JOBS
WORKING
PAPER
Issue No. 70

Towards A Just Coal Transition Labor Market Challenges And People's Perspectives From Silesia

Luc Christiaensen, Céline Ferré, Tomasz Gajderowicz,
Elizabeth Ruppert Bulmer, and Sylwia Wrona

WORLD BANK GROUP
Jobs

TOWARDS A JUST COAL TRANSITION LABOR MARKET CHALLENGES AND PEOPLE'S PERSPECTIVES FROM SILESIA

Luc Christiaensen

Céline Ferré

Tomasz Gajderowicz

Elizabeth Ruppert Bulmer

Sylwia Wrona

1818 H Street NW, Washington, DC 20433, USA.
Telephone: 202-473-1000; Internet: www.worldbank.org.

TOWARDS A JUST COAL TRANSITION

Labor market challenges and people's perspectives from Silesia

THE WORLD BANK
IBRD • IDA | WORLD BANK GROUP

Towards a Just Coal Transition

Labor Market Challenges and People's Perspectives from Silesia

Luc Christiaensen, Céline Ferré, Tomasz Gajderowicz,
Elizabeth Ruppert Bulmer, and Sylwia Wrona.[1]

Background papers, valuable data analysis and comments were provided by Jan Frankowski, Joanna Mazurkiewicz, Jacub Sokołowski and Piotr Lewandowski,[2] Maciej Jakubowski,[3] and Maddalena Honorati.[4]

September 2022

[1] Corresponding authors: Luc Christiaensen (lchristiaensen@worldbank.org), Jobs Group, World Bank; Céline Ferré (cferre@worldbank.org), Jobs Group, World Bank; Tomasz Gajderowicz (tgajderowic@wne.uw.pl.edu), Department of Economics, University of Warsaw.
[2] Institute of Structural Research (IBS).
[3] University of Warsaw.
[4] Jobs Group, World Bank.

Acronyms

AI	Artificial Intelligence
ALMP	Active Labor Market Program
BGT	Burning Glass Technologies
BKL	Human Capital Balance (Bilans Kapitału Ludziego)
CHP	Combined Heat and Power
DCE	Discrete Choice Experiment
EC	Europen Commission
EGD	European Green Deal
EU	European Union
GVA	Gross Value Added
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GUS	Statistics Poland (Główny Urząd Statystyczny)
IBS	Instytut Badań Strukturalnych (Institue of Structural Research)
IEA	International Energy Agency
ILO	International Labor Organization
IO	Input-Output
IRENA	International Renewable Energy Agency
ISCO	International Standard Classification of Occupations
JTF	Just Transition Fund
JTM	Just Transition Mechanism
JSW	Jastrzębska Spółka Węglowa
NDC	Nationally Determined Contribution
NUTS	Nomenclature des Unités Territoriales Statistiques (Nomenclature of Territorial Units for Statistics)
OECD	Organisation for Economic Cooperation and Development
OTJ	On-the-job
PGG	Polska Grupa Górnicza
PES	Public Employment Services
PLN	Polish Złoty
RES	Renewable Energy Sources
SRK	Spółka Restrukturyzacji Kopalń
TA	Technical Assistance
TJTP	Territorial Just Transition Plan
TWD	Tauron Wydobycie
WKK	Węglokoks Kraj
WTP	Willingness to Pay

Executive Summary

Coal-related jobs are at the forefront of the disruption brought about by the transition towards a low-carbon economy. Some displaced workers may be able to transition easily to new job opportunities, whereas many others may not. The resulting disruption to jobs and livelihoods may exacerbate the already challenging labor market environment in remote regions and traditional sectors that have not kept pace with broader economic modernization trends. A series of recent World Bank studies closely examined the labor and skills challenges brought about by the transition out of coal in three Polish regions: Wielkopolska, Silesia, and Lower Silesia.[5] This paper zooms in on the labor market challenges regarding the just coal transition in Silesia, including an estimation of the number of workers indirectly affected. It further examines the affected people's job preferences and opportunities. Particular attention goes to analyzing spatial, expectation, and skill-related mismatches between current and possible future jobs and the implications for job transitions (including through reskilling). Identifying these mismatches is facilitated through a specially developed excel-based "viable-job-transition-pathway" tool.

