CESifo WORKING PAPERS

10715
2023

October 2023

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CESifo

Impressum:

CESifo Working Papers
ISSN 2364-1428 (electronic version)
Publisher and distributor: Munich Society for the Promotion of Economic Research - CESifo GmbH
The international platform of Ludwigs-Maximilians University's Center for Economic Studies and the ifo Institute
Poschingerstr. 5, 81679 Munich, Germany
Telephone +49 (0)89 2180-2740, Telefax +49 (0)89 2180-17845, email office@cesifo.de
Editor: Clemens Fuest
https://www.cesifo.org/en/wp
An electronic version of the paper may be downloaded
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CESifo *Working Paper No. 10715*

Regional Industrial Effects in Germany from a Potential Gas Deficit

Abstract

We estimate potential regional industrial effects in case of a threatening gas deficit. For Germany, the reduction leads to a potential decrease in industrial value added by 1.6%. The heterogeneity across German states is remarkable, ranging from 2.2% for Rhineland-Palatinate to 0.7% for Hamburg. We emphasize the need for regional input-output tables to conduct economic analysis on a sub-national level, particularly when regional industrial structures are heterogeneous. The approximation with national figures can lead to results that differ both in magnitude and relative regional exposure. Our findings highlight that more accurate policy guidance can be achieved by improving the regional database.

JEL-Codes: R110, R150, R190.

Keywords: gas shortage, input-output analysis, regional economic impacts, Germany.

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This version: October 12, 2023
We thank Ruediger Bachmann, Christiane Baumeister, Katja Heinisch, Tom Krebs, Matthias Mertens, Benjamin Moll, and Steffen Mueller for very helpful comments and suggestions.

1 Introduction

On February 24, 2022 the Russian Federation escalated its conflict into a full-blown invasion of Ukraine. Germany as a member state of the European Union (EU) and the North Atlantic Treaty Organization (NATO) joined multilateral sanctions against Russia. Given the large German dependence on gas-intensive production and Russia as one of the main fossil energy exporters worldwide, the NATO member states did not stop buying Russian gas to avoid tremendous negative economic consequences. The question on how large these consequences will become, initiated an intensive discussion in Germany. In this paper, we add to this discussion by asking how potential economic effects are distributed across the German sub-national level due to pronounced differences in the local industrial mix. To the best of our knowledge, we are the first to discuss regional impacts from a potential gas deficit, which might be useful for other countries with even more pronounced regional heterogeneities in industrial structures. Furthermore, we emphasize the need for detailed regional information to formulate meaningful policy advice instead of inferring from the German average.

Bachmann *et al.* (2022) analyzed the potential consequences of a stop of Russian gas imports with a multi-sector macroeconomic model with input-output linkages as developed in Baqaee and Farhi (2019), which is in spirit of the work by Acemoglu *et al.* (2017) and Atalay (2017). In contrast to a broad public belief that a gas embargo might be disastrous, the study found that gross domestic product declines between 0.2% and 2.3% for a gas supply reduction of 30%. Di Bella *et al.* (2022) calculate that a stop of Russian gas imports requires a reduction in German gas consumption by 15%.

Holz *et al.* (2022) estimate a potential range for a gas shortage between 0% and 38%, depending on the respective supply expansion and demand reduction path. The Joint Economic Forecast (2022) used the uncertainty range over gas supply and demand to simulate different gas shortage profiles and potential economic impacts for Germany with an input-output analysis. In the following, we rely on the approach by the Joint Economic Forecast (2022) and apply it to the German sub-national level. Given a simulated gas shortage profile according to their methodology, we find a large heterogeneity in economic impacts across the 16 German states' manufacturing industry. Whereas the impacts for Berlin and Hamburg are rather small (-0.9% and -0.7%), Rhineland-Palatinate and Baden-Wuerttemberg are confronted with much larger effects because of their industrial mix (-2.2% and -2.1%).

The application of more specific regional information is crucial for the calculation of sub-national effects. Whereas the important contribution by Holtemöller *et al.* (2022) scales down national economic effects to the German county level by applying value added shares, we use the inter-regional input-output table for Germany by Krebs (2020). His table ensures that we can explicitly consider regional production structures and characteristics instead of assuming congruence to the German production technology. It turns out that the effects across the two approaches differ both in terms of magnitude and relative regional exposure, thus, regional information are very important for assessing sub-national economic effects.

The paper is organized as follows. Section 2 briefly describes the methodology to simulate a national gas deficit. In Section 3 we describe the method to estimate regional economic impacts and present the results. Section 4 concludes.

2 Simulating a National Gas Deficit

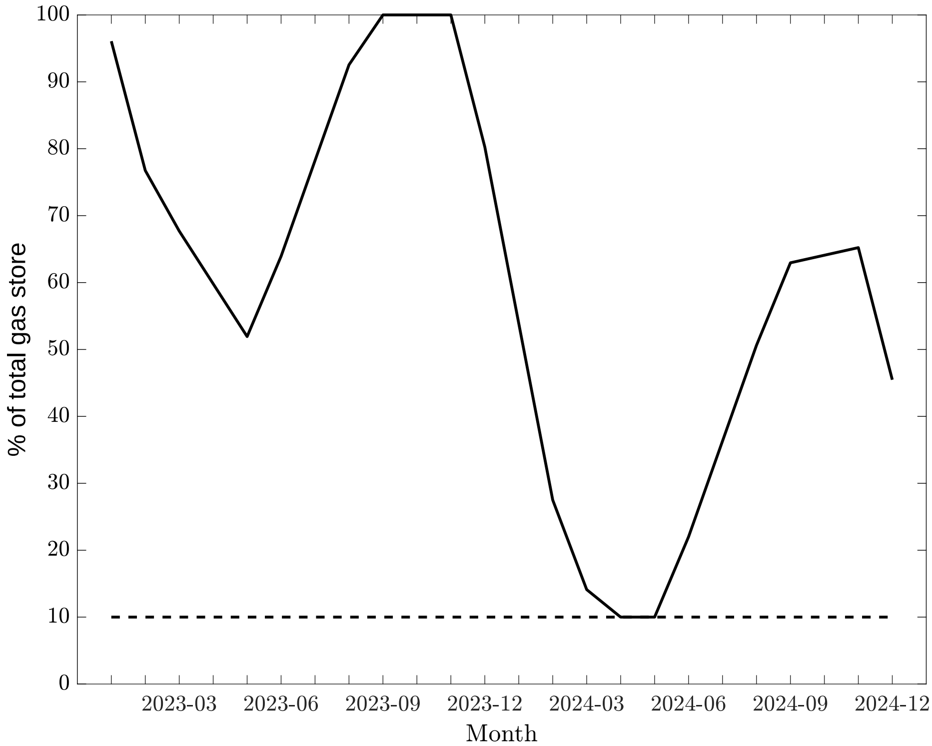
The throttling of gas delivery by the Russian Federation in 2022 has caused an intensive discussion on its economic consequences in Europe. In Germany, several authors and institutions brought forward calculations that led to a controversial public debate. One of these institutions is the Joint Economic Forecast (JEF), a consortium of the leading economic research institutes that biannually publishes a forecast for the German economy. In spring 2022, the JEF presented simulation results for the German gas market until the end of 2024, which have been updated in spring 2023 and served as input for the government's own calculations (see Joint Economic Forecast, 2022, 2023). We will take their gas simulation results for Germany as the basis for our regionalization of economic impacts.

