OIL LEAK ALERT!

Jakub Szabó[1], Tomáš Ševček[2], Tomáš Oleš[3]

Abstract

This paper studies the direct and indirect effects of the decrease in the production of the refinery industry. More concretely, we study how the reduction in the production of the refinery industry in each V4 country individually 'leaks' to other sectors as well as countries. For this purpose, a multi-regional input-output model is employed. We come to a conclusion that geographic proximity matters and the effects are concentrated mostly in the neighbouring countries of the country where the shock originates. Our results indicate that V4 economies that are the most vulnerable to the domestic refinery shock are Poland and Slovakia. An inter-sectoral analysis suggests that the effects of the refinery shock have the most substantial impact in the mining and quarrying, transportation and administrative and creative services sectors.

Keywords

Refinery Industry, Oil Shocks, Production Multipliers, Input-Output Analysis

I. Introduction

Global economic growth is highly dependent on the consumption of fossil energy sources, such as coal (lignite), natural gas and in particular oil (e. g. Batrancea et al., 2019; Živkov et al., 2020). There are authors claiming that it is close to impossible to pinpoint a commodity having a greater influence on the world economy than oil (e. g. Chen et al., 2018). Now, the oil shocks seem to have returned after almost fifty years. Just like back in the 1970s, they trigger some interesting economic phenomena, however, this time, Europe is more affected by them than the US. Recently introduced oil sanction packages by the EU in the context of the Russian aggression in Ukraine are heavily debated in Central Europe because of serious concerns about their impact on key macroeconomic variables, though certain post-communist EU countries have already negotiated some exemptions from the sanction packages and compensatory financial funding from the Commission to mitigate the strong structural dependence on the imports of crude urals oil.

The structural dependence of Central European countries on oil imports, Visegrad group countries in particular, is generally well understood, especially when it comes to imports from the Russian Federation (Akhvlediani and Sledziewska, 2017; Živkov et al., 2020). The interconnectedness stems from the fact that production chains in these countries are adapted to urals oil and the substitution to other types of oil is possible, however, connected with the decrease in production. Current debates are therefore strongly concerned about the direct effects of the production decrease in the refinery industry. As is shown in Lábaj and Majzlíková (2022), the direct effects of a decline in the production of an industry underestimate the overall effects. Therefore, it is important to study the indirect effect of production shocks as well.

Intersectoral interconnectedness among European countries and the direct, as well as indirect effects, have been studied by many scholars. Oja (2015) studies the effect of sanctions on the milk sector's exports on the domestic economy using the multi-regional input-output model. Günther et al. (2019) assess the sectoral interconnectedness between selected EU countries (Austria, Finland, France, Germany and the Netherlands) in the context of the post-2008 crisis focusing on the research & development sector employing a static open input-output model. Hinz and Monastyrenko (2022)

[1] University of Economics in Bratislava, Dolnozemská 1, 851 04 Bratislava, Slovakia. E-mail: jakub.szabo@euba.sk.
[2] University of Economics in Bratislava, Dolnozemská 1, 851 04 Bratislava, Slovakia. E-mail: tomas.sevcek@euba.sk.
[3] University of Economics in Bratislava, Dolnozemská 1, 851 04 Bratislava, Slovakia. E-mail: tomas.oles@euba.sk.

study the effect of a trade embargo on the domestic price level and welfare using a CGE model as well as the difference in differences method. Wang and Yang (2020), for instance, employ a multi-region input-output model and structural decomposition analysis to analyse the trends of oil footprints in German trade. The authors find out that paradoxically Germany as a net goods exporter is at the same time a net importer of embodied oil.