A data-driven and people-centered approach is developed to explore viable job transitions for the affected coal-related workforce. Administrative labor market data and occupation descriptions from Poland are combined with specific job preferences information of the affected workforce. The latter is obtained through newly developed discrete choice experiments (DCEs) and random parameter logistic regressions. Task similarity across occupations is further examined through the application of artificial intelligence text mining algorithms to identify well-matched (and locally available) alternative occupations. Together the findings can help policymakers assess the viability of different job transition pathways in the current labor market as well as the job-generating potential of mine repurposing activities and economic diversification strategies and their accessibility to the affected coal-related workforce. This analytical approach is applied to Silesia, but can also be applied to address similar questions in other coal- or single employer-dominated labor markets, in Poland and beyond.

Among the three regions, Silesia is the most coal-dependent, with mining playing an important role in the regional economy. The mining industry's share of Silesia's GVA was 6.9 percent in 2017 and 80 percent of Poland's mining sector employees are in Silesia. For more than three decades, Silesia has been undergoing a socio-economic transition driven by the broader industrial restructuring and decentralization of the Polish economy. While the productivity of traditional coal-related industries has increased, both employment and physical output have decreased. At the same time, the region has seen robust growth in a new manufacturing base. There is no fixed timeline for future mine closures other than Poland's general commitment to shut down all mines by 2049.

---

[5] The work has been supported by a grant from the Directorate-General for Energy of the European Union.

The affected coal-related workforce in Silesia lives concentrated around the mines, calling for a geographic, or local economic development approach to brokering a just coal transition, rather than a sectoral approach. In Silesia, a substantial number of workers will be *directly* and *indirectly* affected by the transition: 72 thousand workers were still employed in the mining conglomerates, and an estimated additional 17 thousand workers were employed by subcontractors in 2020. The latter estimate is obtained through a bottom-up approach based on the Silesia-based employment generation implied by the public tenders of the Silesian mining conglomerates. The approach is robust to several methodological and data considerations and situates the indirect employment related to coal mining in Silesia at the lower end of the existing range of estimates.[6] More important than the total number of coal-related jobs affected, however, is their spatial concentration. Coal-related jobs in Silesia (direct and indirect) are especially important to the Rybnik subregion, where they make up between 20 and 50 percent of total employment in several of the powiats.[7] These communities, many of which are already lagging behind and whose public finances rely heavily on tax revenue from the mines, stand to be hit particularly hard, pointing to the need for a local economic development approach to just coal transition rather than a sectoral approach.

Higher-educated employees in the mining conglomerates display on average similar transversal skills to other Poles, whereas lower-educated mine employees have lower than average skills. Both categories of mine employees score better on technical skills, but very low on digital skills. Within mining conglomerates, miners have the lowest skill profile, far below managers and professional technicians, power plant employees, administrative and repair staff. The skills gap is largest for organization at work, digital skills, and simple calculus. On the other hand, miners feel more confident about maintenance, assembly, and repair of technical devices. Male employees display better technical and managerial skills and physical strength (most coal-related workers are male); female employees display higher creative abilities and have better cooperation and communication skills. In conclusion, miners make up most of the total coal-related workforce, suggesting that they will face more difficulties in transitioning to other jobs given lower transversal skills. The majority of workers would be willing to reskill or acquire new competencies, however, when looking for another job, including languages and digital skills. No specific skill surveys were conducted among the non coal-related workforce within the mining communities in Silesia. Yet, survey results from Eastern Wielkopolska show that non-coal-related workers in these communities tend to be substantially less skilled than coal-related workers and workers in the rest of the region.

---

[6] Note that the approach only estimates the number of indirect jobs among suppliers. It does not incorporate the employment effects of coal-based industries such as power stations and the coking industry, however, nor does it incorporate the induced employment effects, i.e. the local employment generated through the demand for goods and services emanating from the local spending of the coal workers' salary mass.

[7] Note that 80 percent of the indirect jobs in Silesia are within 20 km of the mines.