Despite large improvements of gas availability, for example by the purchase of Liquefied Natural Gas (LNG), the simulation results of the JEF show that a gas shortage in Germany is still possible. For such a situation, the EU regulation 2017/1938 defines the rough allocation of gas. The highest priority have protected customers such as households and essential social services. The majority of industrial customers do not belong to the group of protected customers and therefore will be rationized first. A gas shortage in month t, $\overline{G}_t$, occurs if gas demand (G_t^d) exceeds gas supply (G_t^s) that is defined as the sum of monthly deliveries and remaining gas from the national gas storage, given that high-prioritized customers are served and with a maximum loss of -1 if industrial customers are fully rationized:

$$\overline{G}_t = \max\left(-1, \min\left(0, \frac{G_t^s - G_t^d}{G_{MAN,t}^d}\right)\right). \tag{1}$$

The simulation results of the JEF determine potential gas shortages for the period from March 2023 to December 2024. According to their calculations, a concrete gas shortage situation can occur in April and May 2024 if monthly gas demand corresponds to its 2021 profile, which is the year with the greatest demand observed for the period 2018 to 2022, and daily gas supply remains at 2,500 GWh, which reflects average daily net gas injections from domestic and foreign companies between September 1, 2022 and March 1, 2023. These injections already include new sources of gas supply such as LNG terminals and the switch from Russian to, for example, Norwegian gas. Furthermore, we consider a safety buffer of 10% or 25 TWh in total gas storage capacities of 250 TWh (see Di Bella *et al.*, 2022). In this constellation, gas storage capacities would fall to the 10% level in April and May 2024, thus, inducing a gas shortage situation (see Figure 1). This gas shortage profile is used in the following calculations to estimate potential economic effects for Germany and each of its 16 states. As industrial firms are rationized first, the gas shortage mainly affects gas demand in manufacturing ($G^d_{MAN,t}$) and thus industrial gross value added. 10 and 20 TWh of gas demand cannot be served in April and May 2024, which amounts to 30% and 60% of monthly industrial gas demand. In the other months of 2024 the simulations do not hint towards a gas deficit. Even if the parameters that determine gas demand—such as the average temperature in the 2023/2024 winter—become surprisingly better, a potential gas deficit is even more likely in 2025, given the current political and economic circumstances. Thus, our results do not become obsolete if the gas storage profile in Figure 1 will not materialize. They should rather be seen as potential losses that can be expected by decision-makers and a sensitization for regional heterogeneities covered by national averages.

Figure 1: Monthly Gas Storage Profile 2023 and 2024



Notes: The figure shows the development of the monthly gas storage over the simulation horizon, expressed in terms of the total amount of gas storage (250 TWh). The dashed horizontal line marks the buffer of 10% (25 TWh).

3 Potential Industrial Effects of a Gas Deficit

3.1 Input-Output Analysis

We compute the potential short-term economic effects in manufacturing in an Input-Output (IO) analysis by assuming a production function of the Leontief-type, following the notation and methodology in Miller and Blair (2022). We determine the output of each manufacturing sector $s \in \{1, \dots, i, j, \dots, S\}$ at the 2 digit-level in region r (each of the 16 German states), $x_{s,r}$, as the minimum available intermediates, $z_{i,j,r}$, normalized by the corresponding input coefficient, $a_{i,j,r}$:

$$x_{s,r} = \min_i \left(\frac{z_{1,j,r}}{a_{1,j,r}}, \dots, \frac{z_{i,j,r}}{a_{i,j,r}}, \dots, \frac{z_{S,j,r}}{a_{S,j,r}} \right) . \tag{2}$$

The intermediate goods $z_{i,j,r}$ can either be purchased from foreign ($z^f_{i,j,r}$) or home suppliers ($z^h_{i,j,r}$), such that $z_{i,j,r} = z^f_{i,j,r} + z^h_{i,j,r}$. Furthermore, intermediate goods from home are sourced from different domestic regions of origin $o \in \{1, \dots, r, \dots, 16\}$, $z^{h|o}_{i,j,r}$, such that $z^h_{i,j,r} = \sum_o z^{h|o}_{i,j,r}$ holds. Given the gas shortage intensity, we compute the change in manufacturing output of sector s, $\Delta x^k_{s,r}$, and the value of available intermediate goods for two consecutive rounds, $k = 1, 2$, using the following IO procedure (see the Supplementary Material for an example):

$$\Delta z^{f,k}_{MIN,s,r} = a_{MIN,s,r}\, \overline{G}_t\, \frac{G^d_{s,r}}{E^d_{s,r}} x_{s,r} \quad \forall s \wedge k = 1\,, \tag{3}$$

$$\Delta z^{h|o,k}_{j,i,r} = \begin{cases} b^{h|o}_{i,j,r} \Delta x^{k-1}_{i,r} & \text{if } k = 2, \\ 0 & \text{if } k = 1, \end{cases} \tag{4}$$

$$x_{s,r} + \Delta x^k_{s,r} = \min_i \left(\frac{z_{1,j,r} + \Delta z^k_{1,j,r}}{a_{1,j,r}}, \dots, \frac{z_{i,j,r} + \Delta z^k_{i,j,r}}{a_{i,j,r}}, \dots, \frac{z_{S,j,r} + \Delta z^k_{S,j,r}}{a_{S,j,r}} \right) , \tag{5}$$

$$\Delta z^k_{i,j,r} = \sum_o \Delta z^{h|o,k}_{i,j,r} + \Delta z^f_{i,j,r}\,. \tag{6}$$

Equation (3) labels the first-round effects and thus the initial impulse that hits Germany and its regions. These first-round effects—expressed in output losses—already include production reductions in upstream sectors.[1] Further, the reductions in foreign intermediate inputs from the mining sector ($\Delta z^f_{MIN,n,r}$), where gas as good is attributed to, reduces the output of all industries in the manufacturing sector. The first-round effect depends on the magnitude of the gas shortage $\overline{G}_t$ and the industry's exposure to gas, measured as the share of gas demand in total energy consumption, $G^d_{s,r}/E^d_{s,r}$. We assume at this stage that all industries need to reduce their gas demand by the same proportion (for example, 20% of total gas demand, which is approximately the reduction in German industrial gas consumption

[1] For instance, an output reduction in car manufacturing already includes less demand for intermediate products from upstream sectors such as parts from the rubber or plastic industry.

observed between 2022 and 2021).[2] Domestic intermediate goods are, as shown in Equation (4), not affected in the first round. Therefore, first-round output reduction is entirely caused by the reduction of intermediate inputs from abroad, as shown in Equation (5). For the second round ($k = 2$), the reduction in domestic output from the first round reduces domestic intermediate goods according to (4), where the output coefficients ($b_{i,j,r}^{h|o}$) are taken as given. Thus, domestic output will decline even further, whereas foreign intermediate goods—according to Equation (6)—are only affected in the first round and remain constant afterwards. All in all, the first-round effects are solely driven by the gas shortage and the non-availability of foreign gas deliveries. The second round, instead, mirrors the effects that are initiated through the regional and sectoral linkages. The overall effect is the sum of both rounds. We calculate these overall effects for each month in 2024 according to our gas shortage profile and average these effects afterwards to generate annual losses. Our computation of second-round effects excludes the possibility of import substitution of domestic gas-intensive intermediate products. We do not explicitly model gas supply and demand in other countries. However, the assumption regarding no import substitution can represent gas shortage situations outside of Germany. Nevertheless, we discuss later which additional import demand would be necessary to avoid second-round effects.

We are aware of the advantages and limitations that come with an Input-Output analysis. The clear advantage of this approach is its possibility to deeply model inter-sectoral linkages across the economy. Its main disadvantage is the assumption of a Leontief-type production function that assumes an elasticity of substitution of zero across inputs. As argued and shown by Bachmann *et al.* (2022) as well as Moll *et al.* (2023), the assumption of a zero elasticity leads to extreme cases in economic losses. Even if the production function at the micro (firm) level is of the Leontief-type, this then does not ultimately lead to an elasticity of zero at the macro level. In our case, there is still heterogeneity within sectors, thus, our results should be interpreted as lower bounds. From our point of view, it is more important to know the heterogeneity across states in order to, for example, politically target specific regions in case of a gas deficit rather than knowing the exact loss magnitude for each state. Furthermore, to the best of our knowledge no region- and sector-specific elasticity estimates exist for Germany, thus, our approach should be seen as the first to shed more light on pronounced heterogeneities across regional entities.

3.2 Top-down vs. Bottom-up Calculations

The IO analysis introduced previously can be executed at two stages. On the one hand, a German IO table can be used to estimate the effects, which are then distributed to the states

[2] The overall regional effects can change in their magnitudes according to the assumed industrial gas reduction scheme. If other gas allocations—instead of an equal reduction by all industries—will be decided (for example, protection of specific industries), some regions might be much more affected compared to other states as the regional gas exposure varies strongly across regional entities.

by means of regional weights. We call this the top-down approach. Its main disadvantage is the assumption of equal production structures across the states. This equality is not appropriate given German-wide differences in economic structures. On the other hand, we use a regional IO table and feed the algorithm with state-specific coefficients and thus production structures. We call this the bottom-up approach. Usually, regional IO tables are not available from official sources. Krebs (2020), instead, introduces an inter-regional IO table for the German districts and district-free cities. His regional IO table is perfectly comparable to the World-Input-Output-Database (WIOD), which is commonly applied in national settings (see the Supplementary Material for more details on the IO table).