The primary objective of this paper is to investigate a potential decrease in production in the refinery industry in the V4 countries. In order to achieve this objective, we simulate a 30-percent decrease in production in the refinery industry, employing a multi-regional input-output model. This paper is structured as follows. Following the introductory remarks in the opening section of this paper, we proceed to the methodology in section II. Subsequently, the results are presented in section III. The results indicate that although the overall impact of the 30-percent decrease in production of Industry C13 is almost negligible, there seem to be differences in terms of the relative impact on different countries, where the Eastern periphery of the EU seems to be affected the most. This phenomenon can be observed within the sectors as well. The results imply the biggest impact on any sector in the case of the Polish economy, namely on the mining and quarrying sector, what might be partly ascribed to the more coal-intensive structure of the Polish economy. Other more substantially affected sectors include transport and administrative and creative services. A drop in the production of Industry C19 can lead to a decrease in the demand for the products and services of Transport and Administrative services. The last section summarizes the main findings stemming from our analysis and concludes the paper.

II. Methodology

Simulations of various, especially mid to long term effects of (not only production) shocks are conducted by means of CGE models (see, for instance, Farzanegan et al. (2016)). However, such models are quite time-consuming to build, and they require a profound knowledge of the studied economy. One alternative to this approach is the use of the input-output model (which is a building block of CGE models). Input-output tables contain a thorough description of the use of inputs for production in a given industry to produce intermediate goods and services and final demand goods in the domestic economy. Multi-regional input-output tables describe the complex linkages between industries both within and across economies.

In this paper we make an extensive use of the FIGARO tables provided by Eurostat. They cover 46 countries and 64 industries for the period of 2010 – 2017. From 2018 to 2019, they provide data for 17 countries and 30 industries. We utilize tables for the year 2017 in our simulations as they combine two of the most appealing features – recent data with a detailed structural linkages across industries.

A detailed treatment of the input-output analysis can be found in Miller & Blair (2009). Here we provide a brief overview only. At the very beginning of our analysis, it is important to partition the Input-output table into various vectors and matrices, namely the matrix of interindustry inputs $\boldsymbol{Z}$, the production vector $\boldsymbol{x}$ and the matrix of final demand $\boldsymbol{Y}$. The matrix of final demand consists of olumn vectors which contain final demand of various sectors of national accounts. In a simplified way, it contains information about the final consumption of households and the general government, gross investments of firms and the export. The basic idea of the Input-output model is to break the production of a given industry down to the interindustry consumption and the production of final products. Therefore, we obtain the following relation for the production of the *ith* industry:

$$x_i = \sum_{j=1}^{n} z_{i,j} + \sum_{k=1}^{m} y_{i,k} \tag{1}$$

where *n* is the number of industries and *m* is the number of final demand components. In a compact matrix notation, we can write:

$$\boldsymbol{x} = \boldsymbol{Z}\hat{\boldsymbol{\imath}} + \boldsymbol{Y}\hat{\boldsymbol{\imath}} \tag{2}$$

where $\hat{\boldsymbol{\imath}}$ is a vector consisting of ones only (since the number of columns of $\boldsymbol{Z}$ and $\boldsymbol{Y}$ does not have to coincide, the vector $\hat{\boldsymbol{\imath}}$ from the previous equation may have a different size). From now on, we consider the vector of final demand in which all of the final demand components are summed in the following manner:

$$\boldsymbol{y} = \boldsymbol{Y}\hat{\boldsymbol{\imath}} \tag{3}$$

It is beneficial to know how much interindustry consumption is needed from industry i in order to create one value unit of production in industry j. Thus we arrive at the concept of technical coefficients defined as:

$$a_{i,j} = \frac{z_{i,j}}{x_j} \tag{4}$$

Putting all of the technical coefficients into one matrix, we can calculate the matrix of technical coefficients:

$$\boldsymbol{A} = \boldsymbol{Z}\hat{\boldsymbol{x}}^{-1} \tag{5}$$

where $\hat{\boldsymbol{x}}^{-1}$ denotes the inverse diagonalized vector of production:

$$\hat{\boldsymbol{x}}^{-1} = \begin{pmatrix} \frac{1}{x_1} & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \frac{1}{x_n} \end{pmatrix} \tag{6}$$

