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Consequences of the energy measures derived from the war in Ukraine on the level of prices of EU countries

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ABSTRACT

The war in Ukraine and the sanctions imposed by the European Union on Russia, which is one of the largest exporters of gas and oil, are currently causing a serious energy crisis. The aim of our work is to analyze the effects that the rise in fossil fuel prices, due to the embargo on Russian gas and oil resulting from the war in Ukraine, is having on the productive sectors of European economies. We apply input-output methodology, which allows to determine and analyze the impacts experienced both in production and prices, when there is a change in an exogenous variable. The results show that not all countries and sector were affected in the same way. In fact, there are significant differences that should be considered. European countries should keep inflation under control, without social welfare losses.

1. Introduction

Historically, the European Union (EU) has needed to guarantee its energy security, due to its high dependence on imports. There have been crises prior to the current one, such as the oil embargo of the Arab countries of the Organization of Petroleum Exporting Countries (OPEC) and, in general, the world oil crisis of 1973–1974. Subsequently, in the first two decades of the XXI century, were the Russian-Ukrainian gas conflicts of 2006 and 2009, and the sharp deterioration of Russian-Ukrainian relations in 2014. We are currently in another new energy crisis which means reshaping the EU's energy policy.

The war in Ukraine has provoked social, political and economic tensions. Although the most important aspect is the human tragedy that the people directly involved in the war are experiencing, there are also other situations derived from the conflict that are affecting and will affect other people. Among these situations are the closures of Ukrainian ports, which prevent grain from being traded to the rest of the world, or the problems arising from the embargo on Russian gas and oil.

In December 2022, the European Union embargo on Russian oil came into effect. The measure prohibits the purchase, importation or transfer of crude oil by sea and certain other petroleum products from Russia to the EU, which account for two thirds of the total flowing to the EU from Russia. As of February 2023, the restrictions also apply to other refined petroleum products. A temporary derogation has been established for imports of crude oil supplied by pipeline to those EU member states which, due to their geographical location, have a specific dependence on Russian supplies and lack viable alternative options. It is this last point which we will refer to in this paper, as the energy embargo that Russia is experiencing due to the war in Ukraine is affecting many European countries and causing widespread increases in the prices of these goods.

Europe is Russia's main market, which in turn is Europe's main supplier. In 2020, Russian gas accounted for more than a third of EU gas imports (37%), while for Russia, the European Union accounted for 85% of its sales (BP, 2021). In this context, Russia's invasion of Ukraine together with the climate crisis has necessitated an urgent transformation of the European energy system. The EU has approved a plan to end its dependence on Russian fossil fuels (REPowerEU Plan). This plan aims to rapidly reduce dependence on Russian fossil fuels and make swift progress in the ecological transition (European Commission, 2022a).

Europe wants to gradually phase out its dependence on Russian fossil fuels (gas and oil) and to this end the Plan seeks energy savings, diversification of energy supply and the deployment of renewable energies, to replace fossil fuels in households, industry and electricity production. Specifically, regarding energy savings, the European Commission proposes to improve energy efficiency measures in the long term, including

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an increase from 9 to 13% in the binding energy efficiency target. The implementation of the complete "Fit for 55″ package (European Commission, 2022b) would reduce our gas consumption by 30% for the year 2030.

The European Commission, in its Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions (European Commission, 2022c), indicates that, in the last 12 months, retail prices of natural gas and electricity have increased by 65% and 30% respectively. Russia's invasion of Ukraine has exacerbated price volatility and supply problems are adding to this difficult situation. This Communication presents the advantages and disadvantages of exceptional short-term specific options to reduce price peaks.

The expansion and acceleration of renewable energies in electricity production, industry, buildings and transport will accelerate our independence, boost the ecological transition and reduce prices in the long run. The Commission proposes to increase the 2030 headline target for renewable energy from 40% to 45% under the "Fit for 55″ package of measures (European Commission, 2022b). In addition, replacing coal, oil and natural gas in industrial processes will reduce greenhouse gas emissions and strengthen safety and competitiveness.

Given this situation, the aim of our work is to analyze the effects that the rise in fossil fuel prices, due to the embargo on Russian gas and oil resulting from the war in Ukraine, is having on the productive sectors of European economies. To that end, input-output methodology will be applied, which allows to determine and analyze the impacts experienced both in production and prices, when there is a change in an exogenous variable. To apply this methodology, the EXIOBASE database 3 version 3.8.2 (2021) will be used, showing the input-output tables of the different countries of the world, defining a multi-regional input-output model (MRIO). In order to be able to determine the impacts on prices in the economic sectors, due to the effects of the energy embargo, the branches relating to intermediate consumption of oil and gas will be exogenized and the analysis will be carried out based on a price model.

This paper provides an exhaustive analysis of the consequences of the war in Ukraine, first of all, on the energy markets and, consequently, on other economic sectors of strategic importance. Modelling work aims to serve as a reference document for EU countries at this time when they have to decide in order to cope with high energy prices, and to help families and businesses most affected by the energy crisis. In particular, this paper can help countries most affected by price rises when adopting measures to help citizens and businesses facing higher energy bills and to establish market correction mechanisms to protect families and the whole economy from excessively high prices.

The work is divided into six sections. After this introduction, the literature review is presented in Section 2. Section 3 describes both imports and the dependence of the European Union on Russian gas and oil and Section 4 describes the methodology used. The results of applying the price model to determine the effect of price increases on the different sectors of the economies of the countries of the European Union are presented in Section 5. The paper ends with a presentation of the conclusions of the work.

2. Literature review

Energy has always been one of the most important geopolitical factors. With an economy already affected by the Covid-19 pandemic, followed by an energy crisis aggravated by the war in Ukraine, energy security is now top of the European Union's agenda. It is therefore necessary to diversify supply and reduce dependence on fossil fuels in households, buildings and industry, as well as in the electricity system.

Energy security has been considered by different authors. Jääskeläinen et al. (2018) address Russian gas imports by the EU, a conflict that has been aggravated by the war in Ukraine. They analyze energy relations between Finland and Russia as a case study, looking at energy security problems related with the significant dependence of imports from a single supplier. They consider three different scenarios of energy policy until 2040. Although their analysis shows that Finland's dependence on imports of primary energy does not pose a serious threat to energy security in terms of supply, they are aware that, given the difficulty of anticipating social, political and economic trends, there are possible developments that could affect Finland.

With the aim of increasing Russia's gas supply to Germany and other EU countries, in order to cover the expected growth of gas demand, together with the need to strengthen the EU's energy security, the Nord Stream 2 gas pipeline (NS 2) was built connecting Russia and Germany via the Baltic Sea. The war in Ukraine will have consequences on this gas pipeline project, infrastructure that has always had detractors within the European Union, considering that this route increases dependence on Russia. Zhiznin and Timokhov (2019) highlight geopolitical factors as determinants in the cooperation between the EU and Russia. They study the economic and geopolitical positions adopted by the supporters and opponents of the project and assess the prospects of the NS 2. They conclude that the project is high on the agenda of both economic relations between the European Union and Russia, and of world politics. The launch of NS 2 was intended to contribute both to providing energy security for the EU and to easing military tensions between NATO and Russia in the Baltic region, but the new war situation in Ukraine has disrupted this project.