Equation (7) presents the differences for the overall economic effect in manufacturing, $\Delta^a x_r / x_r$, across both approaches, a. In the top-down approach, we compute sector-level effects for Germany, $\Delta^{TD} x_{s,G} / x_{s,G}$, by using the IO table from Krebs (2020) aggregated to the national level in advance.[3] These effects are then distributed to the states by applying state-level sectoral shares in value added, $VA_{s,r}/VA_r$, again calculated from the data of Krebs (2020). This procedure mainly reflects that each sector experiences the same effect across all states, leaving regional production structures and interdependencies aside. The impact variation across states is then mainly a reflection of their different sector weights (see, for example, the contribution of Holtemöller *et al.*, 2022). States with a higher value added share in manufacturing thus experience higher output reductions.

$$\frac{\Delta^a x_r}{x_r} = \begin{cases} \sum_s \frac{VA_{s,r}}{VA_r} \frac{\Delta^{TD} x_{s,G}}{x_{s,G}} & \text{if } a = \text{top-down} \\ \sum_s \frac{VA_{s,r}}{VA_r} \frac{\Delta^{BU} x_{s,r}}{x_{s,r}} & \text{if } a = \text{bottom-up} \end{cases} \tag{7}$$

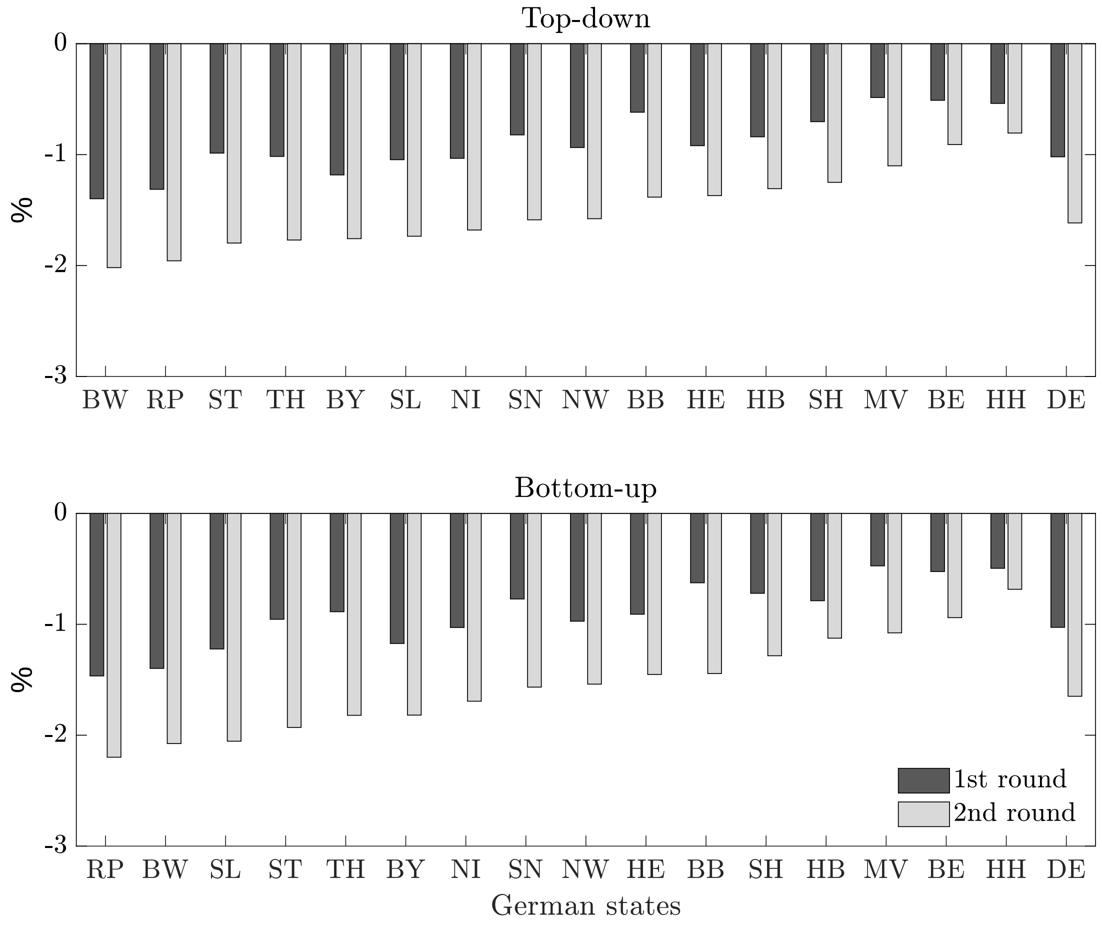
The bottom-up approach takes into account regional production networks, resulting in different sector-level effects across states, $\Delta^{BU} x_{s,r} / x_{s,r}$, based on the inter-regional IO table of Krebs (2020). These effects are again aggregated with state-level sectoral shares in value added to achieve an overall effect. Thus, the bottom-up approach incorporates more regional variation and characteristics compared to the top-down approach. Both approaches can produce results that vary tremendously across the German states. This variation is mainly driven by a large dispersion in second-round effects due to pronounced differences in output coefficients from the Input-Output analysis. The Supplementary Material covers an example for Eastern and Western Germany based on the data by Krebs (2020) and presents a discussion under which circumstances both approaches lead to the same overall effects in manufacturing. In the following section, we present and compare the regional results from both approaches.

[3] To compare the effects of both the top-down and bottom-up approach with each other, we decided to apply only one source of IO table. As Krebs (2020) states that his inter-regional IO table is cell-by-cell compatible to the WIOD data at the national level, we can almost rule out that no methodological differences across IO tables drive our main results.

3.3 Regional Impacts

The overall regional industrial effects across the German states differ both in magnitude and in terms of relative exposure, pointing to the importance of different regional production structures and different input intensities. The top-down effects of a gas shortage for regional, industrial gross value added in 2024 according to Figure 1 lie between -2.0% for Baden-Wuerttemberg and -0.8% for Hamburg (see the top panel of Figure 2). On the opposite, the bottom-up effects vary between -2.2% for Rhineland-Palatinate and -0.7%, again for Hamburg (see the bottom panel of Figure 2). Overall, the average loss is slightly larger for the bottom-up approach (-1.54% vs. -1.50%) and varies stronger across the states (0.44 percentage points vs. 0.36 percentage points), thus, the absolute variation coefficient is higher for the bottom-up approach.

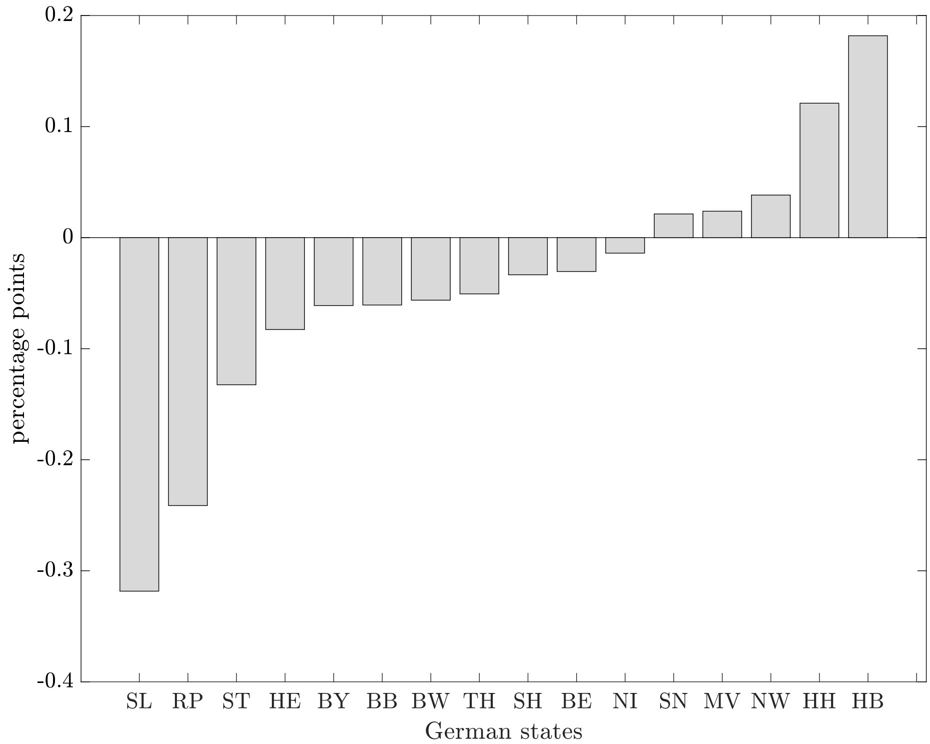
Figure 2: Regional Industrial Effects: Top-down vs. Bottom-up