Coal-related workers in Silesia display a high aversion to relocating and commuting; they also put a premium on job security and continued use of their current competencies. The DCE model estimates that respondents would be willing to sacrifice PLN 1,148 per month for a reduction in the home-to-work commuting time by one hour (each way) (or about one-fifth of an average mining employee's salary). Women are more sensitive to shorter commuting times, along with more educated and older workers. Mining industry workers are similarly reluctant to relocate, needing to earn PLN 2,448 or PLN 1,651 per month more to move abroad or to another region within Poland respectively. Workers very much value the compatibility of the new job with their current education and skill set, as well as employment security as measured by an open-ended contract. They are willing to accept lower job entry conditions if there are good prospects for wage progression in the next few years. Finally, respondents' disutility to change the sector of employment varied between PLN 768 to PLN 1,935 per month. The attachment to work in the mining sector was strongest among older workers and underground workers. It could be seen as an indication of how much miners' personal identities are shaped by their work in the mines, or by the limited job prospects with comparable employment terms in other sectors. Only younger and higher educated (above-ground) workers placed a positive value on working in the renewable energy sector.

Machine learning and administrative job descriptions are further leveraged to determine skills (mis)matches across jobs and to identify *viable* transition pathways for the coal-affected workforce. The job matching tool used big data techniques to identify positions requiring tasks and skills most similar to the position held by the worker at risk of dismissal, narrowing down options to occupations with demand surplus, as identified by the local labor market barometer published annually by the local labor offices, and with wage offerings sufficient to overcome mobility aversion if the job offers are only available outside the affected municipality or region. Viable transition pathways are available in the current local labor market for blue-collar workers (who account for 70 to 80 percent of coal-related workers), but existing labor demand may not be sufficient to absorb everyone; tertiary-educated specialists may need more reskilling given the demand for high specialization. Interestingly, most viable trajectories do not point to retraining and upskilling in renewable energy-related skills, the focus of much of the regional diversification efforts, or in digital jobs, often considered the jobs of the future.

Key challenges going forward will be to provide adequate job opportunities for affected workers, especially non-mine workers in the most affected municipalities. This segment of the population deserves special attention: their numbers are non-negligible, they are less skilled, they operate in already lagging local economies, and they are not covered by the social agreements covering mine workers. The "viable-job-matching tool" can be developed further through ground-truthing and as a planning tool to guide re-purposing plans and economic diversification that leverage the available skills and account for the workforce's key job attribute preferences.

Table of Contents

Tables

Figures

Boxes

1 Introduction

Following the Paris Agreement (2015)[8], the European Union (EU) adopted "climate neutrality by 2050", while also committing to leave no one behind. The aim is to reduce net greenhouse gas (GHG) emissions in the EU to zero by 2050, while also ensuring no one place or person is left behind. This ambition has been converted into law in 2021 through the adoption of the European Climate Law. The Law also sets the intermediate target of reducing GHG emissions by 55 percent by 2030 (compared to 1990 levels). To achieve the intermediate target, a set of concomitant legislative proposals and policy initiatives has further been advanced (the "Fit for 55" package). They include, among others, a reduction of the GHG emission caps of power plants through a modification of the Emission Trading System.[9] To alleviate the socio-economic impacts of the transition in the most affected, mostly carbon-intensive regions, the EU further provides targeted support to help mobilize 100 billion euro in these regions over the 2021-2027 period. These efforts are governed under the Just Transition Mechanism (JTM).[10]

With carbon-neutral energy production at the forefront of reducing GHG emissions, accelerating the coal-phase out is a key area of policy action. The shift to climate neutrality requires a shift to carbon neutral energy production as well as the transformation of production and consumption patterns towards greater energy efficiency and lower resource use.[11] With carbon dioxide the primary contributor to GHG emissions[12], the shift away from fossil fuels (coal, petrol, gas) is at the forefront of the transition. Coal is the most carbon-rich energy source[13], making the accelerated phase-out of coal a primary area of policy action. Over the past decades, coal consumption in the EU has come down substantially already (from 1,100 Mt in 1990 to 437 Mt in 2021).[14] Yet, solid fossil fuels (i.e., coal and coal derived

[8] https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

[9] There are also many other measures such as a reduction of Member States' emission reduction targets, reversing the declining trend of carbon removals through land-use change and reforestation, and increasing efficiency of energy use in transport (including in shipping and aviation), buildings, and industry through a combination of investments, CO_2 emission standards, energy taxation, and carbon border adjustment mechanisms.

[10] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/finance-and-green-deal/just-transition-mechanism_en

[11] Beyond energy production, other heavily affected sectors include energy-intensive industries (such as steel, chemicals, plastics), agriculture, waste management and transport.