Finally, the work of Zhu et al. (2022) addresses the challenges to the security of the gas supply due to the dependence on foreign gas and proposes a comprehensive assessment framework for the security of the supply of natural gas based on two aspects: factors of the suppliers themselves and the factors of interaction between importers and suppliers depending on supply chain risk factors.

Another topic of great interest for the academic literature is energy dependence, and the problems it entails for countries of the European Union. For that reason, we highlight below some studies that analyze this topic. The main objective of the work of Lee (2017) is to explain the 2009 gas conflict between Russia and Ukraine. It shows first that the existing theories in the study of international relations have limitations when accounting for that conflict, proposing that the conflict took place through two critical causal mechanisms: the global financial crisis of 2008 and Ukraine's anti-Russian policy.

Regarding Russian gas imports, Gedich (2017) analyzes the prospects of Russian gas in the European market, given the increased competition and changes in the geopolitical situation. Competition increased in 2012 due to a number of factors, including stagnant gas demand, competition from other energy sources, subsidies for renewable energy, increased surplus of liquefied natural gas and changes in the geopolitical situation. In 2015, dependence on EU gas imports was 70%, with the share of Russian gas exported to the EU at 42%. Most of the complaints against Russian gas were linked to prices and the unequal treatment of different markets. The article considers price models in the European gas market, with the aim of assessing the extent of possible changes in the European gas market and identifying the key factors that Russia and its gas companies should take into account in order to build their strategy in Europe.

For their part, Jafarzadeh et al. (2021) study alternatives to European dependence on Russian gas imports. Specifically, the Caspian and Middle Eastern countries supply gas to Turkey through the southern corridor and then to other European countries. Using a cooperative game theory approach, they investigate different gas export coalitions from this region to Europe and obtain the bargaining power of all countries through the Shapley solution. Their results show that Turkey plays the most important role in the pipeline network as a conveyor, as without this country no area could export gas to Europe.

Also, on the dependence of the European Union on Russian gas imports, Dubský et al. (2021) find that the possibilities for diversification are limited. They identify economic and political criteria for the comparison of pipeline project options and create a methodological framework through the construction of an index for the evaluation and

comparison of individual projects.

In conclusion, energy markets have an oligopolistic structure, based on economic globalization, which requires the importation of energy products. Strong energy dependence on Russia, the Middle East and North Africa makes the European Union vulnerable, both in terms of energy security and trade. This matter is addressed by Elustu (2021), who analyzes the relationship between economic growth and dependence on energy imports, together with the importation of oil and petroleum products, natural gas and solid fuels for EU member and candidate countries between 2014 and 2018. The author highlights the importance of oil and its derivatives for the economic growth of the European Union, for which reason the diversification of exporters will minimize the risk of supplier shortages.

Successive crises have highlighted the importance of energy trade efficiency for energy security. Therefore, trade relations deserve further research, especially in relation to trade in fossil fuels (crude oil and natural gas), due to their high share in global energy trade. Wang et al. (2022) investigate dependencies on fossil fuel trade relations and show that China and Japan have high trade dependencies with Turkmenistan, Kazakhstan and Uzbekistan regarding natural gas imports. They have shown that there is a large market space in the South American region in terms of United States oil trade and that countries like China, Australia, the UK, Russia and Germany, which are important members in each community, can play a leading role in addressing the energy trade dilemma. They suggest that community-leading countries play leadership roles and exert their strong influence on communities to address the specific problems of energy trade.

Finally, there is an extensive literature on the impact in financial terms of rising oil and gas prices. Aliu et al. (2023) highlight the heavy dependence of the German, Austrian and Italian equity indexes, due to the heavy dependence of these countries on Russian gas and oil. They provide evidence on the systemic risk that Russian gas has for the EU equity markets. From a managerial perspective, changes in oil and gas prices are a permanently integral part of portfolio risk analysis. Other papers have addressed the global impact on energy prices of the war in Ukraine. Cui et al. (2023) analyze the impact on GDP in the EU as well as in the USA and other regions, using a CGE model. The contribution of our paper, compared to other published papers, is to analyze the impact in the EU, differentiating by country and by sectors.

3. Imports and EU dependence on Russian gas and oil

Two analyses are carried out in this section. Firstly, Russian oil and gas imports by the countries of the European Union are analyzed and, secondly, the dependence of both countries and productive sectors on Russian oil and gas is quantified.

3.1. Russian gas and oil imports by EU countries

In a first analysis, Russian oil and gas imports by EU productive sectors are compared with those of the rest of the world. The table below shows how the above amount is shared between the EU and the rest of the world.

Table 1
EU Imports of oil and gas 2018–2022, monthly averages (millions of €).

Imports	2018	2019	2020	2021	2022
Oil					
Extra-EU excl. Russia	12,544	12,047	7,679	12,133	23,098
Russia	5,281	4,724	2,661	4,013	4,575
Total	17,824	16,770	10,340	16,146	27,673
Gas					
Extra-EU excl. Russia	2,881	2,617	1,848	5,437	21,587
Russia	2,661	2,185	1,387	3,516	5,474
Total	5,541	4,802	3,235	8,953	27,061

Source: EU Imports of Energy Products, Eurostat

As can be seen on Table 1, oil and gas imports have decreased significantly in 2020 due to the COVID-19 pandemic, recovering in 2021 and increasing in 2022, reaching a total of 27,673 million euros of oil and 27,061 million euros of gas. It could also be observed that, although the total amount has increased considerably, imports from Russia have increased to a lesser extent, due to the conflict in Ukraine.

The following table (Table 2) shows the distribution in percentages of these imports.

It can be seen that, after the start of the war in Ukraine, imports of Russian oil and gas by the EU have decreased, and those of other countries have increased, expected with higher energy prices. In 2018, Russian oil and gas imports represented 29.62% and 48.01%, respectively, decreasing to 16.53% (oil) and 20.23% (gas) in 2022.

The following tables (Tables 3 and 4) show the Russian oil and gas imports by EU countries with respect to the total imports from 2018 to 2022 year.

As mentioned above. since the start of the war in Ukraine. imports of Russian oil by the EU have decreased. due to the embargo imposed on Russian oil. The countries with the highest reduction are. in this order. Croatia. Lithuania. France. Sweden. Finland and Spain. In contrast. Italy and Czechia have increased their imports.

Table 4 shows the percentage of Russian gas imports with respect to the total imported.

As regards imports of Russian gas. these have decreased mainly in Bulgaria. Romania. Czechia and Italy. While the imports have increased in Spain. Hungary. Slovakia. France. Greece. Belgium and Lithuania.

3.2. Dependence of EU countries on Russian gas and oil

Energy imports dependency shows the share of total energy needs of a country met by imports from other countries. The focus of the following analysis is on identifying the weight of Russian gas and oil imports on the total consumption of these products. In this way. we manage to quantify the dependence of each of these countries on Russian gas and oil. We will focus on showing the percentages of European countries. The following tables (Table 5 and Table 6) show the percentage of dependence on Russian oil and gas for each of the countries analyzed.

