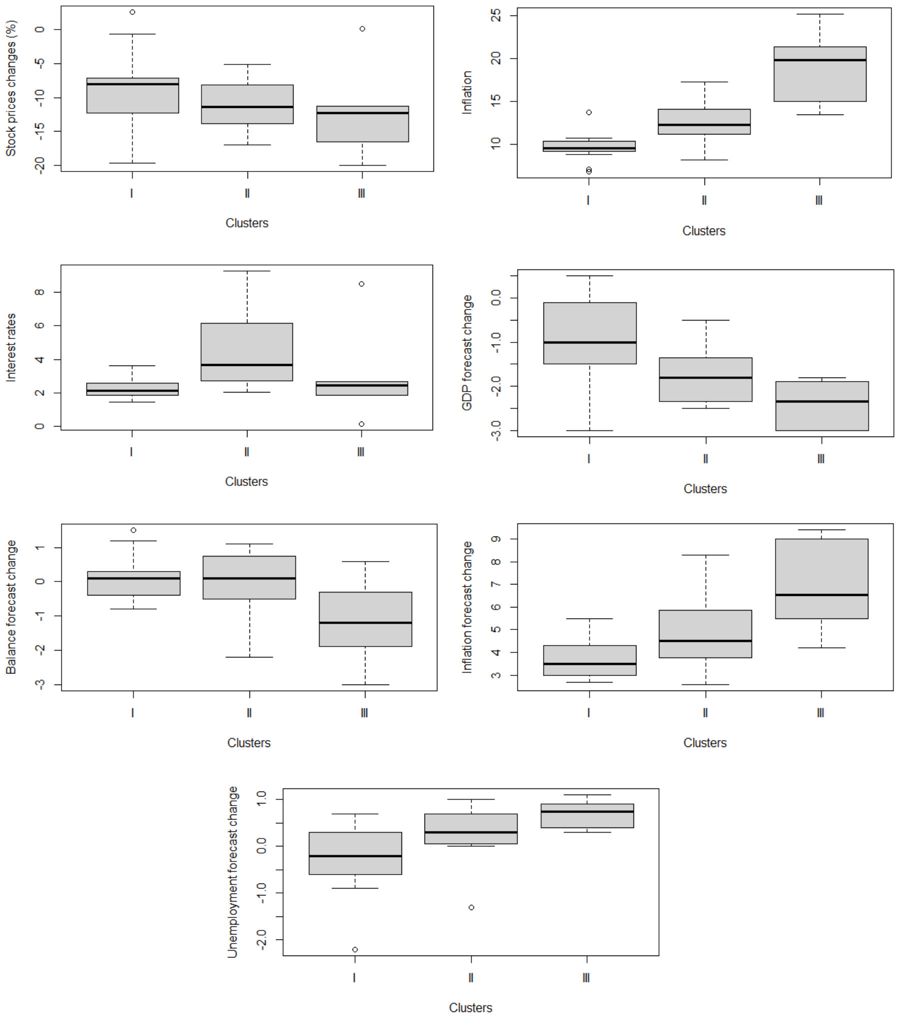

Figure 3. Boxplots for selected macroeconomic indicators in the distinguished EU country groups

Source: own calculations.

spread of the box and whiskers reflects its variability. Similar to Table 2 the boxplots presented in Figure 3 indicate visible differences in the data's distribution pattern between analysed clusters. In more detail they depict reduced economic growth predictions across all clusters with the steepest drop in cluster III. While clusters I and II see little change in the budget balance between autumn 2021 and spring 2022 a significant fiscal decline is projected for cluster III. The spring 2022 forecast elevates the expected 2022 inflation especially in group III. No major unemployment shifts are observed across clusters. However, while groups II and III anticipate a weaker labour market in 2022 group I expects a slight improvement.

In the next step the study verifies whether there are statistically significant differences between distinguished clusters regarding seven selected macroeconomic indicators. The distinguished clusters are not equal. In the situation of unequal samples sizes the nonparametric tests are recommended (Chan & Walmsley, 1997). In the paper the nonparametric Kruskal-Wallis test is applied. The results of the test are presented in Table 3.

Table 3. The results of Kruskal-Wallis test

Indicator	*H* test statistics	*p*-value
Stock prices change	1.810	0.405
Inflation	16.11	<0.001
Interest rates	6.257	0.044
GDP forecast change	9.003	0.011
Budget balance forecast change	4.690	0.092
Inflation forecast change	9.896	0.007
Unemployment forecast change	9.522	0.009

Source: own calculations.

Table 3 results imply statistically significant differences in the median values of six analysed macroeconomic indicators between at least one pair within three distinguished clusters. A significant difference between the distinguished EU country clusters applies to the inflation rate, inflation forecast change and unemployment forecast change—at a 1% significance level, interest rates, GDP forecast change—at a 5% significance level and budget balance forecast change—at a 10% significance level. A significant difference in the median level of stock market reaction to the Russian aggression against Ukraine between distinguished clusters is not revealed.

Additionally, a pairwise comparison Wilcoxon rank-sum test to check whether the significant differences in median values refer to all three distinguished country groups or selected ones is conducted. The results of the pairwise comparison test are presented in Table 4.