Notes: The figure compares the first- (dark gray) and second-round (light gray) effects of the top-down with the bottom-up approach. For both approaches, the states are displayed in ascending order of the second-round effects. The effects for total Germany (DE) are shown at the end of each sub-figure. The state abbreviations—in alphabetical order—are: BB: Brandenburg, BE: Berlin, BW: Baden-Wuerttemberg, BY: Bavaria, HB: Bremen, HE: Hesse, HH: Hamburg, MV: Mecklenburg-West Pomerania, NI: Lower Saxony, NW: North Rhine-Westphalia, RP: Rhineland-Palatinate, SH: Schleswig-Holstein, SL: Saarland, SN: Saxony, ST: Saxony-Anhalt, TH: Thuringia.

To underpin the previous statements, Figure 3 shows the differences in total industrial impacts between the bottom-up and the top-down approach, $\Delta^{BU} x_r - \Delta^{TD} x_r$, for all German states. The two approaches yield different results both in magnitude and in relative regional exposure. The top-down approach suppresses a lot of variation across regions and leads either to an over- or an underestimation of total effects. However, in the majority of cases (11 out of 16 states) the top-down approach produces effects that are smaller in magnitude compared to the bottom-up approach. The largest underestimation can be found for the Saarland (-0.32 percentage points) and Rhineland-Palatinate (-0.24 percentage points). The largest overestimation is observed for Bremen (0.18 percentage points) and Hamburg (0.12 percentage points). These findings call for deeper regional analyses with more granular data to formulate meaningful conclusions for regional decision-makers.

Figure 3: Differences in Impacts between Top-down and Bottom-up Approach

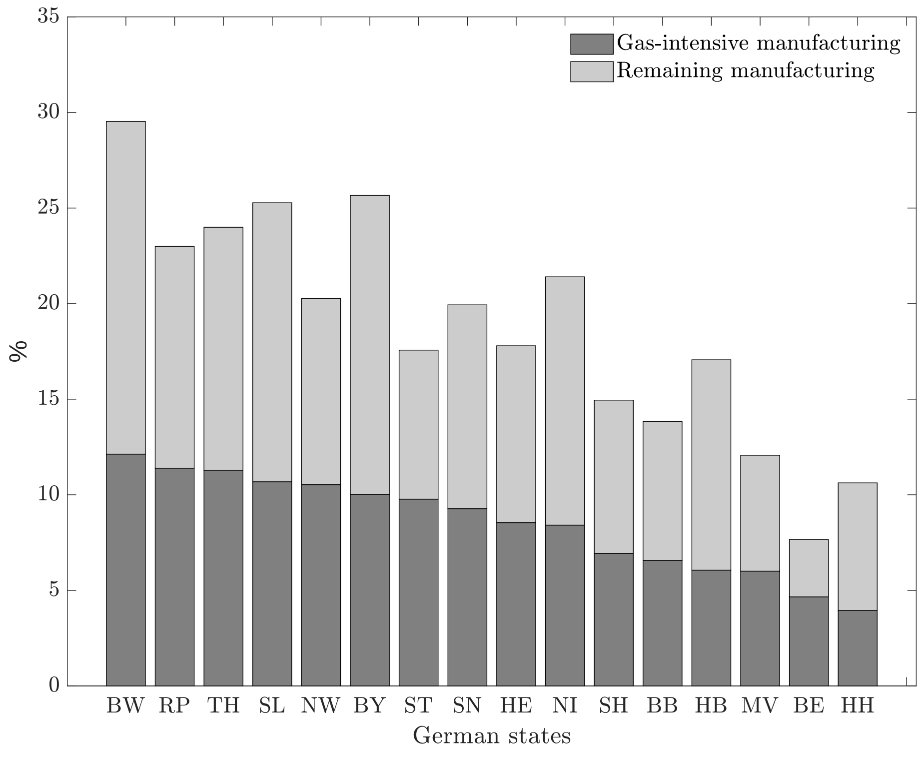


Notes: The figure shows the difference in total economic impacts between the bottom-up and the top-down approach ($\Delta^{BU} x_r - \Delta^{TD} x_r$). The states are displayed in ascending order of this difference. The state abbreviations—in alphabetical order—are: BB: Brandenburg, BE: Berlin, BW: Baden-Wuerttemberg, BY: Bavaria, HB: Bremen, HE: Hesse, HH: Hamburg, MV: Mecklenburg-West Pomerania, NI: Lower Saxony, NW: North Rhine-Westphalia, RP: Rhineland-Palatinate, SH: Schleswig-Holstein, SL: Saarland, SN: Saxony, ST: Saxony-Anhalt, TH: Thuringia.

Turning back to the absolute effects, the most affected German states in our calculations are Rhineland-Palatinate (-2.2%), Baden-Wuerttemberg (-2.1%), and the Saarland (-2.1%). The lowest effects are expected for Mecklenburg-West Pomerania, Berlin, and Hamburg. Several reasons drive our outcome. The most obvious is the industrial mix across states. Figure 4 displays the average employment shares of total manufacturing, divided by gas-intensive sectors and remaining manufacturing. The ordering of states is very much in line with the ordering of total industrial effects from the bottom-up approach; both orderings correlate by

-0.93, thus, the higher the share of gas-intensive sectors in total employment is, the higher is the magnitude of total industrial effects. Digging a bit deeper into the gas-intensive employment shares, we found even more pronounced differences that might explain the ordering. Rhineland-Palatinate and Saxony-Anhalt are among the top 3 German states with the highest employment share in the chemical industry (average 2015-2019: 4.4% and 2.2%), which operates under a very gas-intensive production process; North Rhine-Westphalia completes this picture with an employment share of 2.3%. For Baden-Wuerttemberg and the Saarland, instead, a large share of people are employed in the metal industry (average 2015-2019: 8.7% and 8.0%), which also produces quite gas-intensive. As stated previously, the gas intensity of regional production processes define a large part of the regional industrial impacts. For instance, the first-round effect in Rhineland-Palatinate contributes more than two third to the total effect. All sectors in this state are more gas-intensive compared to the national average. The same is true for Baden-Wuertemberg and Lower Saxony. Mecklenburg-West Pomerania has, instead, a lower-than-average gas share and a quite low share of value added in producing industries.

Figure 4: Composition of Employment in Manufacturing by German State



Notes: The figure shows the state-specific average employment shares (2015-2019) for gas-intensive sectors and the remaining manufacturing in total employment. The sum of both categories equals the average employment share of total manufacturing. The states are displayed in ascending order of the gas-intensive employment shares. The state abbreviations—in alphabetical order—are: BB: Brandenburg, BE: Berlin, BW: Baden-Wuerttemberg, BY: Bavaria, HB: Bremen, HE: Hesse, HH: Hamburg, MV: Mecklenburg-West Pomerania, NI: Lower Saxony, NW: North Rhine-Westphalia, RP: Rhineland-Palatinate, SH: Schleswig-Holstein, SL: Saarland, SN: Saxony, ST: Saxony-Anhalt, TH: Thuringia.

Next to the industrial mix, we furthermore expect inter-regional and international economic linkages to drive the effects. For instance, Hamburg and Berlin show the smallest decrease in gross value added when compared to other German states. Although both states are similarly exposed to gas-intensive industries, the second-round effects in Berlin are larger than those in Hamburg. This difference can be attributed to the fact that Hamburg relies more on imports from the rest of the world, whereas Berlin predominantly sources its intermediate demand from other German states.