[12] In 2019, CO_2 accounted for 81.6 percent of EU GHG emissions.

[13] The amount of CO_2 emitted per million British thermal units (Btu) for coal, petrol and gas are respectively 229/215 (anthracite or hard coal/lignite), 161/157 (diesel/gasoline), and 139/117 (propane/natural gas) pounds (https://www.americangeosciences.org/critical-issues/faq/how-much-carbon-dioxide-produced-when-different-fuels-are-burned).

[14] In 2021, total (hard and brown) coal consumption in the EU stood at 437 Mt (of which 160 Mt hard coal and 277 Mt brown coal). This is down from 1,100 Mt in 1990 (of which 400 Mt hard coal and 700 Mt brown coal). Most coal use is for power production (49 percent of hard coal and 92 percent of brown coal in 2020).

solids)[15] still account for 12.6 percent of the EU's 2020 electricity generation (Eurostat, 2022)[16], but makes up 62 percent of electricity and heating CO_2 emissions (EIA, 2019)[17].

Coal regions and workers are thus particularly exposed to the energy transition, exacerbated by their economies' strong dependence on coal and the attractive labor contracts typically enjoyed by coal mine workers. Coal mines and their associated activities (including power generation) tend to be spatially concentrated around the extraction sites. They are often the main employer in the local economy, providing financially attractive and secure employment for many semi-skilled workers, especially those working in the mines. With few attractive alternatives present in the often lagging and undiversified local economies, coal mine closures tend to heavily affect their workers and communities. The high reservation wage and historical and cultural attachment to mining further impede labor mobility (across sectors and space). Labor unions often successfully manage to negotiate transition packages to somewhat mitigate the social costs of mine closures. Even so, the negotiated packages typically do not (or only partially) apply to workers in the supporting industries or the non-coal-related workers in the local economies, leaving many exposed. They also don't compensate for the broader economic loss. As a result, across the world, transitions out of coal have been fraught with major social challenges, especially in coal producing regions (World Bank, 2018a; Lobao et al., 2021; Ruppert Bulmer et al., 2021). In recognition of this challenge, a specific financial instrument has been created by the EU under the JTM, the Just Transition Fund (JTF), to mitigate the social and employment effects of the coal transition in carbon-intensive regions.

For the EU's coal phase out and its broader climate transition, a successful transition out of coal in Poland is particularly important. After Germany, Poland is the EU's second largest coal producer and consumer.[18] It further employs about half of Europe's coal related labor force (Figure 1). What happens with coal production, coal workers and coal regions in Poland is a first order matter for brokering a just coal and energy transition in Europe. The transition out of coal in Poland started long time ago. But coal remains of strategic importance to the Polish economy. In 2020, over 40 percent of the country's total energy supply (TES) and 70 percent of its electricity generation come from coal and lignite (IEA, 2022), the highest rate in Europe. In 2019, 155,000 people were employed in the coal sector (Eurostat, *lfsa_egan22d*). The mining conglomerates employ about 88,000 people directly in the mines, down from

[15] Solid fossil fuels cover various types of coal (such as hard and brown coal) as well as solid products derived from coal (such as coke which is used in the steel industry).

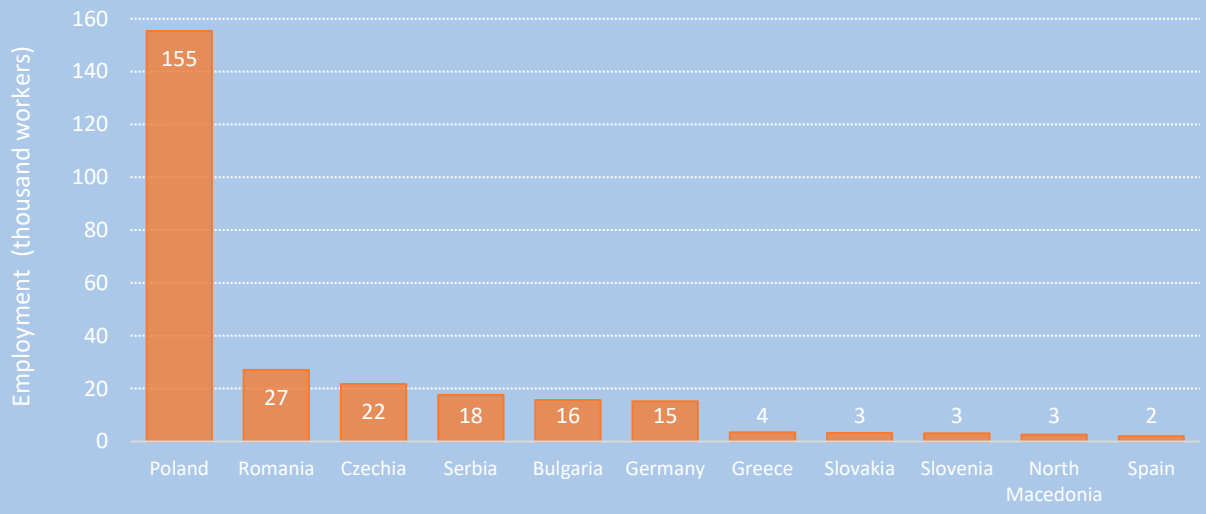
[16] Eurostat consulted on 13 May 2022 (online data code NRG_BAL_PEH) (https://ec.europa.eu/eurostat/databrowser/view/NRG_BAL_PEH__custom_2712428/default/table?lang=en)