Solving for $z_{i,j}$ in Equation (4) and plugging the result in Equation (1), we get:

$$x_i = \sum_{j=1}^{n} a_{i,j}x_j + y_i \tag{7}$$

In matrix notation it is equivalent to:

$$\boldsymbol{x} = \boldsymbol{A}\boldsymbol{x} + \boldsymbol{y} \tag{8}$$

A simple algebraic operation yields:

$$\boldsymbol{x} - \boldsymbol{A}\boldsymbol{x} = \boldsymbol{y} \tag{9}$$

This is equivalent to:

$$(\boldsymbol{I} - \boldsymbol{A})\boldsymbol{x} = \boldsymbol{y} \tag{10}$$

Therefore, the final solution for production is:

$$\boldsymbol{x} = \boldsymbol{L}\boldsymbol{y} \tag{11}$$

where $\boldsymbol{L} := (\boldsymbol{I} - \boldsymbol{A})^{-\mathbf{1}}$ is the Leontief matrix, which is the core part of the analysis. As can be seen, an element $l_{i,j}$ denotes the overall production in the industry represented by i induced by the final demand in the industry represented by j. In terms of differences, this is summarized as follows:

$$l_{i,j} = \frac{\Delta x_i}{\Delta y_j}. \tag{12}$$

In our article, we focus on changes in the production of all industries induced by changes in the production of one particular industry, namely the industry in the section C division 19 of ISIC Rev. 4. - Manufacture of coke and refined petroleum products (henceforth Industry C19). For this purpose, we need to calculate the following matrix:

$$\boldsymbol{L}^* = \boldsymbol{L}\left(\hat{\boldsymbol{L}}\right)^{-1}. \tag{13}$$

Here, $\left(\hat{\boldsymbol{L}}\right)$ denotes a diagonal matrix the diagonal of which coincides with the diagonal of $\boldsymbol{L}$. For an element $l_{i,j}^*$ we obtain:

$$l_{i,j}^* = \frac{l_{i,j}}{l_{j,j}} = \frac{\Delta x_i}{\Delta x_j}\ . \tag{14}$$

Therefore, we can calculate changes in the production of the economy given a vector of direct changes in the production in each industry denoted by $\overline{\boldsymbol{x}}$ as follows:

$$\boldsymbol{x}^* = \boldsymbol{L}^* \overline{\boldsymbol{x}}\ . \tag{15}$$

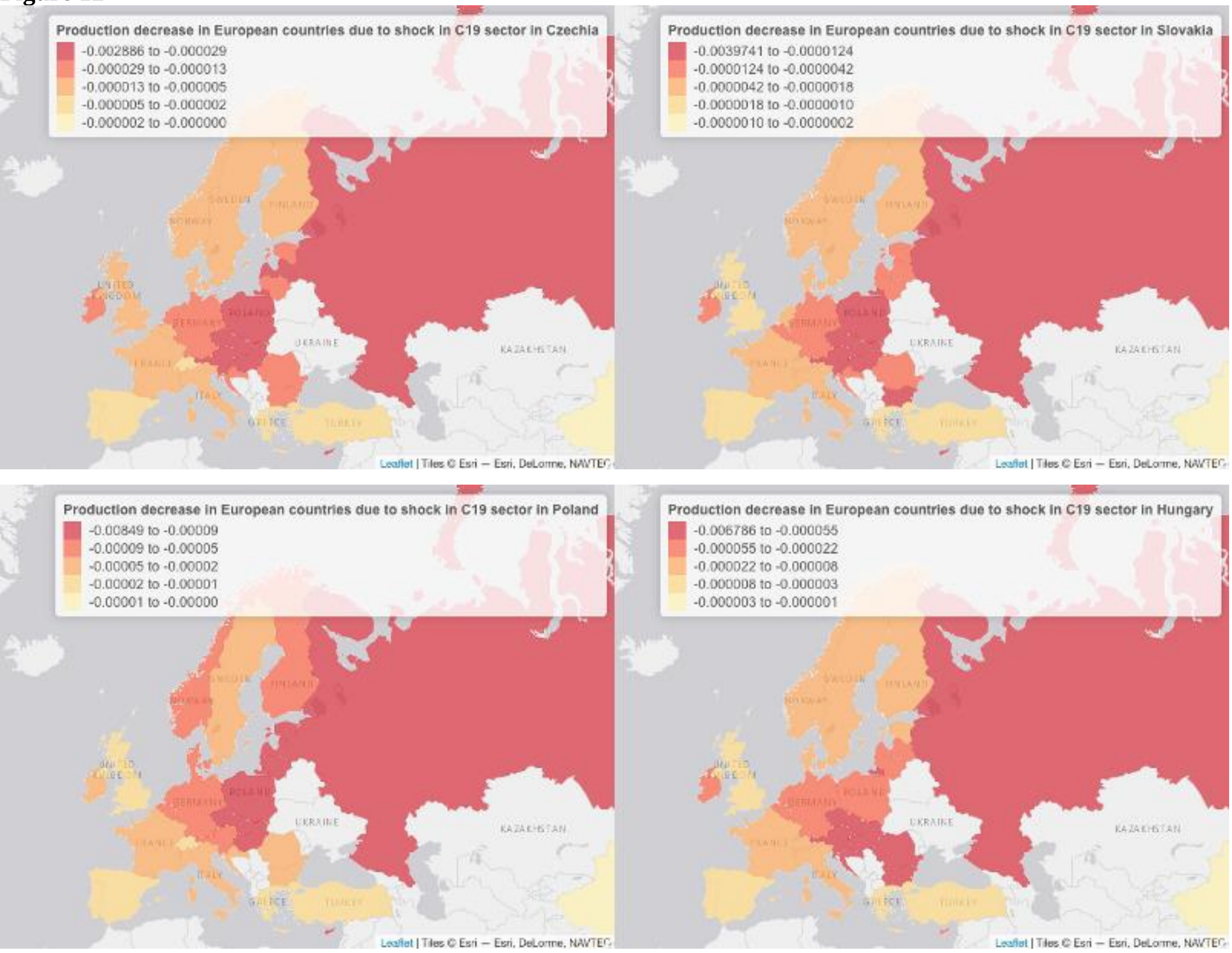
This approach has its pitfalls. Any results presented in this paper hold under the following assumptions. First of all, we assume that the structural relations in the economies do not change in time. Next, no substitution in production as well as in consumption as a result of the reduced production is allowed. Last but not least, an identical structure of firms which operate in the given industry is assumed, while each firm can have different structural linkages to the economy and responses to shocks.

In our study, we reduce the production of Industry C19 by 30 % in each V4 country individually. This reduction is close to the projected real-world reduction in the production of the given industry, as stated by Hernádi in Mandiner (2022) due to a decrease in the oil supply from Russia. Subsequently, we simulate the impact of this reduction on all industries in all economies employing the methods explained above. The results are presented graphically in the next section.

III. Results

In this section, we present the main results of our analysis. The focus of our interpretation is on the relative size studied effects. As can be seen in Figure 1, the overall reduction in the production of all economies is rather minuscule. In the figure below, the total effect of a decrease in the production of Industry C19 in Slovakia has the hugest impact on the reduction in the domestic production in general, while Poland has the least significant impact. Relatively speaking, industrial linkages appear to be tighter between Czechia and Latvia and the UK, whereas Slovakia is more tightly connected to Bulgaria and Switzerland. However, the greatest effects are concentrated in Central Europe, the Balkans and the Baltic countries. When it comes to Poland and Hungary, the effects seem very similar. Poland has a greater impact on the Baltic countries. Hungary on the other hand effects the Balkans more profoundly.

