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The regional economic impact of coal mine closures and coal exit in Western Ukraine

Study for the GIZ project „Supporting Structural Change in Ukrainian Coal Regions"

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Executive summary

In recent years, the Ukrainian government has announced plans to close the country's coal mines and phase out coal-fired power generation. The complete phase-out of coal mining and use in all sectors is a key step towards climate neutrality by mid-century. So far, the plans have not been implemented and the government continues to subsidise state-owned coal mines to preserve jobs, instead of redirecting these subsidies to support structural change in coal regions and ensure a just transition with the creation of alternative new jobs.

This assessment quantifies the economic impact of coal mine closures in the Western Ukrainian coal regions of Lviv and Volyn. The analysis is complemented by a case study of the potential impact of the closure of a large coal-fired power plant in Burshtyn in the neighbouring Ivano-Frankivsk region (oblast).

The analysis shows that the coal mines in Lviv and Volyn oblasts play a limited economic role in their regions and do not generate significant economic impulses beyond the wages paid by the coal mining companies. The reason for this is the weak demand for regionally produced goods and services. The wages paid in coal mining in Western Ukraine are well below the national average for the sector, especially in the Volyn oblast. Moreover, the coal mines in Lviv and Volyn oblasts generate less value than they receive in state subsidies, so compensating for job losses through targeted social transfers at current wage levels would require less money than continuing coal mining. The large coal-fired power plants in Western Ukraine, owned by DTEK, are supplied with coal from other regions, making them completely independent of coal mining in Lviv and Volyn oblasts.

Lviv and Volyn oblasts are therefore regions well suited to start phasing out coal, as the economic impact of the closures is expected to be relatively small compared to other coal regions.

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GDP	gross domestic product
ICT	information and communications technologies
IO	input-output
MinEnergo	the Ministry of Energy of Ukraine
TPP	thermal power plant
UAH	Ukrainian hryvnia
VA	value added

1. Introduction

In 2021, as part of the Ukraine-EU Green Deal, the Ukrainian government announced a comprehensive plan to decommission most of the country's coal mines by 2030 (E&MJ, 2021). The closure of loss-making state-owned coal mines was considered as the first step and is included in the implementation plan for the updated NDC (Ministry of Economy of Ukraine, 2024). A possible phase-out of coal-fired power generation by 2035 is suggested in the current draft of the National Energy and Climate Plan (Ministry of Economy of Ukraine, 2024). In order to make progress towards climate neutrality, the coal phase-out must be extended to end all coal mining and coal combustion in Ukraine.

So far, there has been little action on coal mine closures and the government continues to subsidise the state-owned coal mines in order to preserve jobs in structurally weak regions and thus avoiding structural shifts. This contradicts the original plan to redirect the coal subsidies into regional structural funds to support structural change in the regional economy in parallel with mine closures. The closure of coal mines means for the affected regions both, a loss of household incomes and revenues for local budgets. Targeted social transfers are required to compensate households for income losses, while complementary area-based measures would foster a just transition until alternative new jobs are created.

Against this background and as a part of the ongoing project “Supporting Structural Change in Ukrainian Coal Regions”, the GIZ requested to assess the potential regional economic impacts of coal mine closures and coal exit for the Western Ukrainian coal regions (oblasts) of Lviv and Volyn as well as the possible impact of decommissioning a large coal-fired power plant in Ivano-Frankivsk region. The assessment identifies declining sectors which would be affected by the coal exit and estimates the potential loss of jobs and income.

The quantitative assessment was carried out using a regional input-output (IO) model based on national and regional statistical data, supplemented by information on the coal extracting and coal combusting enterprises in the respective regions. The assessment is based on the current regulatory framework and therefore does not consider future more ambitious climate policies with significant carbon pricing. It is conducted for the reference year 2021 and thus does not consider any war-related damage[1]. Therefore, the findings may not reflect the most recent changes in economic structures and

[1] Millions of people are fleeing the consequences of Russia's war against Ukraine, numerous production facilities have been destroyed or damaged and supply chains have been interrupted. All of this has led to a massive slump in economic output and a drop in domestic demand for electricity and heat. The extensive destruction

linkages. Nevertheless, the main findings of this assessment remain valid. The results indicate that the subsidised state-owned coal mines in Lviv and Volyn oblasts play a rather limited economic role in the regional economy, creating less value in the region than they receive in subsidies. Ending coal mining in Western Ukraine would be therefore a good starting point for a complete phase-out of coal mining and stop of coal combustion in Ukraine.

2. The context of coal exit

2.1 The role of coal in Ukraine

The direct contribution of coal mining to the national economy is relatively small as it accounts for 1.2% of the national value added[2] and 0.4% of the national employment (Figure 1). Coal is more significant indirectly as it is a very important input for other sectors, especially for electricity and heat supply, coke production, the production of basic metals (especially ferrous metallurgy), and the production of non-metallic minerals such as cement, glass, or ceramics. Together, these coal-using sectors contribute 6.8% to the national value added and 3.6% to national employment.

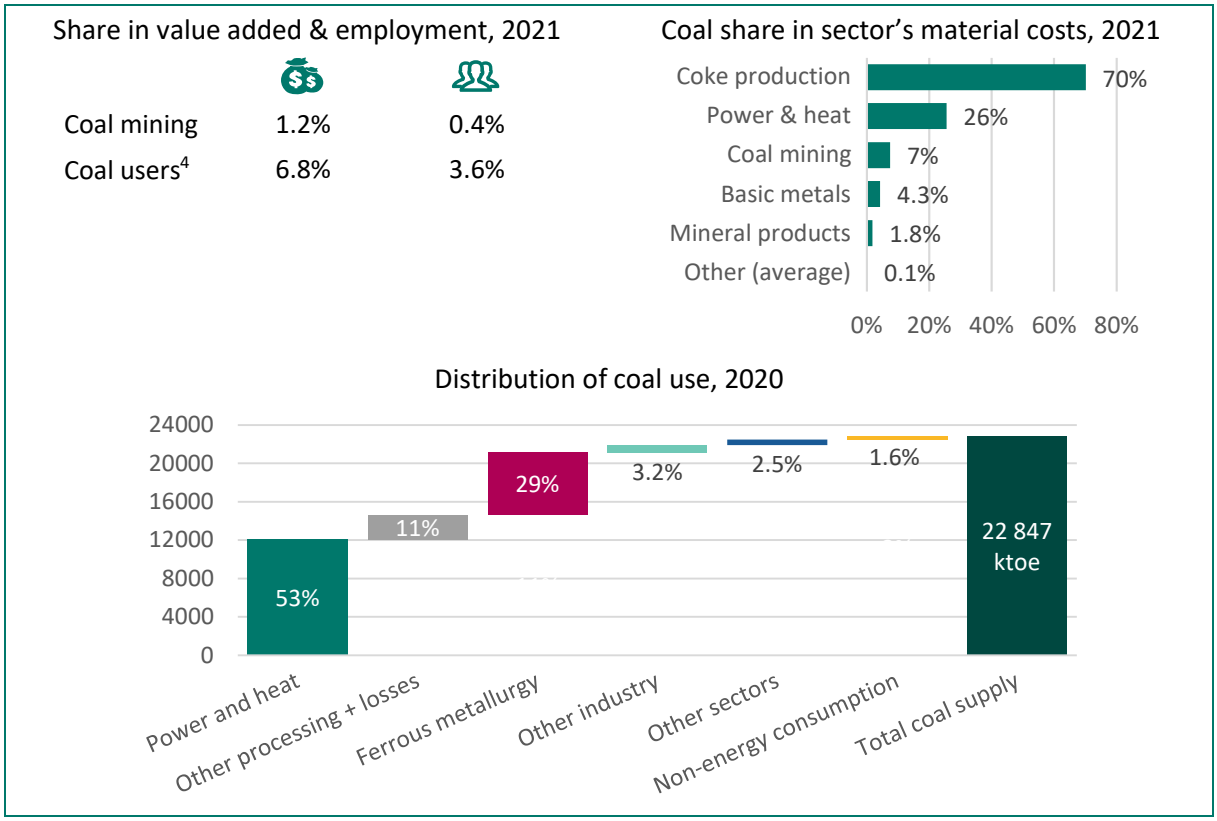
Ukraine's energy supply is relatively diversified, with coal accounting for 26% of total primary energy supply. About half of the coal supply is produced domestically, while the rest is imported. On the demand side, power and heat generation and industry are the largest consumers of coal, with coal accounting for 27% of total electricity generation[3] and 31% of final energy consumption in industry. Coal has a marginal role in the final energy demand of buildings. Among coal users, electricity and heat generation alone consume more than half of Ukraine's total coal supply, while ferrous metallurgy accounts for a further 29%, of which coking coal production and blast furnace use account for 11% and direct coal combustion for 18% (Figure 1, bottom panel).

of the thermal power plants in Ukraine by Russian drones, cruise missiles and ballistic missiles is inevitably leading to a decline in demand for coal.

[2] See in Appendix for the definition of value added.

[3] This is less than, e.g., in Poland or the Czech Republic and comparable to Germany.

Figure 1: Coal in Ukraine - factsheet



Source: Own work based on State Statistics Service of Ukraine (2022b; 2021a).