Regarding Russian oil. Slovakia. Finland. Poland. Lithuania and Estonia have a very high dependence. between 70 and 85%. For most of these countries. dependency continues to decline progressively until 2018. to increase again in 2019. However. other countries. such as Bulgaria. Denmark. Croatia. Malta. Hungary and Czechia. progressively reduced their dependence on Russian oil until 2019 (not taking into account the year 2020 due to the effects of the pandemic). Lastly. the countries with the lowest dependency. less than 20%. in the 2015–2020 period are Spain. Ireland. Cyprus. France and Portugal.

The countries with the greatest dependence on Russian gas are those of Eastern Europe. due to their proximity with Russia. In this order. Latvia. Estonia. Slovakia. Finland. Czechia. Bulgaria. Hungary and Romania stand out with more than 90% dependence. Although Bulgaria and Romania reduce their dependency in 2019 by around 10%.

On the other hand. Lithuania and Greece reduce their dependency in the period 2015–2019 by around 40%. And finally. we highlight the countries least dependent on Russian gas: Malta. Austria. Sweden.

Table 2
EU Imports of oil and gas 2018–2022, monthly averages (percentages).

Imports	2018	2019	2020	2021	2022
Oil					
Extra-EU excl. Russia	70.38	71.83	74.27	75.15	83.47
Russia	29.62	28.17	25.73	24.85	16.53
Gas					
Extra-EU excl. Russia	51.99	54.50	57.12	60.73	79.77
Russia	48.01	45.50	42.88	39.27	20.23

Source: Own elaboration based on EU Imports of Energy Products, Eurostat

Table 3
Russian oil imports by EU countries with respect to the total imports (percentages).

Country	2018	2019	2020	2021	2022
Austria	3.99	5.64	15.06	6.95	0.85
Belgium	11.11	13.58	5.47	0.04	0.03
Bulgaria	56.33	55.47	42.09	35.18	54.88
Cyprus	n.d.	n.d.	n.d.	n.d.	n.d.
Czechia	59.52	53.65	44.39	49.67	67.00
Germany)	37.97	38.28	36.19	31.96	37.97
Denmark	9.93	11.48	14.32	23.19	7.80
Estonia	0.05	0.01	0.67	n.d.	n.d.
Spain	24.42	26.31	18.07	25.45	5.09
Finland	47.51	50.53	39.80	33.70	15.71
France	46.95	32.11	18.38	16.32	10.63
Greece	15.79	22.79	26.27	17.56	2.47
Croatia	53.63	22.08	9.26	5.35	13.95
Hungary	36.25	39.78	46.19	33.60	23.52
Ireland	n.d.	n.d.	n.d.	n.d.	n.d.
Italy	16.99	26.34	15.53	11.96	25.32
Lithuania	63.70	63.67	51.79	51.36	25.78
Luxembourg	n.d.	n.d.	n.d.	n.d.	n.d.
Latvia	n.d.	n.d.	n.d.	n.d.	n.d.
Malta	n.d.	n.d.	n.d.	n.d.	n.d.
Netherlands	54.51	52.83	55.84	52.14	45.25
Poland	49.12	44.68	44.17	33.26	40.81
Portugal	61.02	46.42	n.d.	n.d.	n.d.
Romania	49.56	45.44	34.54	23.80	34.82
Sweden	60.92	52.14	14.64	33.72	27.43
Slovenia	n.d.	n.d.	n.d.	n.d.	n.d.
Slovakia	56.90	60.27	61.73	50.03	42.72

Note: n. d. means no data. The values in the table are estimates made by Eurostat.
Eurostat (2023a) https://ec.europa.eu/eurostat/databrowser/view/NRG_IND_IDOOIL/default/table?lang=en.
Source: Own elaboration based on EU trade (Eurostat, 2023a)

Table 4
Russian gas imports by EU countries with respect to the total imports (percentages).

Country	2018	2019	2020	2021	2022
Austria	n.d.	n.d.	n.d.	n.d.	n.d.
Belgium	2.08	3.87	4.53	3.35	19.16
Bulgaria	19.57	15.52	15.35	34.09	19.01
Cyprus	n.d.	n.d.	n.d.	n.d.	n.d.
Czechia	6.23	10.15	18.41	14.64	5.67
Germany	n.d.	n.d.	n.d.	n.d.	n.d.
Denmark	n.d.	n.d.	n.d.	n.d.	n.d.
Estonia	6.13	2.97	2.28	2.83	4.68
Spain	6.92	14.74	16.96	19.95	57.63
Finland	0.00	0.31	0.66	0.66	10.37
France	4.15	12.81	9.94	18.81	36.08
Greece	15.32	14.22	11.30	26.44	44.06
Croatia	n.d.	n.d.	n.d.	15.00	n.d.
Hungary	44.56	40.99	29.54	51.09	71.66
Ireland (Eire)	n.d.	n.d.	n.d.	n.d.	n.d.
Italy	50.82	40.69	41.47	54.48	48.34
Lithuania	6.81	5.99	4.03	6.76	18.77
Luxembourg	n.d.	n.d.	n.d.	n.d.	n.d.
Latvia	25.41	19.52	12.99	28.27	24.55
Malta	n.d.	n.d.	n.d.	n.d.	n.d.
Netherlands	n.d.	n.d.	n.d.	5.10	10.29
Poland	0.00	0.00	0.00	0.00	0.00
Portugal	n.d.	2.16	16.58	22.24	20.06
Romania	10.06	8.22	9.30	13.49	2.83
Sweden	n.d.	0.59	2.72	3.29	4.53
Slovenia	27.27	8.84	11.17	32.31	31.27
Slovakia	24.44	21.73	18.09	31.09	51.39

Note: n. d. means no data. The values in the table are estimates made by Eurostat.
Eurostat (2023b) https://ec.europa.eu/eurostat/databrowser/view/NRG_IND_IDOGAS/default/table?lang=en.
Source: Own elaboration based on EU trade (Eurostat, 2023b)

Table 5
Dependence of EU countries on Russian oil (percentages).