[17] Solid fuel is defined as coal, peat and oil shale (EIA, 2019).

[18] Total (hard and brown) coal consumption in Poland amounts to 117.6 Mt in 2021 or 26.9 percent of the EU's total (hard and brown) coal consumption (Eurostat, 2022). Most of it is for power generation and heating. Total (hard and brown) coal consumption in Germany is 153.8 Mt in 2021 (36.8 Mt hard coal (all imported) and 127 Mt brown coal).
https://ec.europa.eu/eurostat/statisticsexplained/index.php?title=Coal_production_and_consumption_statistics

about 444,000 in 1989 (415,000 in hard coal; 29,000 in lignite) (INSTRAT, 2021). Europe's commitment to stop its fossil fuel imports from Russia following Russia's invasion of Ukraine will slow down Poland's coal phase-out in the near future to ensure energy security in Europe,[19] but Poland remains committed to complete coal mine closure by 2049.

Figure 1: Most of coal employment in Europe is concentrated in Poland



Note: employment in hard coal and lignite, as registered under sector B05 of NACE Rev.2 classification.
Source: Eurostat (2019), table lfsa_egan22d.

In 2021, coal was still extracted in six regions in Poland: hard coal in Silesia, Lesser Poland, and Lublin; and lignite in Greater Poland (i.e., Wielkopolska), Lower Silesia, and Łódź. Most of the extraction sites are located in the Upper Silesian basin, but only about half of the coal seams are economically viable. In addition to hard coal, Poland exploits several lignite deposits: three sites, exclusively surface mines, are currently operating, in Łódź, Lower Silesia, and Wielkopolska. In contrast to Poland's hard coal mines, which operate at an average working depth of 600 meters, the lignite mines consist almost entirely of mine-mouth power plants.

This report, which focuses on Silesia, is part of a larger set of regional labor market studies on coal transition regions in Poland. Funded by the European Commission, these studies cover the three regions most advanced in their coal phase-out and economic diversification process: Wielkopolska, Silesia, and Lower Silesia. Together, these regions account for 86 percent of all Polish coal mining employment, the preponderance in Silesia. Each region also qualifies for JTF support.

[19] Before Russia's invasion of Ukraine on February 24, 2022, Poland's coal phase-out was on an accelerating path, given the high cost of extraction and the challenge for Polish coal-fired power plants to provide electricity within politically acceptable price margins.

Among the three regions, Silesia is the most coal-dependent, with mining playing an important role in the regional economy. The mining industry's share of Silesia's Gross Value Added (GVA) was 6.9 percent in 2017. The sector also represents 5 percent of the region's total employment, and 80 percent of Poland's mining sector employees are in Silesia. For more than three decades, Silesia has been undergoing a socio-economic transition driven by the broader industrial restructuring and decentralization of the Polish economy. While the productivity of traditional coal-related industries has increased, both employment and physical output have decreased. At the same time, the region has seen robust growth in a new manufacturing base. There is no fixed timeline for coal mine closures other than Poland's general commitment to shut down all mines by 2049.