We observe that total output in German manufacturing does not decrease dramatically, despite a gas reduction of approximately 16% (Joint Economic Forecast, 2023, p.77). Industrial production decreased by only -0.4% in 2022 compared to the previous year. However, this total number dilutes the heterogeneity across industries. Total output of gas-intensive industries strongly decreased: the chemical and pharmaceutical industry reduced its output by 6%, the wood, paper and printing industry by almost 8%, and the industry for metals by approximately 3% (see Table 1). Both the car industry and machinery and electrical equipment instead increased its production by almost 4% or approximately 3%, respectively.

Table 1: Comparison of Actual and Predicted Annual Change in Production and Imports

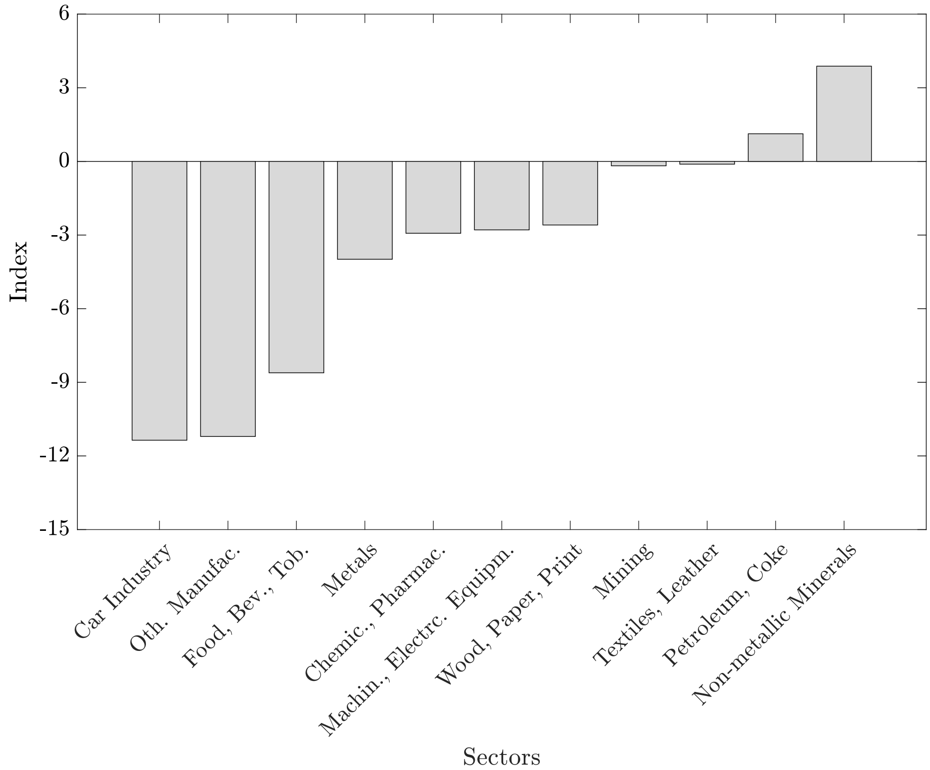
Industry	**Production**		**Imports**		**Gas Share**	
	Actual (in %)	Predicted (in %)	Actual (in %)	Predicted (in %)	Industry (in %)	Total Energy (in %)
Food, Beverages, Tobacco	-1.0	-9.8	0.8	0.5	12.3	61.4
Car Industry	3.8	-7.0	1.9	5.9	4.5	43.8
Petroleum, Coke	6.5	-7.1	0.9	2.8	4.8	44.4
Machin., Electr. Equipm.	2.5	-6.1	10.1	1.5	3.6	38.2
Other Manufacturing	-1.4	-6.2	-9.6	-1.6	0.8	39.0
Non-Metallic Minerals	-2.5	-6.0	-4.6	-3.0	9.2	37.4
Chemicals, Pharmaceut.	-6.0	-6.8	-2.0	-0.3	39.8	42.2
Wood, Paper, Printing	-7.7	-6.5	-8.2	-0.1	9.7	40.8
Mining	-1.9	-3.7	-21.7	-0.1	1.1	23.1
Metals	-2.7	-2.8	-4.2	-0.4	13.5	17.3
Textiles, Leather	-1.0	-1.9	10.2	-0.0	0.7	12.0

Notes: Industrial production is aggregated from the official 2-digit level classification to the sectoral classification used in the inter-regional input-output table by Krebs (2020), weighted by 2021 value added shares. For imports, the classification of goods is aggregated to the sectoral classification by applying the 2021 import shares of a respective sector. Predicted changes for industrial production represent a reduction in gas consumption by 16% multiplied with the share of gas in total energy use. Predicted imports reflect the change in foreign intermediate demand of the respective sectors for the observed change in industrial production. The column 'industry' displays the sectoral gas share in total industrial gas consumption. *Source:* Federal Statistical Office of Germany.

A more detailed look into the usage of gas by industry reveals that especially the figures for the car industry and the production of machinery and electrical equipment reflect a low share of gas used directly in the production process, but rather a higher demand for heating activities, for example, rooms or water (see Rohde and Arnold-Keifer, 2023, for details on gas usage across industries). In contrast, the chemical and pharmaceutical industry uses over 90% of gas directly in its production process. These figures can also explain the discrepancy between the predicted first-round effects for a uniform reduction in gas consumption across industries from our model and the actual change in industrial production. Both the car industry and machinery and electrical equipment are predicted to reduce their output by more than 6%. However, both industries can reduce gas consumption by lowering heating demand by more than 30%, holding output almost constant. Instead, the predicted change for the chemical and pharmaceutical industry with 6.7% is slightly above the observed 6%. A similar picture holds for metals and wood, paper, and printing activities that all use high shares of natural gas directly in their production process. Overall, our model does a good job in predicting economic losses for gas-intensive industries as their production heavily depends on gas. For other industries such as car manufacturing, the model—and the assumption of equal gas reductions over all industries—could, for sure, be improved. However, our figures call for a deeper modelling and understanding of factor inputs for several industries at the regional level and their explicit usage within the production process. If car manufacturing can reduce gas consumption by a large amount without decreasing production, then this is—among other things—an expression for the possibility to substitute gas as factor input, thus, the substitution elasticity must be larger than zero as argued by Moll *et al.* (2023). However, such estimates are currently not available from the academic literature, which might change in the future. Our results should therefore be seen as a first step to shed more light on such issues at the sub-national level.

Another important adjustment mechanism to maintain production at previous levels is import substitution of intermediate goods. It is important to note that overall import demand for intermediates declines according to our computation in almost all considered manufacturing industries. The reduction of production in German gas-intensive industries leads to lower intermediate import demand. A comparison of predicted import demand change conditional on the actual reduction in industrial production and the actual change in imports between 2021 and 2022 reveals that import demand by industry declines in seven out of eleven industries (see Figure 5). Regarding the sign of the predicted change, the method is in ten out of eleven cases correct. Nevertheless, most of the magnitudes cannot correctly be predicted according to the issues discussed in the previous paragraph. However, one has to keep in mind that the actual import change also includes imports for final demand, thus, the observed figures are also driven by other influences, for example, business cycle movements. Import substitution is therefore feasible and does not even require an increase in imports. Therefore, the first-round effects of our analysis are more reliable for medium- to long-run effects of gas shortages. Second-round calculations, instead, are more appropriate to estimate the upper-bound-effects of sudden and unpredictable gas shortages.

Figure 5: Additional Intermediate Import Demand for a Permanent Gas Shortage of 20 Percent



Notes: The index represents the additional intermediate import demand by each industrial sector to avoid second-round effects, arranged in ascending order. A value of 0 indicates that no additional import demand is necessary to maintain production in downstream industries using natural gas-intensive products. A value of -100 (100) indicates that intermediate imports need to go to zero (have to double) to maintain downstream production.