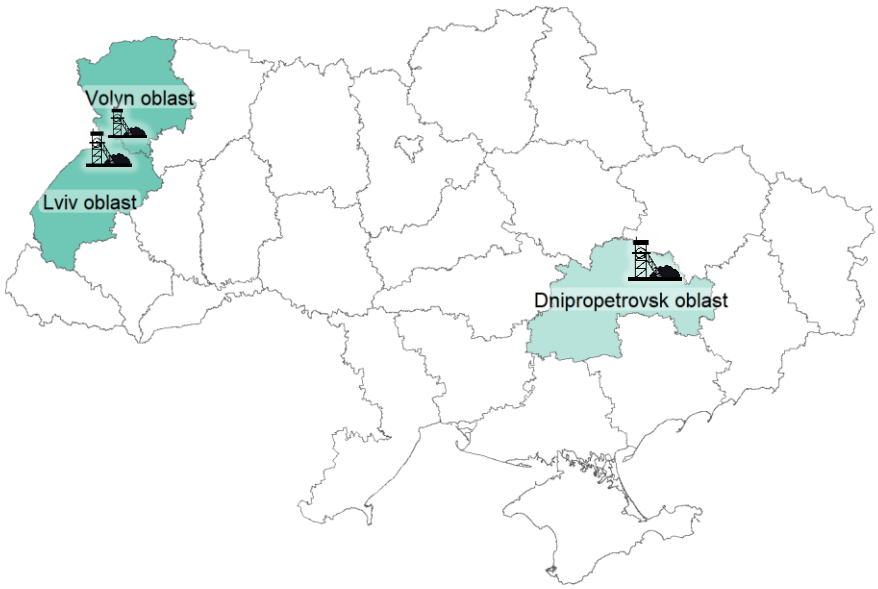
Coal mining and large coal consumers are concentrated in a few regions. We first focus on the two coal mining regions in Western Ukraine and quantify the economic impact of stopping coal mining activities. We then analyse as a case study the regional impacts of ending coal-fired power generation at the Burshtyn TPP in Ivano-Frankivsk oblast. The following section provides an overview of the coal mining regions that are analysed in this study.

2.2 Analysed coal mining regions

Two coal mining regions in Western Ukraine were analysed: Lviv and Volyn oblasts. To provide context to the analysis, the coal mines in Lviv and Volyn oblasts are also compared with coal mining in Dnipropetrovsk oblast. The regions are shown in Figure 2.

[4] Sectors with the highest coal share in costs (coke production, power and heat, basic metals, mineral products).

Figure 2: Analysed coal mining regions



Source: Own illustration.

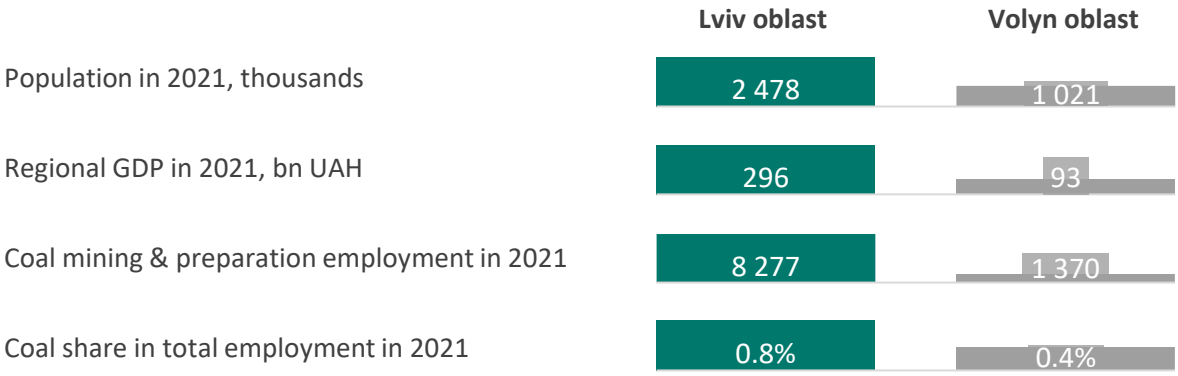
Lviv oblast is the larger Western Ukrainian region in terms of population, economic size, and coal-related employment (Figure 3). With a population of about 2.5 million, it has regional GDP of almost UAH 300 billion, resulting in an average GDP per capita of UAH 120 thousand - the highest of the regions analysed. Almost 8.3 thousand people are employed in the coal mining sector, which represents 0.8% of total employment in the Lviv oblast. The coal mining sector consists of two mining companies (SE Lvivvuhillya, Nadiya Coal Mine) owned by the Ministry of Energy (MinEnergo) and a coal processing plant in Chervonohrad owned by the Lviv Coal Company as of 2023 (62% privately owned). The latter prepares all coal mined in the Lviv-Volyn coal basin (Kochmar & Karabyn, 2022).[5] Table 1 provides an overview of the included companies.

Volyn oblast is less than half the size of the Lviv oblast in terms of population (1 million people) and less than a third in terms of regional GDP (UAH 93 billion), with average per capita GDP of UAH 91 thousand. It employs 1.4 thousand people in two state mining enterprises – SE Volynvuhillya and Coal Mine No. 9 Novovolynska – accounting for 0.4% of the total regional employment. In both, Lviv and Volyn oblasts, the coal mines sell their coal production mainly to the state company Ukrvuhillya (owned by MinEnergo) acting as a 'central planer' and distributing coal to the consumers.[6]

[5] Raw coal from the mine contains impurities and comes in varying sizes and qualities, so it must be prepared (washed, impurities removed and sorted) before it can be marketed and used. From publicly available tender data we can conclude that Lviv Coal Company does not buy coal from mines, but provides preparation and processing services.

[6] The state-owned coal mines sell coal to Ukrvuhillya. However, we could not obtain any reliable information, at what price transactions take place and to whom Ukrvuhillya resells the coal.

Figure 3: Main characteristics of the analysed coal mining regions



Source: State Statistics Service of Ukraine (2022c; 2022a; 2023b).

Table 1: Overview of the analysed companies

Region	**Lviv oblast**			**Volyn oblast**	
Company / unit	**SE Lvivvuhillya**	**Nadiya Coal Mine**	**Lviv Coal Company**	**SE Volynvuhillya**	**Coal Mine Nr 9 Novovolynska**
Ownership	State	State	38% state, 62% private	State	State
Main activity	Coal mining	Coal mining	Coal preparation	Coal mining	Coal mining
Employment	7 152	326	658	953	417*
Sales, UAH million	1 288.8	11.6	444.1	19.2	0
Budget transfers, UAH million	1 040.1	97	0	123.4	69.1
Wages paid, UAH million	1 214	49.2	72.2	93.3	35.4
Profit (+)/loss (-), UAH million	-508.9	-2.1	-8.5	-81.1	-9.5

* 2022 data

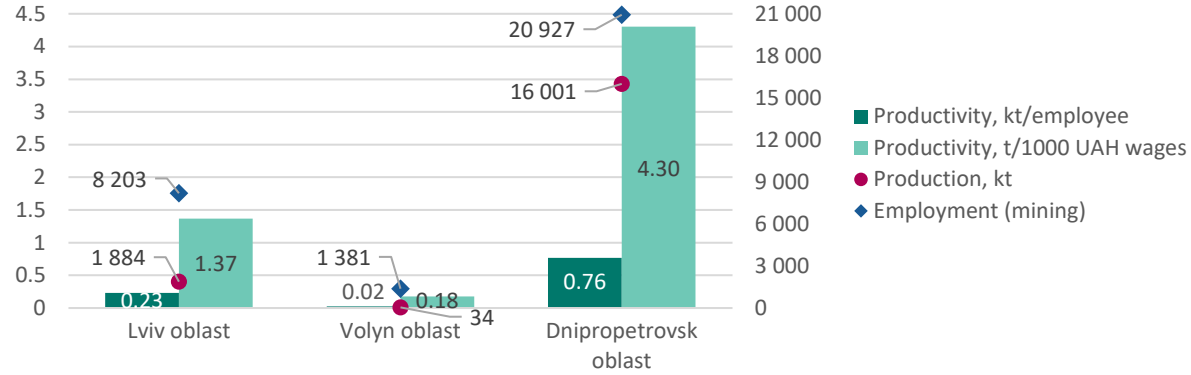
Source: Clarity Project, Opendatabot.

All coal mining companies in Lviv and Volyn oblasts receive central budget transfers to maintain their operations. Subsidies are comparable to or even exceed the actual sales revenues of coal mines. Despite the central budget transfers, all coal mines realize net financial losses, which are also covered by MinEnergo (see below for more details). The Lviv Coal Company, which is only 38% owned by the State Property Fund of Ukraine, officially receives no budget transfers, but has been making losses for years and has been under bankruptcy proceedings since 2018 (Clarity Project, 2020).

To put these financial results into context, it is necessary to consider the circumstances, in which the coal mines operate. To do so, we compare the state-owned coal mines in Lviv and Volyn oblasts with the private owned coal mines of Dnipropetrovsk oblast. The productivity levels of coal mines differ

across the regions in terms of production volumes, employment, and labour costs (Figure 4).[7] In absolute terms, the coal sector in Lviv and Volyn oblasts is much smaller than in Dnipropetrovsk oblast. The productivity of coal mines in Volyn is at the level of 3-5% and in Lviv at the level of 30-32% of the productivity levels in Dnipropetrovsk oblast. The reasons for the large difference in productivity can be attributed to economies of scale in the larger Dnipropetrovsk coal sector, geological conditions, but also managerial differences between private owned and state-owned firms. International evidence suggests that state-owned coal mines are also characterised by lower productivity levels due to redundant staff and outdated production equipment (Fang, Wu, & Zeng, 2009).

Figure 4: Employment, production, and productivity in coal mining, 2020



Source: Own work based on State Statistics Service of Ukraine (2021b), GIZ (2021), own estimates based on the information provided by GIZ.