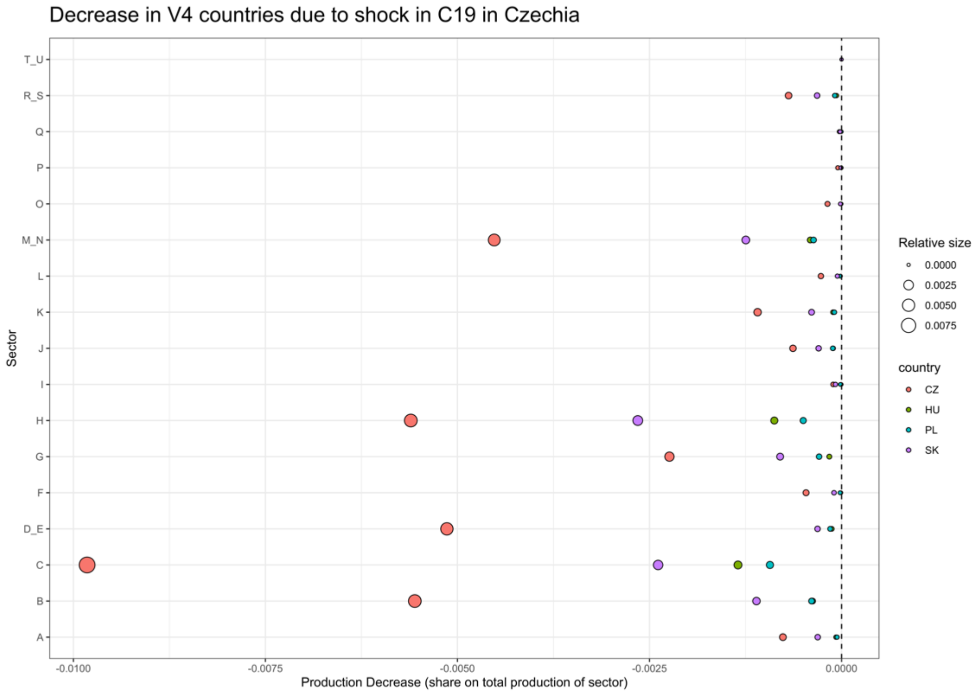
Figure 12



Source: Own illustration.

Although Figure 1 provides an overall picture as to how individual countries are affected by the said reduction, it does not give away any information about the distribution of shock among the individual sectors. Figures 2-5 depict the fall in the production of individual sectors in V4 countries. It ought to be noted that the scales in the figures are different – the biggest impact can be observed in the Poland and Slovakia. In all the countries we observe the greatest impact on the sector of Mining and Quarrying (B) excluding Czechia. It underlines the fact that the mining activities are positioned downstream to the sector of manufacturing. Thus, the simulated impact of a decrease in the production of coke and refined petroleum products should directly reduce the most important part of the direct intermediate demand for the products of this sector.