Table 4 results imply significant differences, at a 5% significance level, in the median level of inflation rate between country groups I, II and III. Moreover, both Figure 3 (boxplot for inflation) and Tables 1 and 2 show that countries characterised by high energy intensity and high dependence on Russian gas (clusters II and III) have the highest medium level of inflation. Additionally, it can be noticed that the higher the country's dependence on Russian ener-

Table 4. The results of Wilcoxon rank-sum pairwise comparison test

Indicator	I–II	I–III	II–III
Inflation	0.012	0.003	0.007
Interest rates	0.041	0.568	0.272
GDP forecast change	0.092	0.028	0.092
Budget balance forecast change	0.970	0.098	0.180
Inflation forecast change	0.169	0.009	0.089
Unemployment forecast change	0.118	0.013	0.118

Source: own calculations.

gy, the higher the HICP rate. The research results confirm the results of Ruiz Estrada (2022) and Prohorovs (2022) who show that this military conflict boosted inflation rates. However, the study offers a more complete and detailed picture, i.e. it indicates the existence of statistically significant differences in the level of inflation and conflict-driven increase in forecasted levels among EU countries. Moreover it reveals that the scale of this negative phenomenon is linked to the country's energy vulnerability including dependence on the Russian natural gas supply.

The Wilcoxon rank-sum pairwise comparison test results show that only clusters I and II differ significantly in terms of interest rates at a 5% significance level. However the results for interest rates are not fully transparent due to the existence of common currency and a common monetary policy in the Eurozone. The results correspond to Aharon and Qadan (2022) and Liadze et al. (2022) who indicate the need for monetary policy tightening by increasing interest rates.

The distinguished EU country groups differ significantly (at a 10% significance level) in GDP forecast change for 2022. Moreover both Figure 3 and Tables 1 and 2 indicate a negative relationship between the clustering energy indicators (energy intensity, including gas intensity, Russian gas dependence, the share of energy in the HICP basket and the average contribution of annual energy inflation to headline HICP) and change in GDP growth. The results reveal that the most significant deterioration of the GDP forecast is observed in cluster III. The research results correspond to Liadze et al. (2022) and Astrov et al. (2022) who find that the countries characterised by tight trade links with Russia and Ukraine and their dependence on Russian energy carriers are expected to experience the greatest decrease in GDP growth rate.

The study results reveal statistically significant differences in forecast changes in budget balance, inflation rate and unemployment rate between clusters I and III. The boxplots in Figure 3 depict a substantial worsening of the three above-mentioned indicators' levels in cluster III and a slight improvement of the forecast for budget balance and unemployment rate. It is in line with Liadze et al. (2022) and Irtyshcheva et al. (2022) who indicate the increase of public expenditure on defence and refugees particularly in the conflict-neighbouring countries. Figure 3 clearly shows the relationship between energy intensity, Russian gas dependence and country groups' macroeconomic situation. Greater energy vulnerability (considering six energy indicators) is linked to a higher inflation rate and adverse changes in forecasts of the inflation rate, GDP growth, budget balance and unemployment rate.

Overall, the study results indicate that a group of EU economies characterised by the most significant energy vulnerability and measured by six energy indicators from the vulnerability matrix suffer the most in the aftermath of the Russian invasion of Ukraine in February 2022.

Conclusions

A country's economic development cannot take place without energy. European Union countries actively use Russian energy supplies, including natural gas. Nevertheless, the level of energy dependence varies among EU member states. The Russian invasion of Ukraine has increased countries' energy security concerns. Moreover, this unprovoked military aggression brought about adverse economic consequences for EU countries.

The paper aims to assess whether there are significant differences in Russo-Ukrainian-conflict-driven macroeconomic indicators among EU member states and whether these differences are linked to the country's energy vulnerability. Based on the k-means clustering, three country groups similar with regards to their energy intensity, energy dependence (including dependence on Russian gas), and household budget exposure to energy prices, are distinguished. The group with Bulgaria, Estonia, Hungary, Latvia, Lithuania and Slovakia represents that with the greatest energy vulnerability.

Based on the Kruskal-Wallis and Wilcoxon pairwise comparison tests the study results reveal statistically significant differences among the distinguished country clusters in the inflation and interest rates level during this military conflict (February-August 2022) and forecasts' change for 2022 of the level of GDP, inflation, budget balance and unemployment. The study finds that a greater country's energy vulnerability is related to the higher HICP rate and a more substantial deterioration of forecasts of GDP growth rate, inflation, budget balance and unemployment.

The results indicate that a group of EU economies characterised by the most significant energy vulnerability economically suffered the most in the aftermath of the Russian invasion of Ukraine in February 2022. It should be noted that both the European Union as a collective entity and the individual governments of each member state are making considerable efforts to reduce dependence on Russian energy carriers and ensure complete energy security. This situation underscores the necessity for state governments to employ a range of policy instruments to foster the development and use of renewable energy sources thereby ensuring energy security and reducing the susceptibility of the energy supply to external shocks.

Due to the research timeline complete macroeconomic data are not yet available. Therefore, the analysis is conducted not only on actual data but also on forecasts which should be considered as a limitation of the study. Moreover, the use of more complex econometric methods is constrained as they require a more extended time series, much longer than the several-month-long period since the Russian aggression against Ukraine. Overcoming the limitations mentioned above remains a challenge for future research.

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