Country	2015	2016	2017	2018	2019
Belgium	33.39	35.08	41.46	34.79	28.60
Bulgaria	71.67	67.59	54.10	57.38	58.12
Czechia	53.51	57.46	50.55	50.03	45.67
Denmark	26.04	29.13	n.d.	16.88	12.12
Germany	35.39	39.40	38.25	37.05	32.13
Estonia	72.40	75.29	70.46	65.96	72.08
Ireland	6.49	9.24	11.78	14.60	11.34
Greece	27.98	22.71	21.14	23.79	22.08
Spain	9.20	10.37	8.11	5.22	7.03
France	15.26	17.01	18.92	17.58	16.16
Croatia	26.42	17.70	17.25	18.13	16.22
Italy	15.71	14.28	11.54	11.39	15.02
Cyprus	14.55	16.00	12.80	8.65	12.33
Latvia	63.68	69.49	62.12	52.96	64.70
Lithuania	72.33	78.34	64.73	67.61	77.47
Luxembourg	24.99	26.17	30.53	25.00	21.46
Hungary	65.03	60.57	50.01	52.07	56.26
Malta	26.61	22.17	9.74	14.04	13.34
Netherlands	35.73	38.87	39.07	38.47	28.97
Austria	18.83	21.85	18.13	14.23	14.08
Poland	78.88	75.64	72.03	71.85	66.47
Portugal	10.21	19.61	23.90	20.32	13.21
Romania	34.73	34.91	34.55	34.16	33.69
Slovenia	14.63	17.50	17.35	15.84	27.83
Slovakia	84.41	82.96	80.41	80.46	80.90
Finland	76.19	78.93	76.77	74.84	78.88
Sweden	44.44	44.82	37.97	35.19	31.81

Note: n. d. means no data. The values in the table are estimates made by Eurostat.
Source: Oil and petroleum products import dependency by country of origin (Eurostat, 2023a).

Table 6
Dependence of EU countries on Russian gas (percentages).

Country	2015	2016	2017	2018	2019
Bulgaria	100.00	100.00	100.00	99.92	85.73
Belgium	3.69	7.93	6.81	11.45	16.42
Czechia	99.81	99.97	99.19	99.50	99.73
Denmark	n.d.	n.d.	n.d.	n.d.	n.d.
Germany	45.32	60.25	54.34	51.22	51.22
Estonia	100.00	100.00	99.84	99.90	99.45
Ireland	0.00	0.00	0.11	1.72	3.60
Greece	71.68	72.25	63.60	71.18	36.89
Spain	0.45	0.44	0.79	3.09	9.93
France	14.47	22.61	20.49	22.42	21.78
Croatia	29.75	36.96	47.35	73.04	69.34
Italy	47.31	43.25	47.74	48.80	47.60
Cyprus	n.d.	n.d.	n.d.	n.d.	n.d.
Latvia	100.00	100.00	100.00	100.00	100.00
Lithuania	82.60	38.29	53.64	56.77	43.27
Luxembourg	25.20	25.22	27.23	27.23	27.23
Hungary	95.00	95.00	95.00	95.00	95.00
Malta	n.d.	n.d.	0.32	0.00	0.00
Netherlands	n.d.	n.d.	n.d.	35.41	33.95
Austria	0.00	0.00	0.00	0.00	0.00
Poland	83.09	84.33	77.78	72.61	68.25
Portugal	0.00	0.00	0.00	0.00	1.90
Romania	97.68	99.77	99.97	98.03	91.72
Slovenia	31.22	34.00	23.00	31.25	11.87
Slovakia	100.00	98.81	84.60	100.00	100.00
Finland	100.00	100.00	100.00	97.99	97.30
Sweden	0.00	0.00	1.63	3.23	3.79

Note: n. d. means no data. The values in the table are estimates made by Eurostat.
Source: Gas import dependency by country of origin (Eurostat, 2023b).

Portugal. Ireland. Spain and Belgium. Although this dependence has grown slightly. reaching 16. 42% and 9.93% in Belgium and Spain. respectively.

4. Methodology

Determining how changes in other variables or economic policy affect prices is a very important aspect. so modelling these changes is fundamental for economic decision-making. As noted above. the main objective of this work is to determine the impact of the increase in energy prices resulting from the war in Ukraine. The input-output analysis (Miller and Blair, 2022) is a methodology that facilitates this objective. Such analysis is an important tool in economic studies. since it allows integrated knowledge by providing information. not only on the relationships between the different sectors. but also on aggregate demand. added value. imports and exports.

Leontief's demand model is defined from the following expression:

$$\boldsymbol{x} = \boldsymbol{X}\boldsymbol{i} + \boldsymbol{y} \tag{1}$$

where $\boldsymbol{x}$ represents total production. $\boldsymbol{X}$ the intermediate demand. $\boldsymbol{y}$ is the final demand and $\mathbf{i}$ is a vector whose elements are ones.

From this model. matrix $\boldsymbol{A}$ of technical coefficients can be defined whose elements are $a_{ij} = \frac{x_{ij}}{x_j}$; that is. the ratio of purchases that sector j makes from i. with respect to the total production of j.

Therefore. equation (1) can be expressed as:

$$\boldsymbol{x} = \boldsymbol{A}\boldsymbol{x} + \boldsymbol{y} \tag{2}$$

which can be rewritten as follows:

$$\boldsymbol{x} = (\boldsymbol{I} - \boldsymbol{A})^{-1}\boldsymbol{y} \tag{3}$$

where $(\boldsymbol{I} - \boldsymbol{A})^{-1}$ is the inverse Leontief matrix.

On the other hand. the supply model is defined by the following matrix equation:

$$\boldsymbol{x}' = \boldsymbol{x}'\boldsymbol{B} + \boldsymbol{v}' \tag{4}$$

in which $\boldsymbol{x}'$ represents the total transposed production vector. $\boldsymbol{B}$ is the distribution matrix whose elements are $b_{ij} = \frac{x_{ij}}{x_i}$ and v' is the transposed added value vector. The elements b_{ij} can be interpreted as the proportion of sales that sector i makes to j. regarding the total production of i.

Again. and analogously to (3). we can rewrite (4) as:

$$\boldsymbol{x}' = \boldsymbol{v}'(\boldsymbol{I} - \boldsymbol{B})^{-1} \tag{5}$$

Again. equations (2) and (4) and using matrix notation

$$\boldsymbol{A} = \boldsymbol{X}\widehat{\boldsymbol{x}}^{-1} \text{ and} \boldsymbol{B} = \widehat{\boldsymbol{x}}^{-1}\boldsymbol{X} \tag{6}$$

therefore.

$$\boldsymbol{A} = \widehat{\boldsymbol{x}}\boldsymbol{B}\widehat{\boldsymbol{x}}^{-1} \text{and} \boldsymbol{B} = \widehat{\boldsymbol{x}}^{-1}\boldsymbol{A}\widehat{\boldsymbol{x}} \tag{7}$$

On the other hand. since the total value of the output matches the total value of the inputs. they can be written

$$\boldsymbol{x} = \boldsymbol{X}\boldsymbol{i} + \boldsymbol{y} \text{and} \boldsymbol{x} = \boldsymbol{i}'\boldsymbol{X} + \boldsymbol{v}' \tag{8}$$

If changes in the exogenous vectors (and $\boldsymbol{v}$) of expressions (3) and (5) are considered. two situations can be established: x_0 (before the change occurs) and x_1 (after the change).