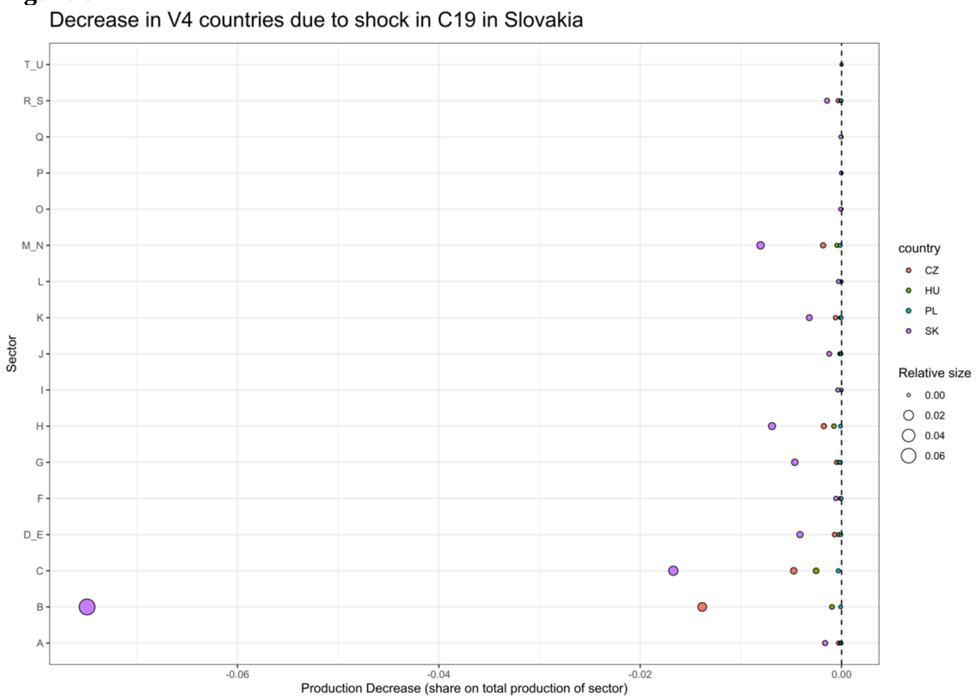
Figure 2



Source: Own illustration

The industrial linkages of Czechia's Industry C19 appear to mostly affect the domestic sector of Manufacturing (C), Transport (H), Mining (B), Energies and water supply (D_E), Administrative and creative services (M_N). Is it noteworthy that Slovakia's sectors are affected the most (excluding domestic Czech sectors). Except for the Manufacturing sector the strongest inter-country impact can be observed in the sector of Transport (H) and the sector of Wholesale and retail (G).

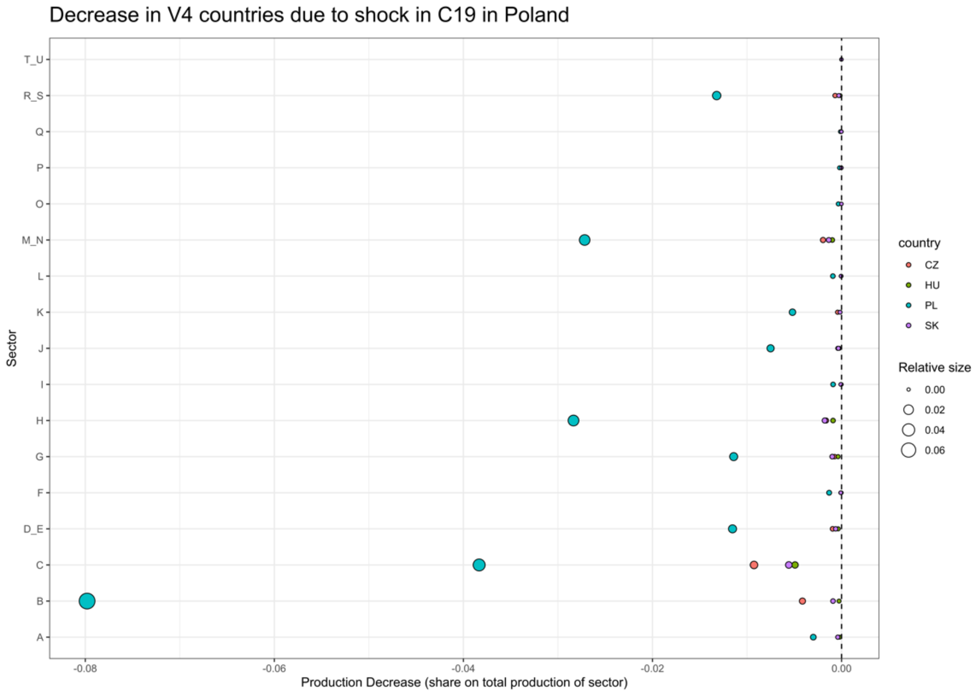
Figure 3



Source: Own illustration

Industrial linkages of Slovakia's Industry C19 tend to mostly affect the domestic sector of Manufacturing (C), Transport (H), Mining (B), Energies and water supply (D_E), Administrative and creative services (M_N) and Financial services (K). The most affected country bar Slovakia seems to be Czechia, but with a much higher scale than the opposite relationship. Hungary is more affected than Poland, while in the previous figure this is not the general case.