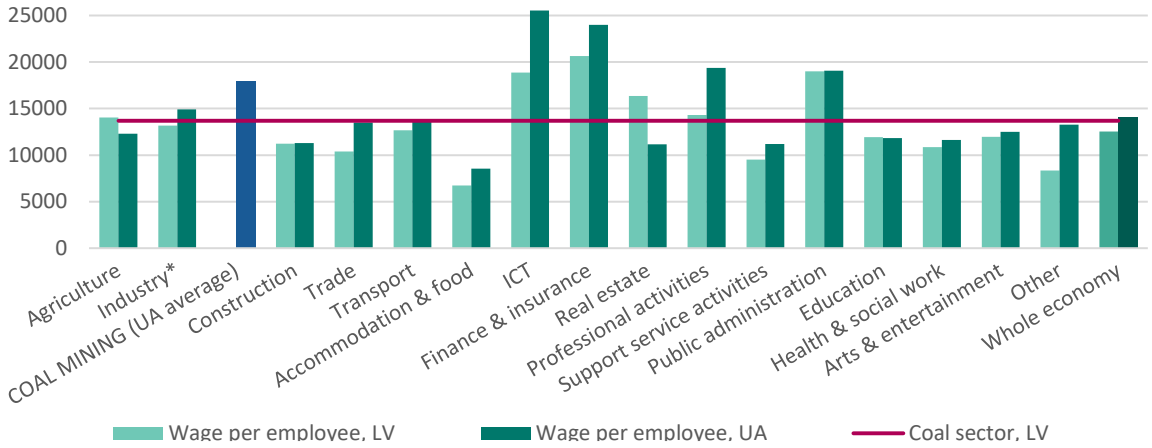
Productivity is also reflected in the value added generated by enterprises and the wages they pay. Measured per employee, the value added generated by Lviv coal mines is moderate compared to other sectors in the region and nationwide. It is higher than, e.g., in agriculture, construction, accommodation and food services, or health and social work in Lviv oblast, but significantly lower than the average value added in industry (see Figure 17 in Annex C). Value added per employee in the Volyn coal mines is lower than in all other sectors in the Volyn oblast and nationally (see Figure 18 in Annex C).

Wages follow a similar pattern (see Figure 5 for Lviv oblast and Figure 6 for Volyn oblast). In Lviv oblast, the wages in the coal mining sector are on average compared to other sectors in the region and nationally. Although lower than in service sectors such as ICT or financial services, the wage level is comparable to the industry average and the sector of professional activities and significantly higher than in construction, accommodation services, or health and social work. In coal mining in Volyn oblast, wages are much lower than in neighbouring Lviv oblast and lower than wages paid in all other sectors

[7] Productivity is defined here as the volume of coal production per employee or per UAH 1000 of wages respectively.

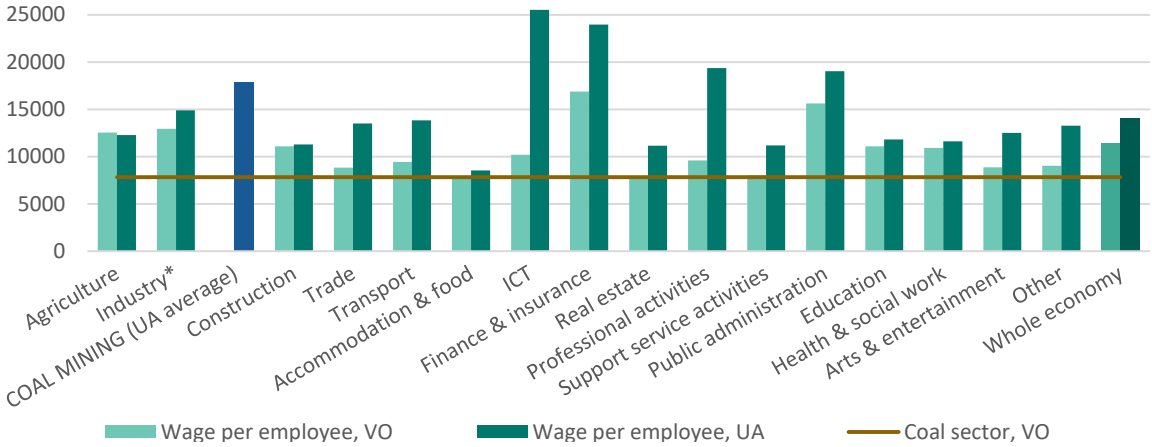
in the Volyn oblast. In both regions is the wage level well below the national average for coal mining (blue bar in Figure 5 and Figure 6). This contradicts the widely held view that coal mining jobs are especially good, high quality, well-paid jobs that maintain the wealth of the region and therefore need to be preserved. This is certainly not the case in Volyn oblast, while the claim for Lviv oblast can be doubted.

Figure 5: Average monthly wage in coal mining companies in Lviv oblast, compared to other sectors in Lviv oblast and in Ukraine, UAH



Source: State Statistics Service of Ukraine (2023a), own calculations based on financial reports.

Figure 6: Average monthly wage in coal mining companies in Volyn oblast, compared to other sectors in Volyn oblast and in Ukraine, UAH

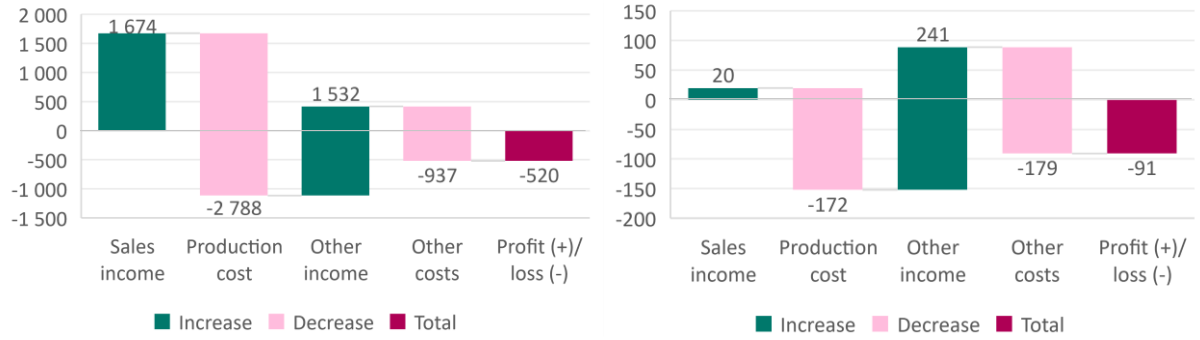


Source: State Statistics Service of Ukraine (2023a), own calculations based on financial reports.

Next, the commercial operations of the coal companies are weighed against the budget transfers that they receive. As stated above, the coal mines in Lviv and Volyn are even after subsidies financially not viable. The most 'independent' SE Lvivvuhillya received 43% of its cash inflows from budget transfers in 2021, while for other coal mines budget transfers accounted for over two-thirds of their cash inflows. Only the Lviv Coal Company, which is 62% privately owned, officially receives no transfers, but it is under bankruptcy administration.

The transfers are required because the state-owned coal mines have to sell coal to state-owned Ukrvuhillya at prices below production costs, resulting in gross losses (Figure 7). Other income, including the central budget transfers, partially covers the production costs. However, in addition to direct production costs, coal mines also have to cover general administration, sales and other costs, so that after central budget transfers the state-owned coal mines still make financial losses. With the exception of the Lviv Coal Company, these losses are technically borne by MinEnergo and are therefore also part of the subsidy to maintain operations.

Figure 7: Incomes and costs of coal companies in Lviv oblast (left) and Volyn oblast (right), UAH million



Source: Financial reports of the included companies (Clarity Project).

Table 2: State transfers and wages in coal companies

	Wages paid, UAH million	Transfers received, UAH million	Wages - transfers, UAH million	Transfers, % of wages	Losses, UAH million
Lvivvuhillya	1 214.0	1 040.1	173.9	86%	509
Nadiya Coal Mine	49.2	97.0	-47.8	197%	2.1
Lviv Coal Company	72.2	0.0			8.5
Lviv oblast total	**1 335.5**	**1 137.1**			**519.6**
Volynvuhillya	93.3	123.4	-30.0	132%	81.1
Coal Mine No. 9 Novovolynska	35.4	69.1	-33.7	195%	9.5
Volyn oblast total	**128.7**	**192.5**			**610.1**

Source: Clarity Project.

The picture becomes more comprehensive when the subsidies are compared with wages paid. SE Lvivvuhillya had a wage bill of UAH 1 212 million, while it received central budget transfers of UAH 1 040 million, or 85.7% of the wages paid. At the Nadiya coal mine in Lviv oblast, the transfers of UAH 97 million were almost twice as high as the wage payments of UAH 49.2 million. The situation is similar in Novovolynska, where transfers from the central budget of UAH 69.1 million are twice as high as the wage bill of UAH 35.5 million. Volynvuhillya received UAH 123.4 million in transfers and paid UAH 93.3 million in wages.

This brief descriptive analysis shows that coal mining in Lviv and Volyn oblasts is not commercially viable and that the continued operation of coal mines depends on a complex system of transfer of state funds to the regions. However, the subsidised operation of coal mines in these regions may be justified if the coal sector makes a significant contribution to the regional economy. This would be the case if at least one of the following conditions applies:

- The coal sector is an important element in regional value chains, creating demand for goods and services through its operations.
- Other economic sectors in the region are highly dependent on the coal sector for supplies.

The following input-output analysis therefore provides insights into the overall economic role of the coal mining sector in Lviv and Volyn oblasts.

3. Regional impacts of coal mine closure

The quantitative assessment of mine closures in Western Ukraine is based on the input-output (IO) analysis, which is a common method for quantifying the economic and regional economic impacts of a specific sector or industry along the entire value chain. Input-output tables describe the interrelationships within an economy and provide key information on how each sector of the economy supplies inputs to, and purchases inputs from, other sectors. The input-output model is therefore a particularly appropriate tool for analysing the overall economic impact of coal mine closures and coal exit in Western Ukraine. The key indicators in the IO analysis are value added and employment, and the economic impacts assessed are differentiated into direct, indirect, and induced effects (see Annex A for a description of the IO approach).