Therefore. the previous equation (3) takes the following expressions:

$$\boldsymbol{x}_0 = (\boldsymbol{I} - \boldsymbol{A})^{-1}\boldsymbol{y}_0 \text{and} \boldsymbol{x}_1 = (\boldsymbol{I} - \boldsymbol{A})^{-1}\boldsymbol{y}_1 \tag{9}$$

and the previous equation (5) takes the following expressions:

$$\boldsymbol{x}_0' = \boldsymbol{v}_0'(\boldsymbol{I} - \boldsymbol{B})^{-1} \text{and} \boldsymbol{x}_1' = \boldsymbol{v}_1'(\boldsymbol{I} - \boldsymbol{B})^{-1} \tag{10}$$

Suppose that there is a change in the costs of the primary inputs. which will cause a change in the added value $\boldsymbol{v}$. and therefore. a change in the total production $\boldsymbol{x}_1' = \boldsymbol{v}_1'(\boldsymbol{I} - \boldsymbol{B})^{-1}$. assuming that the matrix $\boldsymbol{B}$ is of fixed coefficients.

This change in primary inputs can be expressed as

$$\boldsymbol{\omega}' = \boldsymbol{v}_1'\widehat{\boldsymbol{v}}_0^{-1} \tag{11}$$

A diagonal matrix $\boldsymbol{V}$ can also be defined of added value coefficients. which would take the following expressions. before $(\boldsymbol{V}_0)$ and after $(\boldsymbol{V}_1)$ a change in the costs:

$$\boldsymbol{V}_0 = \widehat{\boldsymbol{v}}_0\widehat{\boldsymbol{x}}_0^{-1} \text{and} \boldsymbol{V}_1 = \widehat{\boldsymbol{v}}_1\widehat{\boldsymbol{x}}_1^{-1} \tag{12}$$

From the above expressions it can be deduced that:

$$\boldsymbol{i}' = \boldsymbol{i}'\boldsymbol{X}\widehat{\boldsymbol{x}}^{-1} + \boldsymbol{i}'\widehat{\boldsymbol{v}}\widehat{\boldsymbol{x}}^{-1} = \boldsymbol{i}\acute{\boldsymbol{A}} + \boldsymbol{i}\acute{\boldsymbol{V}} \tag{13}$$

which can be interpreted as the price per unit of production of each sector is equal to the sum of the cost of intermediate inputs and added value (Dietzenbacher, 1997).

Considering the change in costs of primary inputs. which causes a change in prices. we would have

$$\boldsymbol{p}' = \boldsymbol{p}\acute{\boldsymbol{A}}_0 + \boldsymbol{\omega}\acute{\boldsymbol{V}}_0 \tag{14}$$

where p' represents a vector of sectoral output price ratios.

The solution to the Leontief model is. therefore:

$$\boldsymbol{p}' = \boldsymbol{\omega}\acute{\boldsymbol{V}}_0(\boldsymbol{I} - \boldsymbol{A}_0)^{-1} = \boldsymbol{v}_1'\widehat{\boldsymbol{v}}_0^{-1}\widehat{\boldsymbol{v}}_0\widehat{\boldsymbol{x}}_0^{-1}(\boldsymbol{I} - \boldsymbol{A}_0)^{-1} = \boldsymbol{v}_1'\widehat{\boldsymbol{x}}_0^{-1}(\boldsymbol{I} - \boldsymbol{A}_0)^{-1} \tag{15}$$

5. Results

In order to analyze the effects that the rise in fossil fuel prices. due to the embargo on Russian gas and oil. is having on the productive sectors of European economies. the pricing model described in Section 4 has been applied to the available information on the prices of gas and oil imported by EU countries from Russia.

The multi-region input-output table for 2019. provided by EXIOBASE 3 (2021). has been used as a database. This table has been used because it is the last one published before COVID-19 and its results are comparable with those of previous years. However. the subsequent tables. corresponding to 2020 and 2021. present results that are not fully comparable as they refer to a period as uncertain and chaotic as that of the pandemic.

This Table 7 has been aggregated using the CNAE sectoral classification to 21 sectors presented below.

In sector B (mining and quarrying) the gas and oil subsectors have been separated and subsequently considered exogenous in the model.

Table 7
Productive sectors of the MRIO.

Sector	Definition
A	Agriculture. forestry and fishing
B	Mining and quarrying
C	Manufacturing
D	Electricity. gas. steam and air conditioning supply
E	Water supply; sewerage. waste management and remediation activities
F	Construction
G	Wholesale and retail trade; repair of motor vehicles and motorcycles
H	Transportation and storage
I	Accommodation and food service activities
J	Information and communication
K	Financial and insurance activities
L	Real estate activities
M	Professional. scientific and technical activities
N	Administrative and support service activities
O	Public administration and defence; compulsory social security
P	Education
Q	Human health and social work activities
R	Arts. entertainment and recreation
S	Other service activities
T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use
U	Activities of extraterritorial organisations and bodies

Source: Eurostat: European Classification of Economic Activities. NACE Rev. 2 (Adapted to the Classification of Products per Activity: CPA).

The application of the aforementioned model requires information on gas and oil prices at two points in time: before and after the start of the war in Ukraine and of the measures taken by the EU. Given the lack of information on said prices with the necessary level of disaggregation. it has been necessary to estimate them. For this purpose. Eurostat (2022) statistics have been used for oil and gas imported by European countries and prices have been estimated from the ratio between value and quantity. i.e..

$$P_{it} = \frac{V_{i.t}}{Q_{it}} \tag{16}$$

where P_{it} represents the price of the commodity *i*. in the moment *t*; $V_{i.t}$ is the value of the imports of the commodity *i* in the moment *t* and Q_{it} are the quantities imported. The subindex *i* can take two values: gas and oil; on the other hand. the subindex *t* refers to the months of December 2021 and June 2022. This time period has been taken to try to reflect the influence of the Ukrainian war on rising prices. In this sense. December 2021 would constitute the period before the event and would provide information on the price level prior to this crisis. As a final moment we have considered June 2022. as it is one of the last periods for which sufficient information is available. However. information is not available for all countries. so although all countries appear in the table. some do not present data.

The results of this price estimate and its growth rate are shown in the Annex (Table A). The results derived from the input-output model make it possible to carry out two types of analysis: a spatial analysis. from which the countries that have experienced the greatest growth in their prices are determined. and a sectoral analysis. which shows sectors that have had a higher price increase.

5.1. Spatial analysis derived from input-output price model

Given that the majority of European countries are net importers of energy. the rise in their prices has a significant macroeconomic effect. From the application of the input-output model. the countries in which the increase in the price of oil and gas have caused higher increases in the price level have been determined. In order to make a comparison of the impact this price growth has had on the countries of the European Union. a series of spatial indices will be constructed. An index will be calculated for each country in relation to the price increases experienced in the EU at a global level. The formula to be applied will be the Laspeyres type of spatial pricing. expressed as follows:

$$L_{C.EU} = \frac{\sum_i p_{iC} q_{iEU}}{\sum_i p_{iEU} q_{iEU}} \tag{17}$$

where p_i. obtained from the input-output model. represents the price level after the embargo measures imposed by the EU and q_i. the quantities. With i=1…n. the sectors of each economy are represented; with C. the countries and with EU the European Union as a whole.