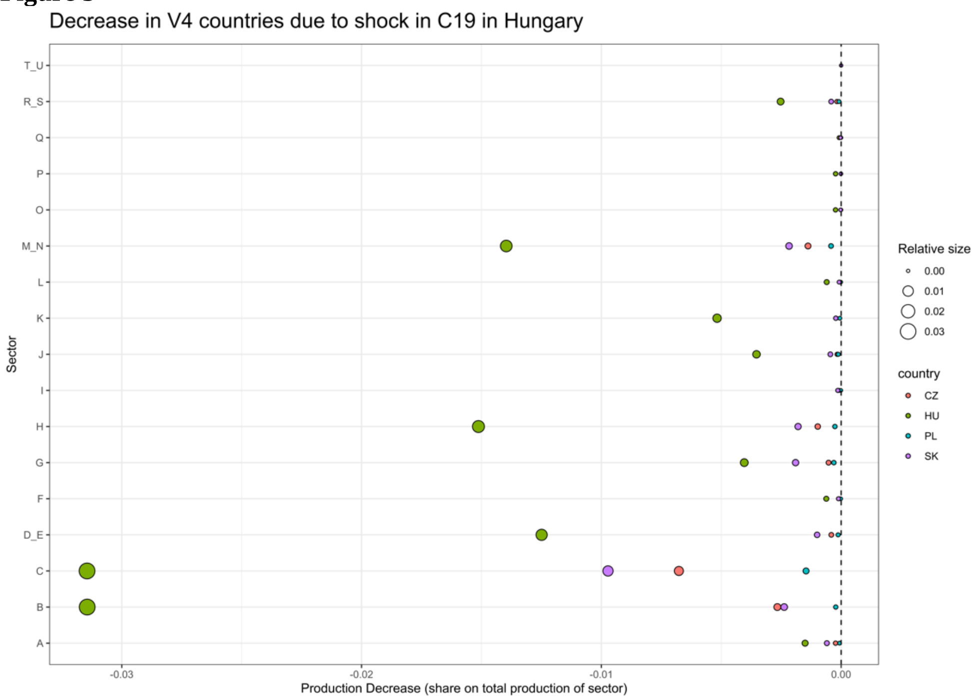
Figure 4



Source: Own illustration

The impact of Industry C19 to other Polish sectors is on the same with sectors as in the previous two samples, with two more sectors showing up, namely Other services (R_S) and Communication and other community services (J). In a vast majority of cases, the most affected economy except for Poland is either Czechia or Slovakia, which makes sense geographically.

Figure 5



Source: Own illustration

Industrial linkages of Hungary's Industry C19 to other domestic sectors tend to be the same sectors as in the previous three samples. The most affected economy excluding Hungary is either Slovakia with a few exceptions in which Czechia's sectors are the most affected.

IV. Conclusion

This article analyses the impact of a reduction in the production of Industry C19 in each V4 country on the production of other sectors as well as other countries. For this purpose, we employ the multi-regional input-output model making use of the Figaro tables for the year 2017. The results indicate that although the overall impact of a 30-percent decrease in the production of Industry C19 is rather minuscule, there are some differences in the relative impact on different countries. Central Europe seems to be affected the most. It confirms the hypothesis that geographic closeness can render production linkages tighter.