4 Conclusion

A potential gas deficit will lead to quite heterogeneous economic impacts across sub-national entities in Germany. According to our input-output analysis at the German state-level, Rhineland-Palatinate and Baden-Wuerttemberg will face higher economic impacts in case of a gas shortage situation compared to Berlin and Hamburg. Furthermore, our paper emphasizes the importance of regional input-output tables in economic analysis to gain a more accurate understanding of the regional economy and its interdependencies, especially when regional economic structures are heterogeneous. The results differ both in magnitude and in relative regional exposure if we either base our analysis on a German input-output table or, instead, on a inter-regional one that explicitly takes local production structures into account. Beyond these results, the comparison of predicted and actual development in 2022 shows that an input-output analysis can serve as a valuable tool for predicting upper-bound-effects. It is essential to acknowledge that our comparison assumes equal proportional reductions in gas demand across industries, reflecting a constructed but realistic rationing regime. In practice, market-based adjustments driven by price signals seem to be favourable than equal weighted rationing implemented by public institutions.

For countries with heterogeneous regional economic structures, the publication of regional input-output tables either by national statistical offices or researchers is crucial for reliable policy advise at the sub-national level. The approximation of local economic impacts by means of scaling national effects down that were calculated from national input-output tables can lead to quite different results. It is therefore highly recommended to further improve official databases to obtain reliable and comprehensive data for informed policy-making.

The next step is to explore the potential of an input-output analysis at the level of one of the largest domestic markets, the European Union. Expanding the analysis to a broader regional scale within the EU can provide valuable insights for policy-making and foster a deeper understanding of the interdependencies across the member states' regions.

Current macroeconomic analysis mainly rely on sectoral data. Mertens and Müller (2022) show that only a small number of products is responsible for the main share of industrial gas consumption in Germany, which might also be imported from other countries. Therefore, in addition to the regional dimension, incorporating the intra-sector heterogeneity is another important way for future research activities.

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Regional Industrial Effects in Germany from a Potential Gas Deficit*

– Supplementary Material –

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This version: October 12, 2023

Abstract

This is the Supplementary Material to the paper "Regional Industrial Effects in Germany from a Potential Gas Deficit". The material contains information on the applied Input-Output analysis (basics, and the calculation of first- and second-round effects), the comparison of the total effects between bottom-up and top-down approach, and some brief information on the applied inter-regional Input-Output table.

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A. Input-Output Analysis

A.1. Basics

We illustrate our calculation of economic effects with the following example. First, consider three regions $r \in \{E, W, R\}$ that represent two German regions, Eastern (E) and Western (W) Germany, and the rest of the world (R). Second, the economy is represented by three sectors $s \in \{1, 2, 3\}$. The regional demand for intermediate goods of sector j from sector i is defined as $z^o_{i,j,r}$, with o as the region of origin the intermediate goods are obtained from. Table A1 shows the corresponding intermediate demand of our example, with columns representing the demand of each sector for intermediate goods and rows representing the distribution of each sector for intermediate usage in other sectors. For example, $z^E_{3,2,W}$ is the value of intermediate goods flowing from sector 3 in Eastern Germany to sector 2 in Western Germany. Another example is $z^W_{1,3,R}$, meaning that sector 3 in the rest of the world demands this value of intermediate goods from sector 1 in Western Germany.

Table A1: Exemplary Intermediate Demand

i \ j	$\mathbf{E_1}$	$\mathbf{E_2}$	$\mathbf{E_3}$	$\mathbf{W_1}$	$\mathbf{W_2}$	$\mathbf{W_3}$	$\mathbf{R_1}$	$\mathbf{R_2}$	$\mathbf{R_3}$
$\mathbf{E_1}$	$z^E_{1,1,E}$	$z^E_{1,2,E}$	$z^E_{1,3,E}$	$z^E_{1,1,W}$	$z^E_{1,2,W}$	$z^E_{1,3,W}$	$z^E_{1,1,R}$	$z^E_{1,2,R}$	$z^E_{1,3,R}$
$\mathbf{E_2}$	$z^E_{2,1,E}$	$z^E_{2,2,E}$	$z^E_{2,3,E}$	$z^E_{2,1,W}$	$z^E_{2,2,W}$	$z^E_{2,3,W}$	$z^E_{2,1,R}$	$z^E_{2,2,R}$	$z^E_{2,3,R}$
$\mathbf{E_3}$	$z^E_{3,1,E}$	$z^E_{3,2,E}$	$z^E_{3,3,E}$	$z^E_{3,1,W}$	$z^E_{3,2,W}$	$z^E_{3,3,W}$	$z^E_{3,1,R}$	$z^E_{3,2,R}$	$z^E_{3,3,R}$
$\mathbf{W_1}$	$z^W_{1,1,E}$	$z^W_{1,2,E}$	$z^W_{1,3,E}$	$z^W_{1,1,W}$	$z^W_{1,2,W}$	$z^W_{1,3,W}$	$z^W_{1,1,R}$	$z^W_{1,2,R}$	$z^W_{1,3,R}$
$\mathbf{W_2}$	$z^W_{2,1,E}$	$z^W_{2,2,E}$	$z^W_{2,3,E}$	$z^W_{2,1,W}$	$z^W_{2,2,W}$	$z^W_{2,3,W}$	$z^W_{2,1,R}$	$z^W_{2,2,R}$	$z^W_{2,3,R}$
$\mathbf{W_3}$	$z^W_{3,1,E}$	$z^W_{3,2,E}$	$z^W_{3,3,E}$	$z^W_{3,1,W}$	$z^W_{3,2,W}$	$z^W_{3,3,W}$	$z^W_{3,1,R}$	$z^W_{3,2,R}$	$z^W_{3,3,R}$
$\mathbf{R_1}$	$z^R_{1,1,E}$	$z^R_{1,2,E}$	$z^R_{1,3,E}$	$z^R_{1,1,W}$	$z^R_{1,2,W}$	$z^R_{1,3,W}$	$z^R_{1,1,R}$	$z^R_{1,2,R}$	$z^R_{1,3,R}$
$\mathbf{R_2}$	$z^R_{2,1,E}$	$z^R_{2,2,E}$	$z^R_{2,3,E}$	$z^R_{2,1,W}$	$z^R_{2,2,W}$	$z^R_{2,3,W}$	$z^R_{2,1,R}$	$z^R_{2,2,R}$	$z^R_{2,3,R}$
$\mathbf{R_3}$	$z^R_{3,1,E}$	$z^R_{3,2,E}$	$z^R_{3,3,E}$	$z^R_{3,1,W}$	$z^R_{3,2,W}$	$z^R_{3,3,W}$	$z^R_{3,1,R}$	$z^R_{3,2,R}$	$z^R_{3,3,R}$

Notes: The table shows the demand for intermediate goods for three regions (E, W, R) and three sectors (1, 2, 3). Each column represents the sectoral demand for intermediate goods and each row represents the distribution of intermediate usage. Superscript letters indicate the region of origin and subscript letters the destination.

For a complete Input-Output analysis we further need the regional output of a specific sector, which is denoted as $x_{s,r}$. With both output and intermediate values we can compute the output coefficients, $b^o_{i,j,r}$, in the following way:

$$b^o_{i,j,r} = \frac{z^o_{i,j,r}}{x_{i,r}}. \tag{1}$$

The output coefficients represent the share in output $x_{i,r}$ that is used as an intermediate input in sector j of region r. In other words, these coefficients measure how much of sectoral output in a specific region is supplied to other sectors and regions.

Instead, input coefficients, $a_{i,j,r}$, determine the amount of intermediate goods used in sector j and region r from the distributing sector i. Input coefficients are computed as:

$$a_{i,j,r} = \frac{\sum_o z^o_{i,j,r}}{x_{j,r}} = \frac{z_{i,j,r}}{x_{j,r}} . \tag{2}$$

To calculate economic effects from a specific shock, we need to set two assumptions beforehand. First, all reported inputs are used in the production process and are therefore not redundant. Second, the economy produces goods in an efficient way, meaning that it operates on the production-possibility frontier. In a Leontief-type of economy, output efficiency is achieved by the following condition:

$$x_{j,r} = \min_i \left(\frac{z_{1,j,r}}{a_{1,j,r}}, \frac{z_{2,j,r}}{a_{2,j,r}}, \frac{z_{3,j,r}}{a_{3,j,r}} \right) . \tag{3}$$

A.2. First-round Effects

Let us consider the case that a change in foreign intermediate inputs in sector 2 used in sector 2, $\Delta z^f_{2,2,r}$, leads to a reduction in output by the amount of $-\delta$. Given the notation introduced, this shock will induce the following sectoral effects:

$$\Delta z^f_{i,j,r} = \begin{cases} -\delta a_{2,2,r} & \text{if } i = 2 \wedge j = 2, \\ 0 & \text{otherwise.} \end{cases} \tag{4}$$