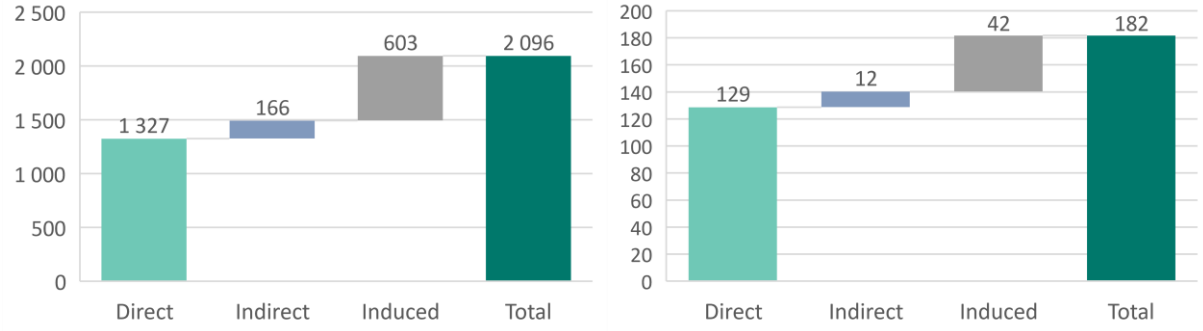
Coal mining in Lviv and Volyn oblasts

In Lviv oblast, coal mines generate a cumulative value added of UAH 2.1 billion (EUR 65 million) directly, through the (indirect) supply chain effects and induced consumption (Figure 8, left panel). This represents 0.8% of the total value added in the region. The total economic impact in Volyn oblast is about a tenth as large: the coal mines generate a cumulative value of UAH 182 million (EUR 6 million), or 0.2% of the region's total value added.

In both regions, the direct effect – i.e., the income generated by the coal companies themselves – dominates the overall economic impact of coal mining. This is due to their relatively low labour productivity and wages (see discussion in Section 2.2). On the one hand, labour costs are the main component of the companies' expenses, while total material costs amount to about one third of the

production value (net of taxes). This means that the coal companies spend significantly more on wages than on goods and services to support their operations, which corresponds to weak economic impulses along the supply chain. In addition, relatively few goods and services are sourced from producers in the region: only an estimated 37-42% of material costs are spent regionally. As a result, the demand for intermediate products flows to other regions and thus contributes relatively little to the regional economy in Western Ukraine, reducing the indirect effect. On the other hand, as the coal mines are loss-making, only direct labour income and (small) indirect value added translate into induced consumption.

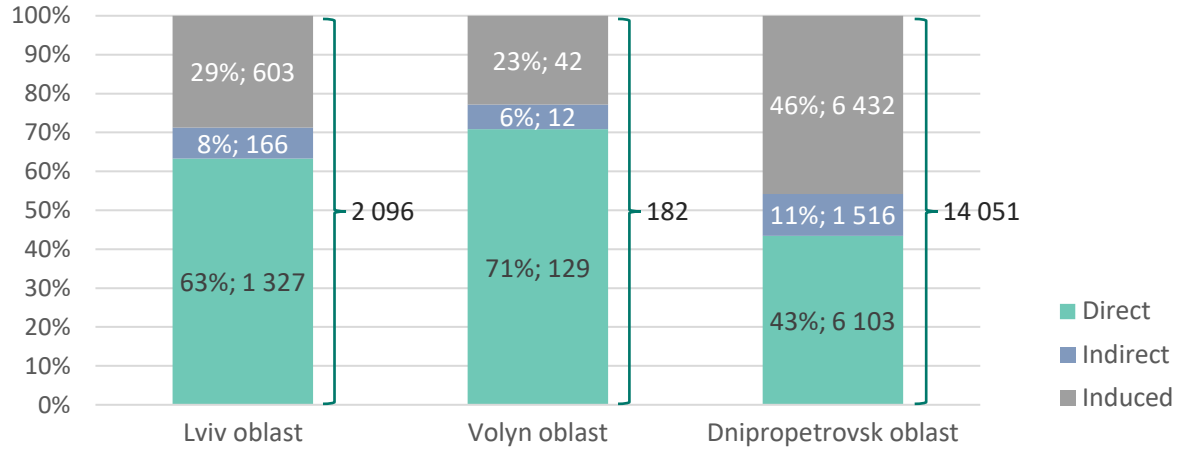
Figure 8: Value added effects of the coal sector in Lviv region (left) and Volyn region (right), UAH million



Source: Own calculations.

Overall, each UAH 1 of value added generated directly by the coal companies translates into UAH 1.6 of value added in the regional economy in Lviv oblast and UAH 1.4 in Volyn oblast. This is significantly lower than, e.g., in Dnipropetrovsk oblast, where the coal mines are privately owned. In Dnipropetrovsk oblast, indirect and induced effects account for a much larger share of total effects (see Figure 9), and UAH 1 of direct value added generates UAH 2.3 of value added in the regional economy. One of the reasons for this is the performance of the enterprises: unlike in Lviv and Volyn oblasts, coal mining in Dnipropetrovsk oblast generates stronger economic impulses through much higher expenditure on materials (two thirds of total expenditure) and investment activities, higher wages, and the generation of profits. Material costs and investment activities contribute to the indirect effect by increasing the demand for intermediate products. Even though in Dnipropetrovsk oblast only 32% of material costs are spent in the regional economy, this additional demand generates a higher indirect effect, accounting for 11% of the total effect, compared to 8% in Lviv oblast and only 6% in Volyn oblast. Higher wages and profits, on the other hand, are additional income that is spent on goods and services and thus induce much higher consumption, so that the induced effects account for almost half of the total effect in Dnipropetrovsk oblast, compared to only 23-29% in Lviv and Volyn oblasts.

Figure 9: Structure of the value-added effects by region, % / UAH million



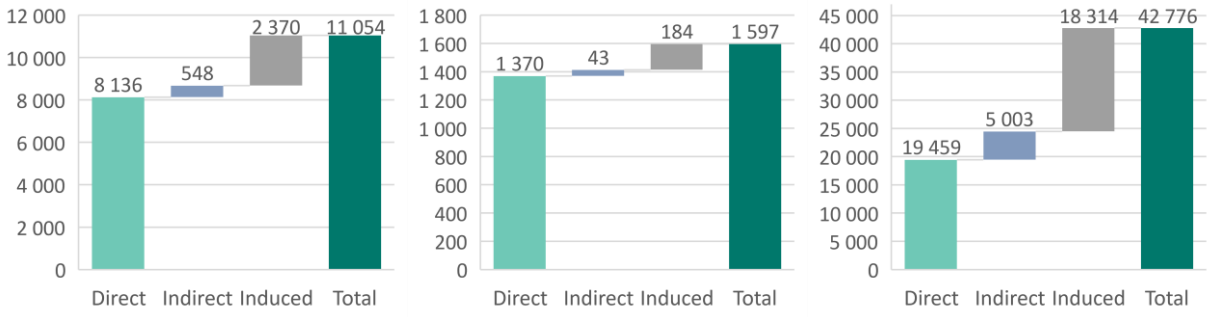
Source: Own calculations.

Regarding employment, Figure 10 shows the direct, indirect, and induced employment effects in the regions of Lviv, Volyn and, for comparison, Dnipropetrovsk oblasts. In Lviv oblast, 11 thousand jobs are directly or indirectly related to coal mining. This represents about 1.1% of the employed population in the region. In terms of employment effects, the direct effect is even more dominant than in VA effects discussed above: more than 8 thousand people, or 74%, are directly employed in the coal sector in Lviv oblast.

In Volyn oblast, 1.6 thousand jobs, or about 0.4% of the region's employed population, are directly or indirectly related to coal mining, of which 86% are direct employment in coal mines.

As in VA, Dnipropetrovsk oblast generates both larger absolute effects and stronger indirect and induced effects. Almost 43 thousand jobs are directly or indirectly related to coal mining in Dnipropetrovsk oblast, which is about 3.2% of the total employed population in the region. Of this total effect, 19.5 thousand jobs, or 45%, result from direct employment in coal mines.

Figure 10: Employment effects in the regions of Lviv (left), Volyn (middle), and Dnipropetrovsk (right) oblasts, persons

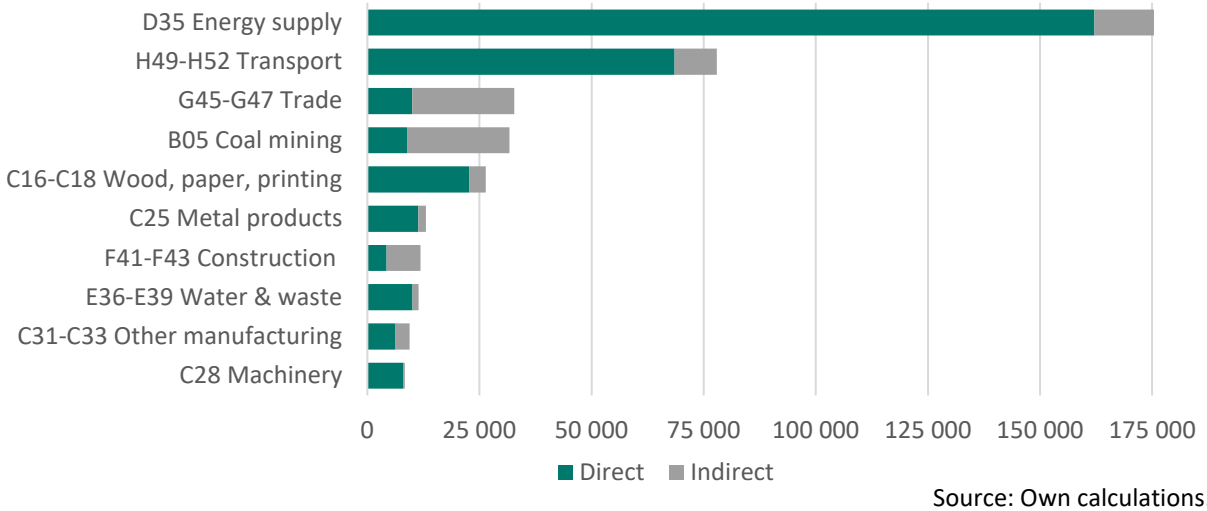


Source: Own calculations.