The report presents a "people" perspective on the transition, giving voice to those affected; it assesses their skills and prospects for future jobs within the context of their local labor markets. It begins by evaluating the number of workers (directly and indirectly) affected by the mine closures within the broader context of the local and regional labor markets within which they operate. It subsequently maps out their skills and job attribute preferences and aspirations. It categorizes the task content of all jobs within Poland and combines this with information on the affected workers' skills and job attribute preferences to identify *viable* job transition pathways for affected workers within the current local and broader regional/national labor markets. To inform these different areas of inquiry, the study uses administrative and secondary labor force data from national labor force surveys and local labor market barometers from the public employment offices. To assess the skills and reveal the job attribute preferences of affected workers, the study further conducted surveys and discrete choice experiments with representative samples of employees of the different mining conglomerates in Silesia.

The findings provide an important piece of the "just coal transition" policy puzzle in Poland, but abstract from labor demand related issues. Among the lessons learned from past mine closures (Box 1) are the importance of timely analysis and broad consultation as well as the need for a comprehensive approach, addressing both labor supply and demand side issues. This report abstracts from the employment opportunities new investors and employers may provide (including through repurposing of the mining lands and assets), i.e., the labor demand side of the challenge, including the investments and policy reforms needed to attract them. As such it produces only part of the information needed. In particular, it provides policymakers and potential investors with an in-depth characterization of the local labor pool, in terms of numbers and demographics, their job attribute preferences and aspirations, as well as their skill profile (cognitive/non-cognitive; routine/non-routine). This helps investors and policymakers with investment decisions and the design, targeting and content of their active labor market programs (ALMPs). The matching tool developed for the report, which identifies viable job transition pathways within the current labor market for those affected, can be readily adapted to identify skill and aspiration gaps vis-a-vis future job opportunities as the mines and their lands are repurposed and the local economies are restructured.

Overall, the report finds that the impact of the transition will be concentrated in those municipalities that are highly dependent on coal extraction, where workers display a strong preference for continuity and stability, and where the most at-risk individuals will be non-mine workers. In Silesia, a substantial number of workers will be *directly* and *indirectly* affected by the transition: 72 thousand workers were still employed in the mining conglomerates, and an additional 17 thousand workers were employed by subcontractors in 2020. Coal-related employment is spatially concentrated around the mines, in a few municipalities where coal-related employment can represent as much as half of total employment. Those municipalities display sluggish labor markets, even though they are embedded in a more dynamic regional economy (Silesia). Mine workers in Silesia want to *remain* in municipalities where they live (and are willing to give up a lot for that); work in *similar* positions/sector of activity; and they value job *security.* The job-matching tool developed for this study proposes *viable* transition pathways and reskilling options under current local labor market conditions, but the number of potential positions available may not be sufficient to absorb all workers who may lose their job in the future.

Future analysis should complement and link the information in this report with the development of a regional economic diversification strategy, an in-depth analysis of the local investment climate to reorient coal-related businesses and attract new domestic and foreign investment, and an assessment of the number and type of jobs the regional strategy it is likely to generate (locally in the mining communities, and/or elsewhere in the region or country). While new employment opportunities should come from all sectors of the economy, the energy sector can still be a catalyst for regional development, including in Silesia.[20] Overall, the key labor market challenge is to create a more supportive environment for firms to thrive and create employment and to provide adequate opportunities for workers to build skills relevant to alternative, more competitive sectors of work.

The report proceeds as follows. Section 2 elaborates on the extent and nature of coal production and employment in Poland by way of background. This is followed by an analysis of the local labor market features and performance in Silesia and the current (and historical) role of coal related activities within it (Section 3). The skills and job attribute preferences and aspirations of Silesia's affected workers are reviewed in Section 4. Based on a decomposition of all jobs in Poland, including those related to coal, into their composite tasks, viable job transition pathways for different types of affected workers within the current labor market are discussed in Section 5. The application also takes workers' job attribute preferences and skill profiles into account. The section further illustrates how the job matching tool can be used when information about future jobs and associated skill needs becomes available, for labor market planning and ALMP programming (such as the nature and design of reskilling programs) as well as for individual case counseling of affected workers. Section 6 concludes.

[20] At the global level, new jobs in transition-related technologies and sectors are expected to outweigh job losses in fossil fuels and nuclear energy (IRENA, 2021).

Box 1: Five lessons from past mine closure in Poland and the U.S.