Furthermore, we assume that this shock is a pure foreign one, thus, the home supply of intermediates is unaffected ($\Delta z^h_{i,j,r} = 0 \ \forall \ i, j$). In this case, the sectoral output effects amount to:

$$\begin{aligned}
x_{j,r} + \Delta x_{j,r} &= \min_i \left(\frac{z_{1,j,r} + \Delta z^f_{1,j,r}}{a_{1,j,r}}, \frac{z_{2,j,r} + \Delta z^f_{2,j,r}}{a_{2,j,r}}, \frac{z_{3,j,r} + \Delta z^f_{3,j,r}}{a_{3,j,r}} \right), \\
x_{j,r} + \Delta x_{j,r} &= \begin{cases} \min_i \left(\frac{z_{1,j,r}}{a_{1,j,r}}, \frac{z_{2,j,r}}{a_{2,j,r}} - \delta, \frac{z_{3,j,r}}{a_{3,j,r}} \right) & \text{if } j = 2, \\ \min_i \left(\frac{z_{1,j,r}}{a_{1,j,r}}, \frac{z_{2,j,r}}{a_{2,j,r}}, \frac{z_{3,j,r}}{a_{3,j,r}} \right) & \text{if } j \neq 2, \end{cases} \\
x_{j,r} + \Delta x_{j,r} &= \begin{cases} x_{j,r} - \delta & \text{if } j = 2, \\ x_{j,r} & \text{if } j \neq 2, \end{cases} \\
\Delta x_{j,r} &= \begin{cases} -\delta & \text{if } j = 2, \\ 0 & \text{if } j \neq 2. \end{cases}
\end{aligned} \tag{5}$$

By assumption, only the output of sector 2 is reduced by the foreign shock in the first round. However, the calculations work in the same fashion if the remaining two sectors are also hit by the foreign shock.

A.3. Second-round Effects

The reduction in output of sector 2 after the foreign shock spills over to the remaining two domestic sectors as it supplies intermediate goods to the rest of the economy. By assuming constant proportions, meaning that the input and output coefficients do not change, the induced output reductions in the second round amount to:

$$\begin{aligned}
\Delta z^h_{i,j,r} &= \begin{cases} -\delta b^o_{i,j,r} & \text{if } i = 2, \\ 0 & \text{if } i \neq 2, \end{cases} \\
\Delta x_{j,r} &= \min_i \left(\frac{\Delta z^h_{1,j,r} + \Delta z^f_{1,j,r}}{a_{1,j,r}}, \frac{\Delta z^h_{2,j,r} + \Delta z^f_{2,j,r}}{a_{2,j,r}}, \frac{\Delta z^h_{3,j,r} + \Delta z^f_{3,j,r}}{a_{3,j,r}} \right), \\
\Delta x_{j,r} &= \begin{cases} \min_i \left(\frac{0}{a_{1,j,r}}, \frac{-\delta \sum_o b^o_{2,j,r}}{a_{2,j,r}} - \delta, \frac{0}{a_{3,j,r}} \right) & \text{if } j = 2, \\ \min_i \left(\frac{0}{a_{1,j,r}}, \frac{-\delta \sum_o b^o_{2,j,r}}{a_{2,j,r}}, \frac{0}{a_{3,j,r}} \right) & \text{if } j \neq 2, \end{cases} \\
\Delta x_{j,r} &= -\delta \begin{cases} \frac{\sum_o b^o_{2,j,r}}{a_{2,j,r}} + 1 & \text{if } j = 2, \\ \frac{\sum_o b^o_{2,j,r}}{a_{2,j,r}} & \text{if } j \neq 2. \end{cases}
\end{aligned} \tag{6}$$

It becomes obvious that the reductions for the domestic sectors 1 and 3 are driven by the intermediate reduction from the domestic sector 2 and their corresponding input and output coefficients. The overall effect for the domestic sector 2 has two components. First, the reduction from the foreign shock. And second, the spillover from its own inter-sectoral linkages that will work after the shock occurred.

A.4. Example: Eastern and Western Germany

In the following we illustrate the methodology of an inter-regional input-output table by an example for Eastern and Western Germany based on the data by Krebs (2020). Table A2 illustrates intermediate demand of the primary (1), secondary (2) and tertiary (3) sector—together with final demand (FD) and total output (O)—for Western Germany (W), Eastern Germany (E) and the Rest of the World (R). All values are expressed in bill. Euro.

Table A2: Input-Output Table for Western Germany, Eastern Germany and the Rest of the World

i \ j	$\mathbf{W_1}$	$\mathbf{W_2}$	$\mathbf{W_3}$	$\mathbf{E_1}$	$\mathbf{E_2}$	$\mathbf{E_3}$	$\mathbf{R_1}$	$\mathbf{R_2}$	$\mathbf{R_3}$	**FD**	**O**
$\mathbf{W_1}$	2,340	22,928	1,927	187	1,300	121	1,648	4,877	759	11,527	47,614
$\mathbf{W_2}$	5,174	216,471	178,462	590	13,254	12,611	10,012	254,262	192,978	502,830	1,386,644
$\mathbf{W_3}$	13,631	301,715	1,291,929	1,346	13,395	45,333	3,016	53,497	183,894	2,136,337	4,044,093
$\mathbf{E_1}$	133	1,288	117	847	6,011	587	314	877	152	3,669	13,995
$\mathbf{E_2}$	272	11,304	10,035	1,122	24,321	22,373	1,301	29,996	22,597	74,616	197,937
$\mathbf{E_3}$	758	12,958	41,758	2,767	33,320	182,148	505	8,554	24,718	417,384	724,870
$\mathbf{R_1}$	1,000	10,889	951	384	2,134	228	600,483	1,825,553	321,711	1,613,691	4,377,024
$\mathbf{R_2}$	3,611	253,726	137,020	816	28,170	18,103	645,877	15,190,661	10,004,779	9,496,582	35,779,345
$\mathbf{R_3}$	1,450	55,639	149,305	282	10,128	26,344	530,870	7,117,739	26,954,433	49,512,061	84,358,251

Notes: The table shows the demand for intermediate goods for the three regions Western Germany (W), Eastern Germany (E) as well as the Rest of the World (R) and the three sectors (primary 1, secondary 2, tertiary 3). The last two columns represent final demand (FD) and total output (O). For the intermediate matrix, each column represents the sectoral demand for intermediate goods and each row represents the distribution of intermediate usage. The values are expressed in bill. Euro. *Source:* Krebs (2020).

From this Input-Output table we can compute the output coefficients, $b^o_{i,j,r}$, which denote how much of the output from sector i in the region of origin o is allocated to sector j in region r. Table A3 shows that there are both strong inter-sectoral linkages and connections within regions. For example, 16% (= $216,471/1,386,644$) of total output of sector 2 in Western Germany is used as intermediate goods by its own. Especially strong are the linkages within the regional tertiary sector (32% and 25%). The connections across Eastern and Western Germany are rather weak. However, some slight spillover might be expected. Overall, one-fourth, one-third and the half of total output from the primary, secondary, and tertiary sector is used for final demand, respectively.

Table A3: Output Coefficient Matrix

i \ j	$\mathbf{W_1}$	$\mathbf{W_2}$	$\mathbf{W_3}$	$\mathbf{E_1}$	$\mathbf{E_2}$	$\mathbf{E_3}$
$\mathbf{W_1}$	0.049	0.482	0.040	0.004	0.027	0.003
$\mathbf{W_2}$	0.004	0.156	0.129	0.000	0.010	0.009
$\mathbf{W_3}$	0.003	0.075	0.319	0.000	0.003	0.011
$\mathbf{E_1}$	0.010	0.092	0.008	0.061	0.430	0.042
$\mathbf{E_2}$	0.001	0.057	0.051	0.006	0.123	0.113
$\mathbf{E_3}$	0.001	0.018	0.058	0.004	0.046	0.251

Table A4 presents the input coefficients, $a_{i,j,r}$. They point to the distribution of intermediate goods demand. For example, 35% (= $(216,471 + 11,304 + 253,726)/1,386,642$) of total output of sector 2 in Western Germany is achieved by intermediate goods demand from the global secondary sector. In other words, the input ratio of the global secondary sector for the Western German sector 2 is 35%.