The IO analysis also makes it possible to identify the sectors which are important suppliers to the coal sector and which may therefore have to reduce their activities if coal mining ceases in the region. In

both Lviv and Volyn oblasts, energy and transport are by far the largest supplier sectors to the coal sector, followed closely by trade, coal mining itself and wood products when indirect effects are taken into account (see Figure 11 for Lviv oblast). For energy supply and transport, the direct demand from the coal sector dominates, while trade activities are important for both the coal sector and its suppliers, so that the indirect effect dominates. Interestingly, coal mining seems to generate significant (indirect) demand for itself. This is mainly due to the high demand for electricity, which in turn uses a lot of coal.[8]

Figure 11: Top 10 sectors by production effect in Lviv oblast, UAH thousand



Source: Own calculations.

Finally, to better reflect the fact that some sectors may depend on coal supply for their activities, a hypothetical extraction of coal mining from the Lviv regional economy was carried out. It captures all upstream and downstream linkages, thus combining the value added and input demand of coal companies with the output they provide to the downstream value chain. It is therefore expected that the indirect and induced effects of a hypothetical extraction are stronger than if only the upstream side is considered.[9] Figure 12 shows the direct, indirect, and induced effects of the hypothetical extraction on VA and employment.

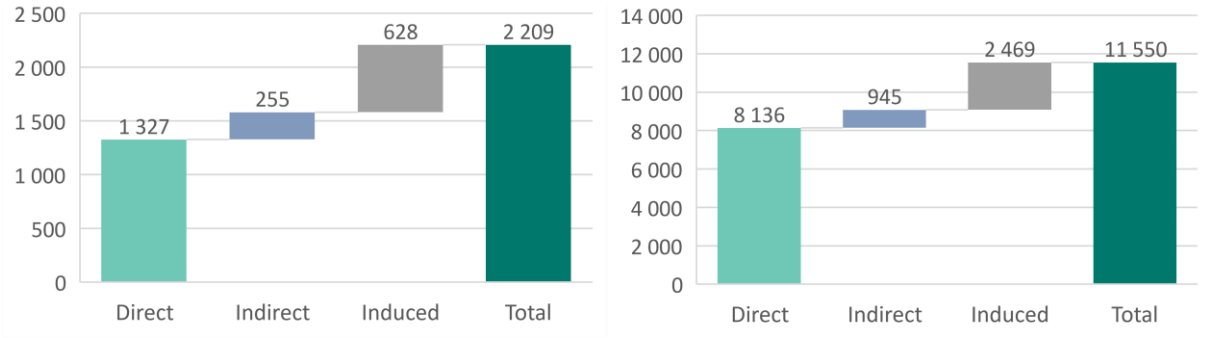
The complete removal of the coal mining sector from the Lviv oblast economy does not change the overall picture. The hypothetical total loss of value added would increase by UAH 113 million to a total of UAH 2.2 billion, an increase of 5.4% compared to the upstream-only perspective. The change in the employment effect is slightly smaller: the hypothetical total employment loss increases by 496 jobs to

[8] The direct effect of the coal sector on its own production is likely due to a lack of information on business linkages between coal mining and coal processing enterprises in the region.

[9] The direct effect will remain unchanged by definition.

11.6 thousand, an increase of 4.5%. In both cases, the direct effect is still dominant: it accounts for 60% of the total VA effect and for 70% for of the total employment effect.

Figure 12: Hypothetical extraction – value added (left) and employment (right) effects in Lviv oblast, UAH million



Source: Own calculations.

Value creation by the coal sector and state support

As discussed in Section 2.2, state support for unprofitable coal companies may be justified if they generate significant economic impulses for the regional economy through value chain effects. In other words, the budget transfers to the coal companies should be weighed against both, direct and indirect effects on value added.[10] Induced VA, on the other hand, results from the consumption of the income generated directly and indirectly, so that targeted social or budgetary transfers to compensate for job losses would generate the same induced effects.

The total (central) budget expenditure on coal mining in 2021 was UAH 5.46 billion (Ministry of Finance of Ukraine, 2024). Of this, UAH 548 million are classified as funds for liquidation of loss-making firms, UAH 300 million as labour costs in coal firms, and the rest – UAH 4.6 billion – as funds for the restructuring of the coal industry. Comparing these budget expenditures with the transfers to the analysed coal companies, the Lviv and Volyn oblasts receive a quarter of the government's coal expenditures: Lviv oblast receives a total of 21% (19% SE Lvivvuhillya, 2% Nadiya Coal Mine) and Volyn oblast receives 4%.[11] In comparison, Lviv oblast supplies almost half of the coal produced by MinEnergo mines (GIZ, 2021).

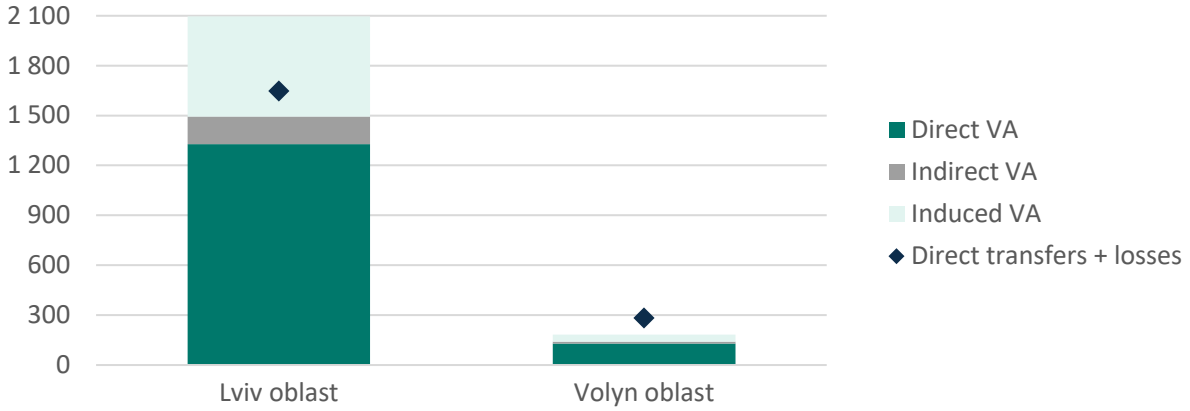
As Figure 13 shows, in both the Volyn and Lviv coal sectors, the sum of direct budget transfers and financial losses covered by MinEnergo exceeds the sum of direct and indirect value added. So the

[10] As discussed above, the profits or losses of the state enterprises accrue to the central budget, and not to the regional economy. Therefore, the losses of the coal companies in Lviv and Volyn oblasts are part of the subsidy and should be added to the direct budget transfers when comparing the VA and state support.

[11] Data on budget transfers to the Lviv and Volyn coal companies are taken from their cash flow statements, where the reporting date is based on the actual cash flow. These figures may differ slightly from the financial and budget reporting, but the magnitude remains the same.

continued operation of these coal mines is not economically justified. In fact, compensating for job losses through targeted social transfers at the level of present wages would require less money than continuing operations.[12] In other words, the closure of these coal mines would improve Ukraine's economic welfare.

Figure 13: Value added in the coal sector compared to budget transfers, UAH million



Source: Own calculations.

Distribution of employment effects within the regions

So far, the analysis has considered the economic role of coal mining at the regional (oblast) level. Due to data limitations, it is not possible at this stage to carry out the IO analysis at the rayon[13] or municipality level. However, it should be noted that the impact of the coal phase-out will not be evenly distributed across the oblasts. As Figure 14 shows, employment in the coal mines is highly concentrated two particular rayons of Lviv and Volyn oblasts.

In Volyn oblast, coal mining employment is concentrated around the two mines in Volodymyr-Volynski rayon, with most workers living in the two towns of Novovolynsk and Volodymyr-Volynski. As both towns are municipal centres, the coal mining employment accounts for a significant but still relatively small share of the local employment.[14]

The picture is very different in Lviv oblast. Here, too, coal mining is concentrated in one rayon, Chervonohradski, but coal employment accounts for a significant 5.4% of rayon's total population. The town of Chervonohrad, which is the centre of the rayon and where also most of the coal mines are