First, timing and pace are key: transition takes a long time and preparation should start early. When many workers, businesses and communities are implicated, fundamental change to an industry cannot happen quickly, even with the best advance planning and post-closure transition policies in place. The timing and speed of transition are subject to political economy dynamics. Uncertainty around commodity prices makes it difficult for communities to transition because prices affect both willingness and capacity to diversify toward other industries. Where actors are public (e.g., Poland), governments have the power to act quickly but risk the future support of the electorate. Where actors are private, but unions are strong and/or regulatory authority is weak or captured by private interests (e.g., the U.S.), boom and bust cycles can be exacerbated, which could create obstacles to both the design and implementation of effective transition policies. Finally, severe social dislocation in a context of fragile local economic viability may also pass a point of no return. The risk is higher where long-term dependence on coal has delayed acceptance of transition.

Second, transition requires a comprehensive approach with complementary initiatives, policies and incentives to sway the many actors along the coal value chain, including those with vested interests like utility monopolies and manufacturers of mining equipment. Labor demand (attracting firms) and labor supply (e.g., reskilling) challenges must be addressed simultaneously, with inappropriate or delayed repurposing of the mining lands and assets often leaving many missed opportunities.

Third, economic diversification is essential and requires help from both local and higher-level government with respect to planning and financial resources. Advance planning, investment in infrastructure, addressing environmental degradation and attracting private investment are key ingredients of economic diversification, requiring significant local and regional institutional capacity and coordination, including for repurposing of the mining lands and assets.

Fourth, transition support packages need to be inclusive, to help workers who are directly or indirectly affected by mine closure to find new jobs. Addressing worker transition challenges effectively requires a solid understanding of the scope and nature of the potential impacts of transition. Policymakers need to understand the ways in which a future transition away from coal may affect the livelihoods of both coal and non-coal workers and their surrounding communities, in order to implement policies and programs for managing transition effectively. Transition assistance programs targeting formal mine workers fall short of meeting the needs of informal or subcontracted workers in and around the mines. Even large mine operators employ a significant share of their workforce on temporary and/or informal contracts. Informal coal sector workers are at greater risk than their formal counterparts and less equipped to weather income shocks. Packages can include jobs search support, reskilling, counseling, entrepreneurship training, and/or access to financial resources.

Fifth, the advantages of inducing voluntary job separations through generous compensation packages are offset by the risk of inflicting long-term damage on local economies. High reservation wages dampen local labor demand and economic recovery through diversification, and this can undermine public fiscal health and ultimately diminish local institutions and social capital. Too-generous severance packages can induce labor force exit, which can accelerate a coal community's decline.

Source: Ruppert Bulmer et al. (2021).

2 Coal in Poland – A declining sector with peculiar employment features

2.1 Decarbonization adds impetus to Poland's longstanding decline of coal production

Poland's coal production has more than halved since the 1990s, driven by reduced economic viability. Over the past three decades total coal production in Poland has more than halved, from 229 Mt in 1990 to 108 Mt in 2020. Most of the reduction happened in hard coal (from 147 Mt in 1990 to 55Mt in 2020). This is consistent with the broad downward trend in coal production in the Europe Union. In fact, Poland is by now virtually the only hard coal producer left in the EU (producing 96% of all EU hard coal production; the Czech Republic produces the remainder). Hard coal reserves in Poland are managed through a few state-owned conglomerates. Hard coal mostly consists of steam coal for electricity generation and heating (72 percent).[21] It is deep-mined and fully mechanized with over 90 percent of coal produced by longwall systems (EURACOAL, 2020). Nonetheless, only half of the Polish coal seams are still considered economically viable (at least until the recent price hike following Russia's invasion of Ukraine on Feb 24, 2022).[22] Poland further exploits several lignite deposits, which consist almost entirely of mine-mouth power plants. Productivity is around 6,800 tons per employee, which is much lower than the levels observed in Germany (the largest EU lignite producer) and Greece (EURACOAL, 2020). Finally, state-owned mines or units of integrated mines (whether hard coal or lignite) that are unprofitable and slated for phase-out are transferred to the public entity Spółka Restrukturyzacii Kopalń (SRK) to manage their eventual closure. In 2021, there were 12 mines or units of mines managed by the restructuring company (SRK, 2021).