By and large, this phenomenon can be observed in the sectors as well. As can be seen in figures above, we have found the biggest impact on any sector in the case of the Polish economy, namely on the Mining and quarrying sector. This result might be partly ascribed to the energetic mix since the Polish economy is more coal intensive. Other hugely affected sectors include Transport and Administrative and creative services. A drop in the production of Industry C19 can lead to a decrease in the demand for the products and services of Transport and Administrative services. This is due to the fact that Administrative services sector includes accounting and legal services.

All of the results presented in this paper should be interpreted with the utmost care. Should the structure of the economy change as a result of the studied decrease, our conclusions might no longer hold. Moreover, no substitution effects are taken into consideration[1]. However, the weakest link of our analysis lies in the aggregation of sectors. Ideally, we would simulate a shock in the refinery production only, but at the lowest level of aggregation available to us this production is put together with the production of coke in Industry C19. Therefore, some of the results might be biased because the decrease pertains to both the refinery as well as the coke production.

Some of the issues mentioned in the previous paragraph could be remedied by employing different methods and techniques. For instance, CGE models could be utilized to analyse the very same shock. Another possibility is the use of econometric techniques, such as VAR models. This is, however, beyond the scope of this paper, and is left as a prospect for further research.

An important lesson to learn from this paper is that it is not only the direct effects which matter in the economy, but the indirect effects due to sectoral and interregional interconnectedness can have an even greater impact on key macroeconomic variables.

Acknowledgements

The paper was elaborated as a part of the project of young teachers, researchers and PhD students named no. I-22-105-00: 'Synchronization as a necessary condition for the effective functioning of monetary union' and research project VEGA 1/0781/21: 'Industrial policy in the context of deindustrialization and automation'.

References

Akhvlediani, T., & Sledziewska, K. (2017). Implications of the European integration: Revisiting the hypothesis of 'hub-and-spokes' model. *Baltic Journal of Economics*, 17(1), 45–56.

Batrancea, I. et al. (2019). An econometric approach on production, costs and profit in Romanian coal mining enterprises. *Economic Research-Ekonomska Istraživanja*, 32(1), 1019–1036.

[1] Neither can they in a static input-output framework.

Chen, Y., Li, W., & Jin, X. (2018). Volatility spillovers between crude oil prices and new energy stock price in China. *Romanian Journal of Economic Forecasting*, 21(2), 43–62.

Farzanegan, M. R., Khabbazan, M. M., & Sadeghi, H. (2016). Effects of oil sanctions on Iran's economy and household welfare: new evidence from a CGE model. In Economic welfare and inequality in Iran (pp. 185-211). Palgrave Macmillan, New York.

Günther, J., Kristalova, M., & Ludwig, U. (2019). Structural stability of the research & development in European economies despite the economic crisis. *Journal of Evolutionary Economics*, 29(1), 1414-1432.

Hinz, J., & Monastyrenko, E. (2022). Bearing the cost of politics: Consumer prices and welfare in Russia. *Journal of International Economics*, 137, 103581.

Lábaj, M., & Majzlíková, E. (2022). Drivers of deindustrialisation in internationally fragmented production structures. *Cambridge Journal of Economics,* 46(1), 167-194.

Mandiner. (2022). *Senkinek nincs joga agyonütni Közép-Európát – Hernádi Zsolt a Mandinernek*. Retrieved July 5, 2022, from https://mandiner.hu/cikk/20220608_hernadi_zsolt_interju.

Miller, R. E., & Blair, P. D. (2009). *Input-output analysis: foundations and extensions*. Cambridge university press.

Oja, K. (2015). No milk for the bear: the impact on the Baltic states of Russia's counter-sanctions. *Baltic Journal of Economics*, 15(1), 38-49.

Živkov, D., Đurašković, J., & Papić-Blagojević, N. (2020) Multiscale oil-stocks dynamics: the case of Visegrad group and Russia, *Economic Research-Ekonomska Istraživanja*, 33(1), 87-106.

Wang, Q.; & Yang, X. German's oil footprint: An input-output and structural decomposition analysis. *Journal of Cleaner Production*, 242(1).