If the value of said index for a particular country exceeds the unit. it means that the price increase in that country exceeds the EU average and the opposite. if it is below the unit. The values are shown in the following table (Table 8):

In the table above. and in relation to gas. it can be seen that Belgium. Bulgaria. Estonia. Greece. Croatia. Italy. Lithuania and Slovakia show price increases above the EU average. The largest increases are in Bulgaria and Lithuania. of approximately 60%. Among the countries with the lowest increases. relative to the EU. we can refer to the Czech Republic. Finland. Portugal and Sweden. These results are in line with Kotek. et al. (2023). Baqaee et al. (2022). Sgaravatti et al. (2022). Di Bella. et al. (2022). among many others. As far as oil is concerned. the countries that have experienced the highest price growth over the EU price level are Austria. the Czech Republic or Croatia. In the former. prices have risen more than 15 per cent and in the remaining two.

Table 8
Value of the Laspeyres spatial price index.

Country	Gas	Oil
Austria	n.d.	1.156
Belgium	1.085	1.027
Bulgaria	1.695	1.015
Cyprus	n.d.	n.d.
Czechia	0.330	1.090
Germany	n.d.	0.997
Denmark	n.d.	1.039
Estonia	1.325	n.d.
Spain	0.610	1.001
Finland	0.471	0.942
France	n.d.	1.067
Greece	1.075	0.995
Croatia	1.227	1.061
Hungary	0.895	0.996
Ireland	0.743	1.087
Italy	1.264	1.015
Lithuania	1.620	0.983
Luxembourg	n.d.	n.d.
Latvia	0.938	n.d.
Malta	n.d.	n.d.
Netherlands	n.d.	1.013
Poland	n.d.	1.048
Portugal	0.445	1.051
Romania	n.d.	0.960
Sweden	0.498	1.005
Slovenia	0.538	n.d.
Slovakia	1.389	1.032

Note: n. d. means no data.
Source: Own elaboration

slightly below 10 per cent. Finland. Romania and Lithuania show price increases of under 5%. Similar results can be seen in Mardones (2023). Baqaee et al. (2022) and Redeker (2022). among others.

In the graph below (Fig. 1). countries have been classified according to their Laspeyres spatial index values for gas and oil. It can be seen that Finland and Hungary show increases below the unit for both gas and oil; Lithuania and Greece. however. have been more affected (above the EU average) by changes in gas prices. Bulgaria. Italy. Slovakia. Belgium and Croatia are experiencing price increases above the EU average due to both gas and oil. and finally Spain. Sweden. Portugal. Ireland and the Czech Republic due to oil prices.

5.2. Sectoral analysis derived from input-output price model

The application of the input-output model of prices also allow us to determine the sectors that have experienced the greatest increases in their prices. due to the embargo policies on Russian oil and gas.

Table 9 shows the productive sectors most affected by the price increase. which are those where the price growth is 95% higher than the EU economies. The results are presented by sector. country and according to the type of fuel (gas and oil).

As can be appreciated in Table 9 the sectors that have experienced a higher price increase due to the rise in gas prices are: the Electricity. gas. steam and air conditioning supply (D) sector in Lithuania. Italy. Hungary. Czech Republic. Sweden and Spain. This increase may be due to the fact that gas is used intensively to produce electricity in combined cycle power plants. Accommodation and food service activities (I). arts. entertainment and recreation (R). education (P). public administration (O) and human health (Q). also have high values. all of them in Sweden. As regards the sector accommodation and food service activities uses gas and electricity both for heating. air conditioning or for the preparation of food. The other sectors mentioned above: arts. entertainment and recreation. education. public administration and human health require. in order to carry out their activity. heating and air conditioning during a very important part of the day. The results obtained are in line with those obtained in Bijnens. et al. (2022). among others. Regarding the

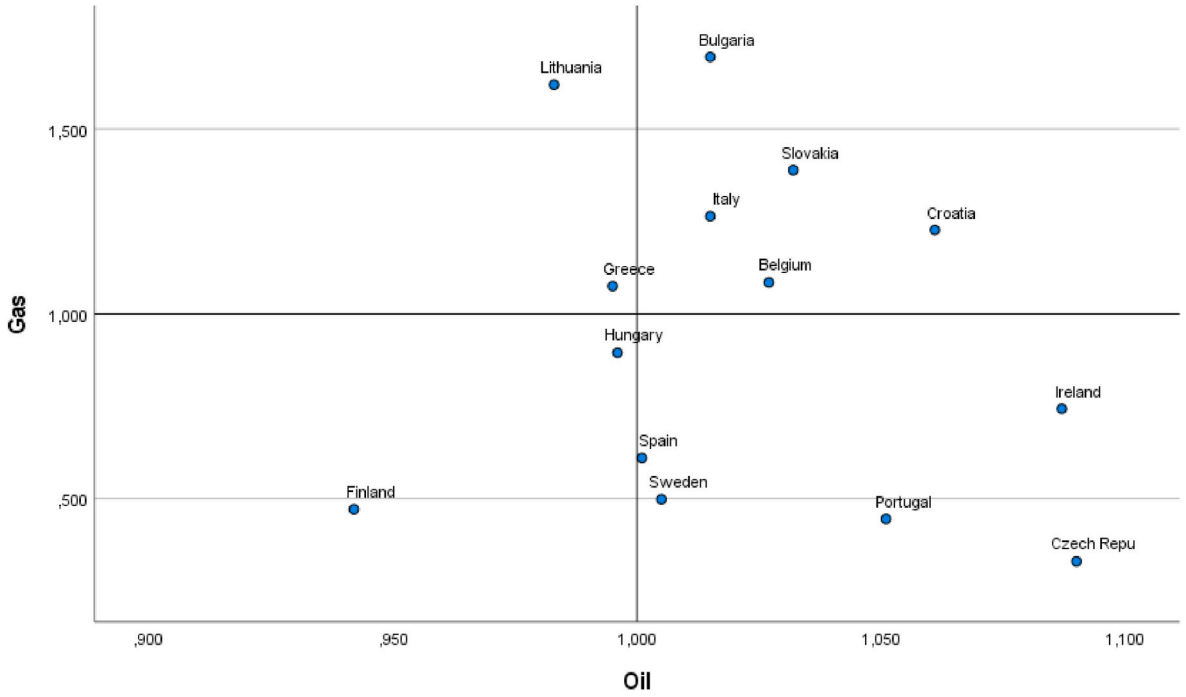

Fig. 1. Representation of EU countries according to the Laspeyres spatial index.
Source: Own elaboration

Table 9
Sectors that have experienced a price increase of over 95% due to increases in the price of gas and oil.