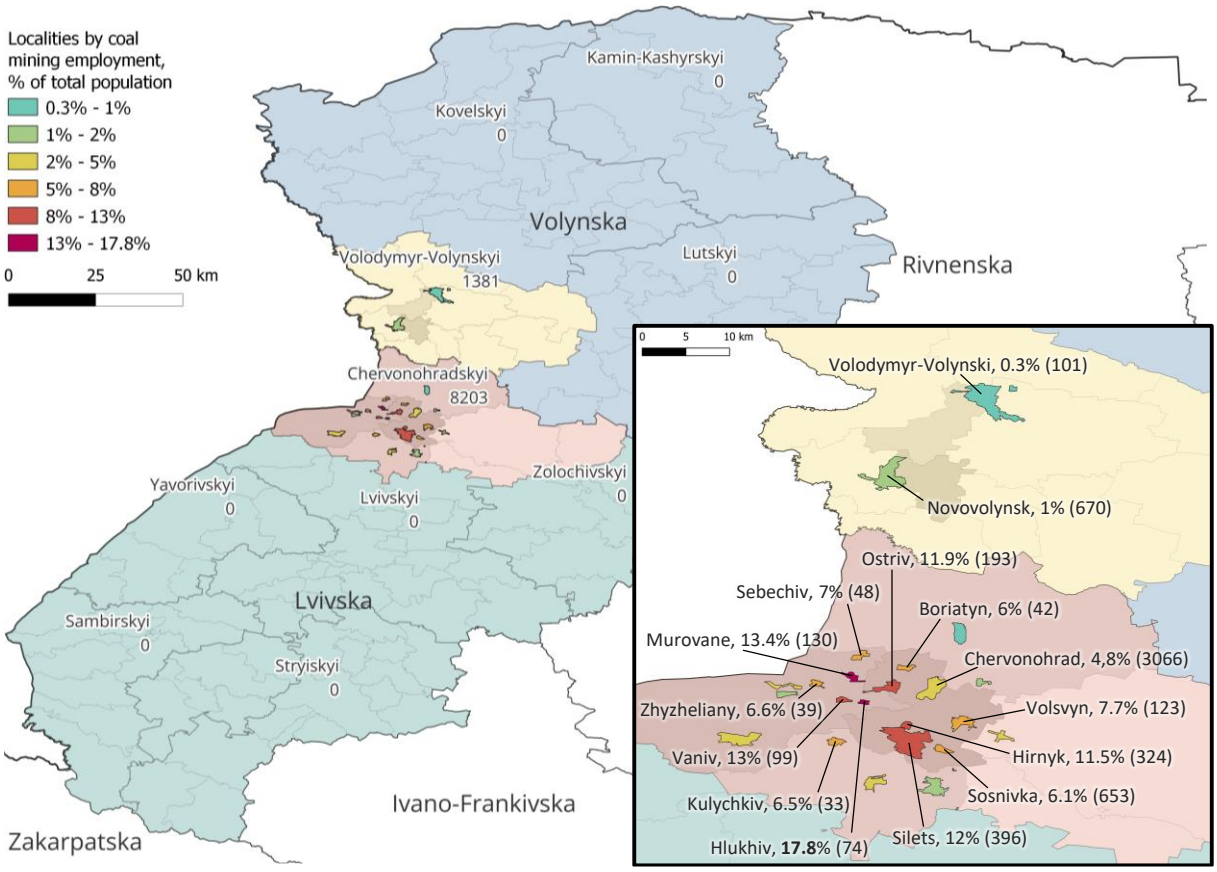
[12] This comparison refers to the alternative use of budgetary resources that are currently allocated to the coal mines. Pension payments to the retired workers or future retired workers are independent of the continued operation of the mines and are not paid from the government budget, so they are not discussed further here.

[13] A "rayon" is an administrative territorial unit of an "oblast" in Ukraine.

[14] There is no information on employed population at the rayon, municipality, or settlement level. Figure 14 compares coal mining employment to total population, so this indicator should be treated with caution. Considering the age structure and labour force participation at the oblast level, it is likely that around 40% of population are employed.

located, employs by far the largest number of people. In relative terms, the role of coal employment is somewhat mitigated by the town's relatively large population. The remainder of coal employment is spread across smaller towns and villages, in some of them the coal mine workers account for up to 17.8% of the total population of the settlement. On the one hand, coal mine closures will have a massive impact on these communities. On the other hand, the fact that these workers already commute to their place of work means that they have a certain degree of mobility, and possibly new employment opportunities could be acceptable in nearby settlements and communities.

Figure 14: Employment in coal mining companies by place of residence at the rayon and localities level



Notes: Employment as of 01/07/2020. Employment at the district (rayon) level includes all employees of coal mining enterprises, including employees of non-mining branches if they are separate from coal mines (administrative, sales, scientific, etc.); employment in localities includes only employees of coal mines. Only localities with a significant number of employees are included. For these two reasons, the number of persons employed by locality does not add up to the total number of persons employed in the district.

Source: Own illustration based on information provided by GIZ, State Statistics Service of Ukraine (2022c).

4. Coal exit in power generation – case study of Burshtyn TPP in Ivano-Frankivsk oblast

As discussed in Section 2.1, coal-fired power and heat generation is the largest coal consumer in Ukraine. In this section, we therefore focus on the economic impacts of coal-fired power generation as an example of phasing out coal use in Western Ukraine. We analyse the regional impact of the Burshtyn thermal power plant (TPP), located in Ivano-Frankivsk oblast. It is one of the largest coal-fired power plants in Ukraine, accounting for 89% of the total installed capacity in the region.

Ivano-Frankivsk oblast has a population of 1.3 million and a regional GDP of UAH 120 billion, slightly larger than Volyn, and a comparable income level with an average regional GDP per capita of UAH 89 thousand. The Burshtyn TPP employs an estimated 1.7 thousand people, or 0.3% of regional employment (Table 3). The TPP is owned by DTEK Zakhidenergo and is mainly supplied with coal within the DTEK value chain, i.e. the coal mined in Dnipropetrovsk and Donetsk oblasts (DTEK, 2021). Thus, although the TPP is located close to the Lviv-Volyn coal basin, it is independent of the activities of the coal mining companies in Western Ukraine. It will therefore not be affected by coal mine closures in Western Ukraine.[15]

Table 3: Overview of Ivano-Frankivsk oblast and the analysed power plant

Oblast:	**Ivano-Frankivsk**	**Company / unit:**	**Burshtyn TPP (DTEK Zakhidenergo)**
Population in 2021, thousands	1 352	Ownership	Private
Regional GDP in 2021, bn UAH	119.7	Main activity	Power generation
Coal employment in 2021*	1 749	Employment	1 749*
Coal employment share in 2021	0.3%	Sales, UAH million	12 106.5*
Coal share in power generation capacity	89%	Budget transfers, UAH million	7.8*
		Profit (+)/loss (-), UAH million	0*

* Own estimates based on company's financial and ecological reports

Source: State Statistics Service of Ukraine (2022c; 2022a; 2023b), own estimates.

Unlike the coal mining companies in Lviv and Volyn oblasts, the Burshtyn TPP is also independent of state transfers, which account for less than 0.1% of the company's cash inflows. The profit or loss of the TPPs could not be reliably estimated because the operations of DTEK Zakhidenergo are optimised

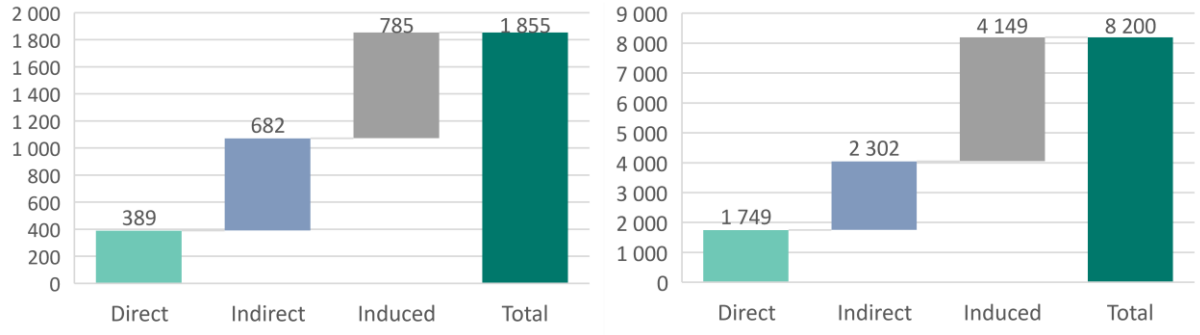
[15] DTEK Zakhidenergo also owns the coal-fired Dobrotvir TPP in the Lviv oblast. It is not included in the analysis due to its relatively small size (it represents 0.03% of regional employment and 5% of the direct value added of the coal mining companies in Lviv).

within the vertically integrated DTEK company, and, although DTEK Zakhidenergo has sometimes reported net losses in recent years, these are likely to have been offset elsewhere within DTEK. However, this analysis abstracts from potential future climate policies, such as the introduction of a meaningful carbon price. Carbon pricing may reduce the profitability of TPPs and their closure would be in line with Ukraine's climate goals.

Regional impacts of coal-fired power generation in Ivano-Frankivsk

The scale of the overall economic impact of the Burshtyn TPP in Ivano-Frankivsk oblast is comparable to that of the coal mining industry in Lviv region. The Burshtyn TPP generates about UAH 1.9 billion (EUR 57 million) in direct, indirect, and induced value added, which is 1.8% of the total value added in the region. It is also associated with a total of 8.2 thousand jobs, or about 1.5% of regional employment.

Figure 15: Value added (left) and employment (right) effects of coal-fired power generation in Ivano-Frankivsk oblast, UAH million / persons



Source: Own calculations.

However, unlike in the Lviv and Volyn coal mines, the cost structure in DTEK Zakhidenergo, the operator of the Burshtyn TPP, is dominated by material costs and investment expenses. Total material costs account for 95% of the production value (net of taxes), of which almost 70% is the cost of coal supply. However, coal is supplied by DTEK's own mines (and possibly imports) from outside the Ivano-Frankivsk oblast. Overall, only about 14% of the goods and services purchased by the TPP are sourced within the Ivano-Frankivsk region. Despite this small share, the ratio of labour costs (wages paid) to regional material costs is still about 1:4 (compared to 4.6:1 for coal companies in Volyn and 3.7:1 in Lviv). This cost structure, with strong demand for intermediate products, results in higher indirect VA and employment effects than the direct value and employment creation.

In addition, the Burshtyn TPP pays higher wages and creates significantly more direct value added per employee than the coal companies in Lviv and Volyn oblasts. For example, the estimated average monthly wage in the TPP is about UAH 18,500 per employee per month, compared to UAH 13,700 per employee per month in the Lviv coal companies and only UAH 7,800 per employee per month in the

Volyn coal companies. Similarly, VA per employee in the Burshtyn TPP is around UAH 222,000 per year, compared with UAH 163,000 in the Lviv coal industry and UAH 94,000 in Volyn oblast. This higher level of income generates a strong induced effect on value creation in the regional economy, which is further reinforced by the stronger indirect effect.

In contrast to the coal mining companies in Lviv and Volyn oblasts, the Burshtyn TPP in Ivano-Frankivsk oblast is independent of budget transfers. However, as it receives almost no transfer payments, its closure in the course of decarbonisation would lead to losses in the regional economy unless measures are taken to create new employment opportunities.

5. Conclusion

This study has quantified the economic impacts of the phase-out of coal mining in Western Ukraine using input-output analysis. The focus was on coal mining and processing in Lviv and Volyn oblasts and coal-fired power generation in the Ivano-Frankivsk region. To put the results into perspective, they were compared with private coal mines in Dnipropetrovsk oblast. Table 4 gives a brief overview of the main results.