Table A4: Input Coefficient Matrix

i \ j	$\mathbf{W_1}$	$\mathbf{W_2}$	$\mathbf{W_3}$	$\mathbf{E_1}$	$\mathbf{E_2}$	$\mathbf{E_3}$
1	0.073	0.025	0.001	0.101	0.048	0.001
2	0.190	0.347	0.080	0.181	0.332	0.073
3	0.333	0.267	0.367	0.314	0.287	0.350

We utilize both matrices for our exemplary calculations. In the following, we assume a shock to foreign intermediate supply of the secondary sector, resulting in a reduction of output in the secondary sectors of Eastern and Western Germany by $\delta = 100$ mill. Euros. According to Equation (6), the second-round effects amount to:

$$\begin{pmatrix} \Delta x_{1,W} \\ \Delta x_{2,W} \\ \Delta x_{3,W} \\ \Delta x_{1,E} \\ \Delta x_{2,E} \\ \Delta x_{3,E} \end{pmatrix} = -100 \times \begin{pmatrix} \frac{b^E_{2,1,W}\Delta x_{2,E}+b^W_{2,1,W}\Delta x_{2,W}}{a_{2,1,W}} \\ \frac{b^E_{2,2,W}\Delta x_{2,E}+b^W_{2,2,W}\Delta x_{2,W}}{a_{2,2,W}} + 1 \\ \frac{b^E_{2,3,W}\Delta x_{2,E}+b^W_{2,3,W}\Delta x_{2,W}}{a_{2,3,W}} \\ \frac{b^E_{2,1,E}\Delta x_{2,E}+b^W_{2,1,E}\Delta x_{2,W}}{a_{2,1,E}} \\ \frac{b^E_{2,2,E}\Delta x_{2,E}+b^W_{2,2,E}\Delta x_{2,W}}{a_{2,2,E}} + 1 \\ \frac{b^E_{2,3,E}\Delta x_{2,E}+b^W_{2,3,E}\Delta x_{2,W}}{a_{2,3,E}} \end{pmatrix} = -100 \times \begin{pmatrix} \frac{0.001+0.004}{0.190} \\ \frac{0.057+0.156}{0.347} + 1 \\ \frac{0.051+0.129}{0.080} \\ \frac{0.006+0.000}{0.181} \\ \frac{0.123+0.010}{0.332} + 1 \\ \frac{0.113+0.009}{0.073} \end{pmatrix} \approx \begin{pmatrix} -3 \\ -161 \\ -223 \\ -3 \\ -140 \\ -167 \end{pmatrix}.$$

The amount of the second-round effects mainly depend on the degree of intermediate linkage to the domestic sector shocked in the first round. In our simple case both the secondary and tertiary sector of Western Germany are more affected compared to Eastern Germany. This simply reflects the lower dependency of Eastern German sectors from domestic secondary intermediates.

A.5. Top-down vs. Bottom-up Approach

In the following, we illustrate under which conditions both approaches, top-down and bottom-up, lead to identical results. In case of the bottom-up calculations, we compute output reductions that are different across regional sectors, $\Delta x_{j,r}/x_{j,r}$, as they are based on varying regional input and output coefficients, $a_{i,j,r}$ and $b^o_{i,j,r}$. Instead, the top-down calculations are based on German input and output coefficients, $a_{i,j,G}$ and $b^o_{i,j,G}$, leading to equal sectoral output reductions across regions, $\Delta x_{j,r}/x_{j,r} = \Delta x_j/x_j \ \forall r$. In the end, the regional and sectoral effect from the top-down calculations is simply the German effect distributed to the regions by sectoral shares, $x_{j,r}/x_{j,G}$. The difference between the two approaches is then given by:

$$\Delta^{BU} x_{j,r} - \Delta^{TD} x_{j,r} = \left(\frac{\sum_o b^o_{i,j,r}}{a_{i,j,r}} - \frac{b_{i,j,G}}{a_{i,j,G}} \frac{x_{j,r}}{x_{j,G}} \right) \delta \,. \tag{7}$$

Both approaches yield the same results if two conditions are met. First, the input coefficients are equal across all regions, $a_{i,j,r} = a_{i,j} \ \forall r$, reflecting that sectors proportionally require the same amount of inputs compared to their output. Second, the intermediate demand of a sector for goods from a sector impacted in the first round is proportional to its relative size in national output $\sum_o b^o_{i,j,r} = b_{i,j,G} \frac{x_{j,r}}{x_{j,G}}$.

For instance, consider the second-round effects computed with both the top-down and bottom-up approach for the previous example on the tertiary sector in Western Germany. According to Equation (7), we need to calculate the input and output coefficients for Germany beforehand. The German input coefficient amounts to $a_{2,3,G} = (178,462 + 10,035 + 137,020 + 12,611 + 22,373 + 18,103)/(4,044,093 + 724,870) = 0.079$. The value of the German output coefficient is $b_{2,3,G} = (178,462 + 12,611 + 10,035 + 22,373)(1,386,644 + 197,937) = 0.141$. The tertiary sectoral share of Western Germany in total German sectoral output amounts to $x_{3,W}/x_{3,G} = 4,044,093/(4,044,093 + 724,870) \approx 0.85$. Using these values reveals

$$
\begin{aligned}
\Delta^{BU} x_{3,W} - \Delta^{TD} x_{3,W} &= \left(\frac{b^W_{2,3,W} + b^E_{2,3,W}}{a_{2,3,W}} - \frac{b_{2,3,G}}{a_{2,3,G}} \frac{x_{3,W}}{x_{3,G}} \right) \delta \,, \\
&= \left(\frac{0.129 + 0.051}{0.080} - \frac{0.141}{0.079} 0.85 \right) \times (-100) \,, \\
&= -\,223 - (-152) = -71 \,.
\end{aligned}
$$

The bottom-up approach leads to a stronger second-round effect than the top-down approach. Whereas the input coefficients across Eastern and Western Germany are almost identical, the important driver for the different results are the output coefficients. These indicate that the tertiary sector in Western Germany relies more on domestic inputs than the tertiary sector in Eastern Germany. From this simple example we summarize that it is valuable to apply inter-regional Input-Output tables to achieve meaningful economic effects.

B. Inter-regional Input-Output Table

In the following, we present some features of the inter-regional Input-Output table constructed and presented in Krebs (2020). The basis for his regional table is the World Input-Output Database (WIOD), which is the standard source for worldwide Input-Output analyses at the national level. Thus, the results based on the inter-regional table are perfectly comparable to existing studies with a national focus. The table covers all 402 German regions (districts and district-free cities) and distinguishes between 26 countries and 17 sectors (see Figure B1). Next to its comparability to the WIOD, another main advantage of Krebs' table is its possibility to carry out inter-regional (for example, within Germany) analyses. For further details on the applied data sources and methods, we refer to Krebs (2020).

Figure B1: Sectoral and Country Coverage of the Inter-regional Input-Output Table

#	Description
1	Agriculture
2	Mininig
3	Food, Beverages, Tobacco
4	Textiles, Leather
5	Wood, Paper, Printing
6	Petroleum, Coke
7	Chemicals, Pharmaceuticals
8	Non-Metallic Minerals
9	Metal
10	Machinery, Electrical Equipment
11	Transport Equipment
12	Other Manufacturing
13	Utilities
14	Construction
15	Trade, Communication, IT
16	Financial, Insurance, Business
17	Government, Education, Health

ISO3	Name	ISO3	Name
AUT	Austria	NLD	Netherlands
BEL	Belgium	POL	Poland
BGR	Bulgaria	PRT	Portugal
CHE	Switzerland	ROU	Romania
CZE	Czech Republic	RUS	Russia
DEU	Germany	SVK	Slovakia
DNK	Denmark	SVN	Slovenia
ESP	Spain	SWE	Sweden
EST	Estonia	TUR	Turkey
FRA	France		
GBR	United Kingdom		
HRV	Croatia		
HUN	Hungary		
ITA	Italy		
LTU	Lithuania		
LUX	Luxembourg		
LVA	Latvia		

Source: Krebs (2020, p.9).

References

Krebs, O. (2020). RIOTs in Germany – Constructing an Interregional Input-Output Table for Germany. University of Tübingen Working Papers in Economics No. 132.