Gas			Oil		
Country	Sector	Price increase (%)	Country	Sector	Price increase (%)
Lithuania	D	32.35	**Latvia**	B	5.98
Italy	D	28.19	**Hungary**	C	5.85
Sweden	I	12.06	**Lithuania**	B	5.78
Sweden	C	9.74	**Slovenia**	C	5.71
Sweden	P	8.79	**Slovakia**	C	5.56
Hungary	D	7.92	**Czech Republic**	C	5.56
Sweden	O	6.82	**Bulgaria**	C	5.11
Sweden	Q	4.63	**Poland**	C	4.96
Czech Republic	D	3.57	**Belgium**	C	4.77
Slovenia	G	3.50	**Denmark**	H	3.92
Sweden	D	3.41	**Croatia**	Q	3.80
Sweden	K	3.16	**Bulgaria**	F	3.74
Sweden	M	3.13	**Hungary**	Q	3.66
Sweden	N	2.49	**Slovenia**	Q	3.62
Sweden	S	2.41	**Lithuania**	A	3.60
Sweden	J	2.05	**Croatia**	C	3.60
Spain	D	1.45	**Slovakia**	D	3.54
Italy	B	1.37	**Greece**	C	3.23
Italy	S	1.22	**Lithuania**	C	3.22
Italy	E	1.16	**Hungary**	F	3.15
Lithuania	E	1.09	**Greece**	F	3.02
Lithuania	R	0.63	**Belgium**	B	3.00
Lithuania	T	0.20	**Portugal**	C	2.92
Italy	P	0.07	**Slovenia**	B	2.92
Lithuania	O	0.01	**Romania**	M	2.91
			Spain	C	2.91
			Germany	C	2.90

Source: Own elaboration

consequences of the increase in the price of oil. the manufacturing sector (C) is the most affected in a large number of countries. such as Hungary. Slovenia. Slovakia. the Czech Republic and Bulgaria. The increase in oil prices has caused the production costs of manufacturing sectors to rise. such as the production of metal. paper or wood products. The mining and quarrying sector (B) in Latvia. Lithuania or Belgium is also affected. The rise in oil prices is the most recent challenge facing the mining sector. Mining companies use fuel to generate electricity and for transportation. The construction sector (F) is also experiencing a sharp rise in prices in Bulgaria. Hungary and Greece. The high price of oil and electricity make it more expensive to extract and transport fundamental materials for construction. Similar results can be seen in Bijnens. et al. (2022) and Sun. et al. (2022)

6. Discussion and conclusions

European countries will be affected differently by a fall in Russian gas and oil supplies. While the Czech Republic. Hungary. Italy. Lithuania and Latvia are the countries that consume most Russian gas. Germany. Finland. Italy. the Netherlands and Poland are the countries that use most Russian oil.

In terms of the degree of dependence of the national economies of these sectors. the Czech Republic. Estonia. Hungary. Italy and Latvia stand out as the most dependent on Russian gas. whereas Finland. Latvia. Slovakia. Poland and Lithuania as the national economies most dependent on Russian oil.

An input-output price model has been used to determine the price increases generated as a result of the Russia Ukraine war and subsequent sanctions. In order to apply this model. it was necessary to estimate the growth in the prices of gas and oil imported from Russia in the different European countries. In this sense. the countries that have experienced the greatest impact due to the increase in oil prices have been Austria. the Czech Republic. Croatia. Finland. Romania and Lithuania. Belgium. Bulgaria. Estonia. Greece. Croatia. Italy. Lithuania and Slovakia were the countries that experienced the greatest price increase due to the increase in gas prices.

These increases in the price of gas and oil have necessarily led to increases in the prices of the productive sectors. impacting mainly on the transport sector. followed by industry and. finally. the services sector. The countries that have seen their prices increase the most due to the increase in the price of gas have been the Netherlands. Poland. Portugal

and Slovenia. Similarly. due to rising oil prices. the countries most affected have been the Czech Republic. the Netherlands. Poland. Slovakia and Sweden.

The war in Ukraine may lead to further increases in energy prices. The amount of Russian gas transported by pipeline to Europe has decreased dramatically since April 2022. In addition. in December 2022 the EU began an embargo on Russian oil which has forced governments to rethink their transport policies. There is therefore great uncertainty regarding the levels of gas and oil supply for the coming years. Possible energy rationing in Europe would affect key productive sectors and substantially reduce growth in the euro area. with negative cross-border side effects.

On the other hand. the main cause of the increase in electricity prices is the gas market. since gas producers are still the energy suppliers who usually have the last access to the electricity market to meet real demand. Therefore. to contain the rise in energy prices. interconnections are needed to fully integrate the energy market. along with more renewable energy. energy efficiency measures and diversification of the energy supply to avoid dependencies.

Faced with this situation. the EU27 economies have a serious inflation problem. due to rising food and energy prices and persistent imbalances between supply and demand. Therefore. controlling inflation should be the top priority of the economic authorities at this time. Furthermore. the most industrialized countries are more vulnerable to changes in the energy market and. in particular. to any disruptions of Russian oil and gas supply. Finally. we should not forget that the loss of purchasing power of the citizens can involve risks to the political stability in Europe.

We are aware that this study has some limitations. One of them refers to statistical information. it would be appropriate to improve the information in both the spatial and temporal dimensions. It would be convenient to obtain data relative to the level of energy prices of all European countries. especially those with a greater weight in the EU economy and. on the other hand. to increase the period considered in the analysis. which will allow a study deeper into the impact of the conflict on the European economy.

Once more information is obtained. we intend to continue and expand this analysis and estimate the impact of the policies implemented by the different governments of the EU member countries to alleviate and address the economic problems derived from the increase of energy prices.

Author statement

M. A. Martínez: collected the data and performed the empirical calculations. C. Ramos: designed the methodology. A. Cámara: prepared the literature review. M. A. Martínez, C. Ramos and A. Cámara: writing, reviewing, editing and validation of the results.

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Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

ANNEX.

Table A
Estimated imported oil and gas prices in euros and growth rates in percentage

	Oil			Gas		
Country	**2022–01**	**2022–06**	**Rate**	**2022–01**	**2022–06**	**Rate**
Austria	56.74	83.66	47.45	n.d.	n.d.	n.d.
Belgium	49.53	74.82	51.06	157.66	153.56	−2.60
Bulgaria	48.77	59.05	21.07	118.58	152.00	28.19
Cyprus	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Czechia	52.15	71.06	36.26	46.32	50.21	8.40
Germany	48.87	79.04	61.75	n.d.	n.d.	n.d.
Denmark	51.35	90.76	76.74	n.d.	n.d.	n.d.
Estonia	n.d.	n.d.	n.d.	183.05	250.47	36.84
Spain	49.10	80.11	63.15	82.80	105.45	27.35
Finland	46.90	72.94	55.54	64.99	55.75	−14.22
France	52.77	79.03	49.76	n.d.	n.d.	n.d.
Greece	48.63	78.11	60.62	145.70	189.19	29.85
Croatia	51.68	89.34	72.86	170.72	270.94	58.70
Hungary	47.55	5..97	11.40	124.56	160.25	28.66
Ireland	55.62	89.45	60.82	108.04	101.25	17.53
Italy	49.91	77.40	55.09	105.22	192.07	82.54
Lithuania	48.06	86.00	78.95	132.51	274.57	107.21
Luxembourg	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Latvia	n.d.	n.d.	n.d.	125.96	169.85	34.84
Malta	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Netherlands	49.74	78.58	57.97	n.d.	n.d.	n.d.
Poland	50.40	70.93	40.75	n.d.	n.d.	n.d.
Portugal	51.51	85.26	65.53	61.25	177.99	190.57
Romania	47.20	71.82	52.16	n.d.	n.d.	n.d.
Sweden	49.76	86.13	73.09	65.04	168.45	159.00

(*continued on next page*)

Table A (*continued*)

	Oil			Gas		
Slovenia	n.d.	n.d.	n.d.	50.99	179.01	251
Slovakia	49.36	62.51	26.63	144.25	189.53	31.38
European Union	49.86	78.07	56.56	131.59	182.45	38.65

Note: n. d. means no data.
Source: Own elaboration

References

Aliu, F., Mulaj, I., Hašková, S., 2023. Consequences of the Russia-Ukraine war: evidence from DAX. ATX. and FTSEMIB. Stud. Econ. Finance 40 (3), 549–568. https://doi.org/10.1108/SEF-12-2022-0555.