Table 4: Summary of main results

	Coal mining			Coal TPP
	Lviv oblast	**Volyn oblast**	**Dnipro-petrovsk oblast**	**Ivano-Frankivsk oblast**
Total VA, UAH million (% of regional VA)	2 096 (0.8%)	182 (0.2%)	14 051 (3%)	1 855 (1.8%)
Direct VA, UAH million (% of total effect)	1 327 (63%)	129 (71%)	6 103 (43%)	389 (21%)
Total employment, % of regional employment)	11 054 (1.1%)	1 597 (0.4%)	42 776 (3.2%)	8 200 (1.5%)
Direct employment (% of total effect)	8 136 (74%)	1 370 (86%)	19 459 (45%)	1 749 (21%)
Subsidies[16], % of direct+indirect VA	110%	217%	0%	1%
Wage level, % of national average in the sector	76%	44%	95%	94%
Coal production share, % of national total (2020)	8%	0.1%	66%	-

Source: Own calculations.

The analysis shows that, regionally, the coal mines in Lviv and Volyn oblasts cause more economic harm than good and they do not generate significant economic impulses beyond the level of wages

[16] Direct budget transfers plus financial losses borne by the state.

paid because of their weak demand for goods and services. This is illustrated by in comparison larger share of the direct effect on the regional economy. Second, the coal mines in Lviv and Volyn oblasts do not supply important local power generators. The two largest coal-fired power plants in Western Ukraine are privately owned and supplied with coal from other regions. As the coal mined in Lviv and Volyn oblasts is sold to the central trader and distributor, it was not possible to trace where it is actually used. Third, the coal mines in Lviv and Volyn oblasts generate less value than they receive in subsidies.[16] In Volyn oblast in particular, state support is more than double the value added that the coal mines generate directly through their activities and indirectly through value chain effects.

Moreover, compared to the national level, the coal mines in Lviv and Volyn oblasts are among the weakest with a very limited economic role. Total coal production in both regions is less than 10% of national production and, including coal imports, less than 5% of Ukraine's total coal supply. In addition, the level of wages paid by coal companies is well below the national average in the coal mining sector, especially in Volyn oblast.

In conclusion, Lviv and Volyn oblasts are regions that are well suited to start phasing out coal, as the "economic damage" is expected to be relatively small compared to other coal regions. The supply-side (upstream) effects are limited, as the demand for intermediate products is rather low and a large part of these intermediate products is imported from outside the region. The demand-side (downstream) value chain within the two regions is also limited, and the closure of coal mines will not affect large regional TPPs. At the national level, coal mining contributes 1.2% of Ukraine's value added, and power generation (which is the most obvious use case for the lower-quality coal from Western Ukraine) another 3.9%, but only about a quarter of power generation is coal-fired. Therefore, because of the small production volumes and the low value added the phase-out of coal mining in Western Ukraine would not have a significant negative impact on the overall economy of Ukraine.

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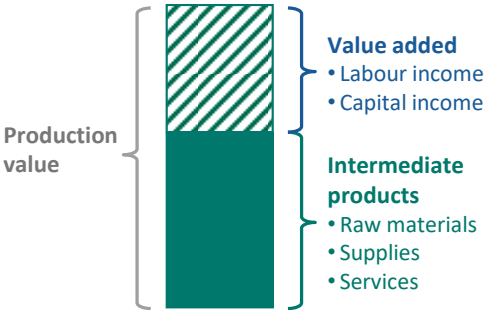
Annex A. Input-output approach

Input-output (IO) analysis is a common method for quantifying the impact of a sector or industry on the overall or regional economy by taking into account along the interdependences between different sectors of the economy and their effects along the entire value chain. The key indicators in the IO analysis are value added and employment (see Box 1).

Box 1: Value added and employment

- **Value added** is the most critical measure to assess the economic performance of an industry or economy. It is defined as the total value of all goods and services produced minus the value of all intermediate goods and services. So, it records the total income generated from labour and capital, i.e. wages and profits. In other words, value added is generated by turning inputs (supplies and materials) into outputs using capital (equipment, financial assets, etc.) and labour (jobs).
- **Employment** refers to the number of all employees (workers, civil servants, etc.), self-employed persons or contributing family members, who carry out an activity aimed at economic gain (i.e., receiving income), independent of the number of hours worked.

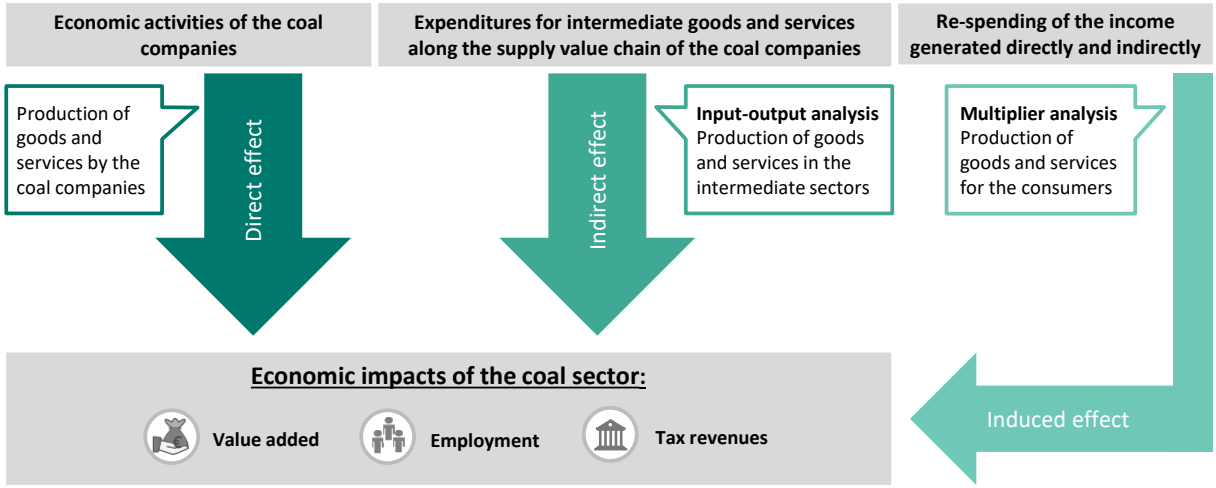


The economic impacts assessed in the IO analysis are divided into direct, indirect, and induced effects:

- **Direct effects** are generated by the economic activity of coal companies, i.e. their employment and value added (capital and labour income).
- **Indirect effects** occur when the coal companies purchase goods and services from their suppliers. This demand in turn creates value added and employment at the suppliers, which can be indirectly linked to the activities of the coal companies. For example, coal companies partly outsource the transport of coal, which increases the demand for transport services in the economy and thus boosts employment and value added in the transport sector. The transport companies in turn need more fuel and repair services to meet this demand, and so the effects are spread throughout the entire supply-side (upstream) value chain. Indirect effects arise from both operating expenditure and investment activities.
- **Induced effects** include employment and value added generated when the employees and shareholders of the coal companies (direct effect) and their suppliers (indirect effect) spend their income on goods and services.

Figure 16 illustrates total economic effects of operations and investments of coal companies in Western Ukraine.

Figure 16: Direct, indirect, and induced effects of coal companies in Western Ukraine



Source: Own illustration.

The quantification of the economic impact of the coal companies in Western Ukraine is based on the information on their operating costs and investment activities as well as on regional statistics for Lviv, Volyn, and Ivano-Frankivsk oblasts (see Annex B for more information on the data). Investment and operating costs are differentiated by economic sector, and a distinction is made between the expenditure within the region where the respective coal company is located and imports from other regions or outside of Ukraine. Only regional expenditure is relevant for the impact of coal mining on the regional economy.

The direct economic effects are calculated from the company data on the number of employees (employment effect) and employee remuneration and profit/loss (VA effect). It should be noted that most of the companies analysed are owned by MinEnergo and their profits or losses accrue to the central state budget. Therefore, for the state-owned companies, the profit/loss is not spent in the region[17] and therefore does not affect the regional economy and is not included in the VA in the modelling exercise.

To estimate the indirect economic effects, investment and operating cost data are combined with the regionalised IO table. The State Statistics Service of Ukraine only publishes the IO tables at the national level, and the regional IO table is constructed based on regional employment and trade statistics using the location quotients technique (Miller & Blair, 2009).

[17] A loss would reduce the income that can be re-spent.

Finally, the induced economic effects are calculated in the IO model by combining the direct and indirect VA and employment effects with a regional consumption multiplier derived from statistical data. The multiplier analysis reflects that when the income is spent on goods and services the providers of those goods and services also generate income (wages and profits). This income is in turn spent on further goods and services, generating further income, and so on. Thus, one euro of initial income spent generates more than one euro of value added in the economy. At the same time, the multiplier analysis takes into account that consumers spend only a fraction of their income in the domestic economy, as gross income is taxed and the remaining net income is split between saving and consumption of imported and local goods and services. Thus, of all the income generated, only a fraction spent on local goods and services is relevant to regional value added.

The total economic impact of coal mining activities can be quantified as the sum of the direct, indirect, and induced effects.

Classical IO analysis measures the effects that a sector generates along its supply (upstream) value chain. In order to examine the total effect for both, upstream and downstream sectors, a so-called hypothetical extraction was carried out for Lviv oblast. This approach measures the hypothetical loss of total production in the economy if a sector is completely removed from the economy without changing the remaining sectoral linkages or replacing it with imports.

Annex B. Data sources

The IO model is based on data published by the State Statistical Service of Ukraine and the regional statistical offices: the national IO table, national and regional data on GDP, VA and employment by sector, trade, household expenditure, and taxes. The reference year for the modelling is 2021, which is the last year, for which all the necessary statistical and firm-level data could be collected.