Baqaee, D., Moll, B., Landais, C., Martin, P., 2022. The economic consequences of a stop of energy imports from Russia. Focus 84, 2022.

Di Bella, G., Flanagan, M.J., Foda, K., Maslova, S., Pienkowski, A., Stuermer, M., Toscani, F.G., 2022. Natural gas in Europe: the potential impact of disruptions to supply. IMF Working Papers 2022 (145). https://doi.org/10.5089/9798400215292.001.

Bijnens, G., Konings, J., Vanormelingen, S., 2022. The impact of electricity prices on European manufacturing jobs. Appl. Econ. 54 (1), 38–56. https://doi.org/10.1080/00036846.2021.1951647.

BP, 2021. Statistical Review of World Energy 2021 Full Report – Statistical Review of World Energy 2021 (bp.Com).

Cui, L., Yue, S., Nghiem, X.H., Duan, M., 2023. Exploring the risk and economic vulnerability of global energy supply chain interruption in the context of Russo-Ukrainian war. Resour. Pol. 81, 103373 https://doi.org/10.1016/j.resourpol.2023.103373.

Dietzenbacher, E., 1997. In vindication of the Ghosh model: a reinterpretation as a price model. J. Reg. Sci. 37 (4), 629–651. https://doi.org/10.1111/0022-4146.00073. Vindication of the Ghosh Model: A Reinterpretation as a Price Model (wiley.com).

Dubský, Z., Tichý, L., Pavliňák, D., 2021. A quantifiable approach to the selection of criteria and indexation for comparison of the gas pipeline projects leading to the EU: diversification rationality against securitisation? Energy 225, 120238. https://doi.org/10.1016/j.energy.2021.120238.

Elustu, S., 2021. Energy security of the European union: the relationship between energy import dependency and economic growth. Istanbul Journal of Economics-Istanbul Iktisat Dergisi 71 (1), 133–162. https://doi.org/10.26650/ISTJECON2021-942116.

European Commission, 2022a. Plan REPowerEU. Plan REPowerEU (europa.Eu).

European Commission, 2022b. Fit for 55. Fit for 55 - the EU's Plan for a Green Transition - Consilium (europa.Eu).

European Commission, 2022c. Communication from the Commission to the European Parliamente. The European Council. The Council. the European Economic and Social Committee and the Committee of the Regions. Security of Supply and Affordable Energy Prices: Options for Immediate Measures and Preparing for Next Winter. COM/2022/138 Final EUR-Lex - 52022DC0138 - EN - EUR-Lex (europa.Eu).

Eurostat, 2022. EU Trade since 2002 by CPA 2.1. https://ec.europa.eu/eurostat/databrowser/view/DS-059268/legacyMultiFreq/table?lang=en.

Eurostat, 2023b. Natural Gas Import Dependency by Country of Origin. https://ec.europa.eu/eurostat/databrowser/view/NRG_IND_IDOGAS/default/table?lang=en.

Eurostat, 2023a. Oil and Petroleum Products Import Dependency by Country of Origin. https://ec.europa.eu/eurostat/databrowser/view/NRG_IND_IDOOIL/default/table?lang=en.

EXIOBASE 3, 2021. EXIOBASE 3 (versión 3.8.2) [Conjunto de datos]. Zenodo. https://doi.org/10.5281/zenodo.5589597.

Gedich, T., 2017. Transformation of the European natural gas pricing model. ЕкономІчний часопис-XXI 164 (3–4), 36–39.

Jääskeläinen, J.J., Höysniemi, S., Syri, S., Tynkkynen, V.P., 2018. Finland's dependence on Russian energy—mutually beneficial trade relations or an energy security threat? Sustainability 10 (10), 3445. https://doi.org/10.3390/su10103445.

Jafarzadeh, A., Shakeri, A., Ghasemi, A., Javan, A., 2021. Possibility of potential coalitions in gas exports from the Southern Corridor to Europe: a cooperative game theory framework. OPEC Energy Review 45 (2), 217–239. https://doi.org/10.1111/opec.12196.

Kotek, P., Selei, A., Tóth, B.T., Felsmann, B., 2023. What can the EU do to address the high natural gas prices? Energy Pol. 173, 113312 https://doi.org/10.1016/j.enpol.2022.113312.

Lee, Y., 2017. Interdependence. issue importance. and the 2009 Russia-Ukraine gas conflict. Energy Pol. 102, 199–209. https://doi.org/10.1016/j.enpol.2016.11.038.

Mardones, C., 2023. Economic effects of isolating Russia from international trade due to its 'special military operation'in Ukraine. Eur. Plann. Stud. 31 (4), 663–678. https://doi.org/10.1080/09654313.2022.2079074.

Miller, Blair, 2022. Input-output analysis. Foundations and extensions. 3rd edition. Cambridge university press input output analysis foundations and extensions. In: Econometrics. Statistics and Mathematical Economics, third ed. Cambridge University Press.

Redeker, N., 2022. Same Shock. Different Effects. EU Member States' Exposure to the Economic Consequences of Putin's War.

Sgaravatti, G., Tagliapietra, S., Zachmann, G., 2022. National policies to shield consumers from rising energy prices. Bruegel Datasets 10.

Sun, M., Song, H., Zhang, C., 2022. The effects of 2022 Russian invasion of Ukraine on global stock markets: an event study approach. SSRN 4051987. https://doi.org/10.2139/ssrn.4051987.

Wang, W., Fan, L.W., Zhou, P., 2022. Evolution of global fossil fuel trade dependencies. Energy 238, 121924. https://doi.org/10.1016/j.energy.2021.121924.

Zhiznin, S.Z., Timokhov, V.M., 2019. Economic and geopolitical aspects of the Nord Stream 2 gas pipeline. Baltic region 11 (3), 25–42. https://doi.org/10.5922/2079-8555-2019-3-2.

Zhu, K., Zhao, Y., Xu, X., Hao, L., 2022. Measuring the natural gas supply security performance of China's natural gas suppliers: a comprehensive framework using FAHP-Entropy-PROOTHEE method. J. Clean. Prod. 345, 131093 https://doi.org/10.1016/j.jclepro.2022.131093.