The national IO table was regionalised using the location quotients technique, which calculates so-called regional purchasing quotas from regional employment and trade statistics. This required employment data at the same level of sectoral disaggregation as the IO table. However, data on the employed population were only available at a more aggregated level, merging the 24 mining, manufacturing, and utilities sectors of the IO table into one 'industry' sector[18] and providing a single aggregate for each of the transport and warehousing, ICT, and professional services sectors, each of which is divided into 2-3 sectors in the IO table. As these sectors are dominated by enterprises (as opposed to other organisational forms, e.g., in public administration or education), the employment indicators have been interpolated to the IO sectors using regional statistics on persons employed in enterprises, which are much more detailed[19].

In order to quantify the economic impulses generated by the coal companies' activities and their demand for goods and services, detailed questionnaires were sent to the companies concerned. As no replies were received, and so publicly available information (financial data, employment, and expenditure) from transparency projects was used to estimate the volume and structure of the demand for goods and services from the companies analysed:

- **Clarity Project**[20] was used to access the financial reports of the state enterprises and some private companies. From the financial reports, data were extracted on sales, budget transfers, total material expenditure, employee remuneration, taxes and social contributions paid, and profit/loss.
- **Prozorro**[21] is a portal that lists the purchases made by state enterprises through tender procedures, including the item purchased, the contract price, the contract date, and the name and

[18] In Lviv oblast, somewhat better disaggregation into mining (three IO sectors), manufacturing (17 IO sectors), energy supply, and water and waste management (corresponding to the two IO sectors) is available.

[19] At the national level, employment in enterprises covers about 80-90% of employed population in the affected sectors and can therefore be considered a good predictor for the distribution of employed population.

[20] https://clarity-project.info/

[21] https://bi.prozorro.org/

region of the contractor. This is a valuable source of information on spending structure of coal companies.

- **Opendatabot**[22] was used as a complement to the Clarity Project, as it provides information on the number of employees in state and some private enterprises, in addition to general legal and financial data.

For the direct effects, employment, employee remuneration and profit/loss data were taken directly from the reports. For the regional expenditure by sector required for the calculation of indirect effects, the following procedure was used:

State-owned companies covered by Prozorro: the data do not fully overlap with the total expenditure data in financial reports. This may be partly due to incomplete coverage of expenditure (some purchases are not made by competitive tender), but also to the timing of reporting: the date of contract signature, the date of the actual flow of goods or services, and the date of the cash flow are usually three different dates. In addition to the lack of overlap, there are large variations in the types of expenditure between years. Therefore, in order to estimate expenses by economic sector, we took the total of purchases reported at Prozorro over 2020-2022, excluding purchases that fall under business linkages (see Box 2), and calculated the average share of each sector in the total expenditure. Not all IO sectors are represented in the tendered purchases. The covered sectors represent 90% or more of the expenditure structure according to the national IO table for all companies considered. For the covered share of expenditure, the material costs and investments from the cash flow statement were split according to the shares of Prozorro purchases. The missing sectors (not exceeding 10% of expenditure) were split according to the shares of the economic sectors in the IO table. Prozorro also provides information on the region of the contractor. For the covered sectors, the regional expenditure was calculated as the share of Prozorro purchases within the region of the coal company in its total purchases from the respective sector, excluding purchases falling under business linkages. For the sectors not covered, regional purchasing quotas were used according to the IO regionalisation methodology.

Companies with no information on the structure of expenditure: when no information on the structure of expenditure was publicly available, the estimation was based entirely on the IO model. Total material costs and investments from the cash flow statement were allocated to sectors according to the input structure of the coal mining sector in the national IO table, and regional expenditure was calculated using regional purchasing quotas according to the IO regionalisation methodology.

[22] https://opendatabot.ua/

Box 2: Business linkages in input-output analysis

Information on business linkages between the companies considered in the IO analysis is necessary to consolidate possible economic linkages (i.e. supply relationships) while avoiding double counting. Consider a company A that supplies goods worth EUR 1 million to company B in the same region. These are recorded as sales (production value) by company A and as costs by company B. The costs of company A already include the expenses necessary for the production of the goods it sells to company B. Considering the aggregate of both companies will therefore lead to double counting of the EUR 1 million when calculating the direct and indirect economic effects of both companies together: the first time when the expenses of company B are recorded and the production and the related expenses along the whole value chain are assessed and the second time when the expenses of company A are recorded and their effects along the whole value chain are assessed. It is therefore important to deduct this amount from the costs of company B. This also applies to the internal linkages of a company when there are supply relationships between its different sites or subsidiaries.

Coal-fired power plants: The thermal power plants (TPPs) in Burtshtyn (Ivano-Frankivsk oblast) and Dobrotvir (Lviv oblast) are a special case in terms of data availability. Both TPPs, together with the Ladyzhyn TPP in Vinnitsya oblast, are owned by DTEK Zakhidenergo, for which no public information is available in the transparency projects mentioned above. However, DTEK Zakhidenergo has published company-level financial reports for 2019-2020 and ecological reports for 2019-2021. In addition, information on the installed capacity of each TPP is available from the Global Coal Plant Tracker[23]. These data have been used as follows:

- From the ecological reports, it was possible to derive the total power generation in 2019-2021, which was used as a measure of the level of activity to extrapolate the financial data to 2021.
- The 2019-2020 financial reporting of DTEK Zakhidenergo provides a rough breakdown of operating costs in the financial statement. The shares of four sectors (coal mining, electricity and gas supply, transport, banking) could be directly allocated, the rest could be allocated to four main groups (materials/supplies, production-related services, professional services, other). The fifth group consists of investment goods, to which the investment costs are allocated. The IO sectors, with the exception of coal mining, electricity and gas supply, transport, and banking, were then allocated to these five groups. The group cost shares were thus taken from the financial reports, and the allocation within each group was made on the basis of the input shares in the IO table.
- Total expenses were taken from the cash flow statement extrapolated to 2021 and allocated to the IO sectors for the company's cost structure as described above. For plant-level expenses, the

[23] https://globalenergymonitor.org/projects/global-coal-plant-tracker/

company's costs were allocated between the Burshtyn, Dobrotvir, and Ladyzhyn TPPs based on their installed capacity in operation. Regional expenditure was calculated using regional purchasing quotas according to the IO regionalisation methodology.

- Employment in the two included TPPs was calculated based on their installed capacity in operation and employment multipliers calculated from other Ukrainian TPPs, for which information was publicly available (State Property Fund of Ukraine, 2023).

As the necessary indicators for the input-output analysis have been estimated on the basis of sources with different levels of detail, this affects the accuracy of the data. Firstly, incomplete or missing expenditure data and consequently the estimation of the demand structure reduces the accuracy of the allocation of expenditure to sectors. As sectors differ in their multiplier effects along the supply value chain, this may introduce some bias in the estimates of indirect and induced effects, although the direction of the bias cannot be determined. Second, there is very little data on sales between included enterprises (business linkages), so the indirect and induced effects may be overestimated due to double counting of expenditure and sales. Third, the estimates for the TPPs are based on strong assumptions – albeit the best available in the absence of firm-level data – so the estimates should be treated with caution. Overall, the accuracy of the estimates could be improved if data and information were provided by the companies, but this would not change the magnitude of the results.

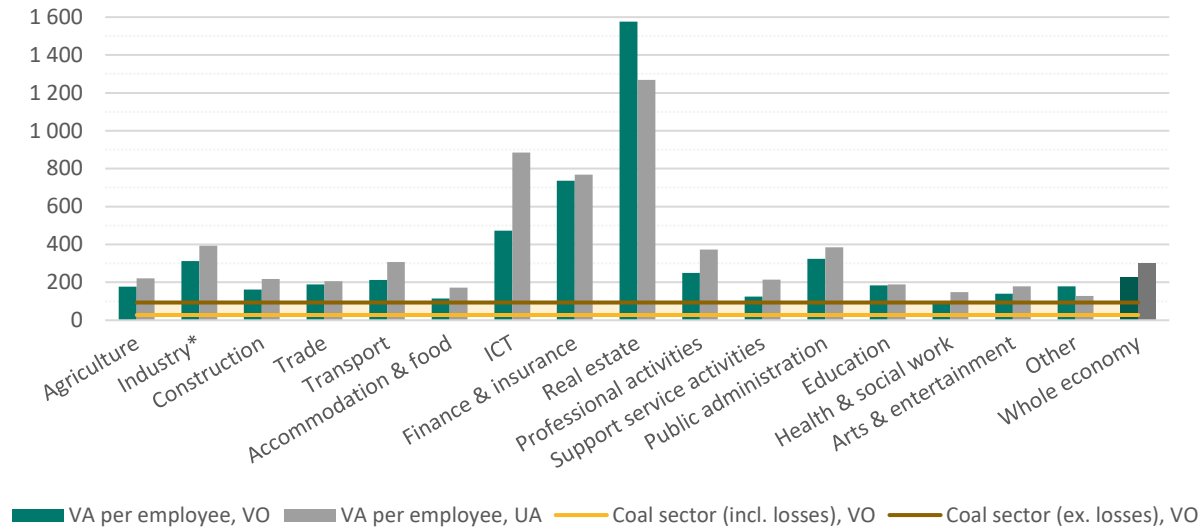
Annex C. Supplementary figures

Figure 17: Value added per employee in coal mining companies in Lviv oblast, compared to other sectors in Lviv oblast and in Ukraine, 1000 UAH

Note: As financial losses of state coal mines are born by MinEnergo (central budget), they are not included in value added. Inclusion of losses would reflect a perspective of private companies in competitive markets.

Source: Own calculations.

Figure 18: Value added per employee in coal mining companies in Volyn oblast, compared to other sectors in Volyn oblast and in Ukraine, 1000 UAH



Note: As financial losses of state coal mines are born by MinEnergo (central budget), they are not included in value added. Inclusion of losses would reflect a perspective of private companies in competitive markets.

Source: Own calculations.