In the May 2021 "social agreement" between the government and mining trade unions, Poland presented a decarbonization plan that lays out the timetable for hard coal mines closure.[23] Following the European Green Deal and in line with the "social agreement", the coal sector in Poland will gradually reduce its output capacities and close its mines, over the next three decades, with the last mines closing in 2049. In the energy sector, the country wants to replace its coal-fired power generation capacity with increased production from renewable energy, including a significant portion from offshore wind, coupled with nuclear energy, to stabilize output in an increasingly RES-dependent power grid. Poland is facing a historic challenge to transition quickly from an energy model based on coal extraction – in place for the past 70 years – to a zero-emission future. This is further compounded by the

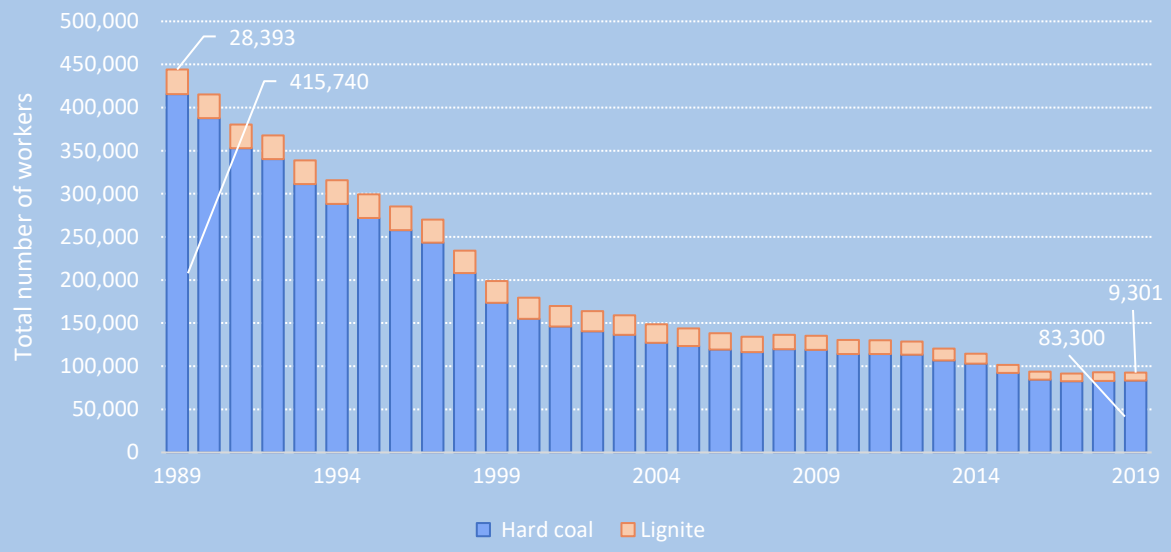
[21] The rest mostly consists of coking coal.
[22] As a result, until recently, part of Poland's hard coal consumption was imported (in 2020, 10.6 Mt out of the 65.6 Mt of hard coal consumed in Poland was imported, much of it from Russia). Brown coal or lignite is little traded.
[23] https://www.gov.pl/web/aktywa-panstwowe/umowa-spoleczna.

February 2022 invasion of Ukraine by Russia, which undermines the potential of natural gas as transition fuel.[24]

2.2 Concomitantly, employment in the mining sector has fallen sharply to 88,000 jobs

Since 1989, as coal production declined, employment in the coal mining sector[25] has fallen by 80 percent. Over the past three decades, Poland's coal mining sector lost approximately 300,000 jobs, down to 92,600 in 2019 (Figure 2) and subsequently to 87,600 by end-2020. Most of the reduction in employment happened in the first decade, during Poland's transition from a centrally planned model to a market economy (1989-2002). Coal extraction now represents only 1 percent of total employment in Poland. But it still represents 5 percent for the largest extracting region (Silesia),[26] and it can represent up to half of employment at the local level, rendering coal-intensive municipalities particularly vulnerable, as discussed further below.

Figure 2: Employment in the mining sector was divided by 4.5 between 1989 and 2019



Note: Totals exclude employment in coal processing.
Source: INSTRAT, 2021.

The sharp reduction in coal mining employment was the result of hard coal mine closures in the early 1990s. Between 1990 and 1995, employment reduction was achieved almost entirely through a hiring freeze. The remaining cuts were achieved through a combination of

[24] Russia has traditionally been an important supplier of gas for Poland, which now needs to be sourced from elsewhere. Ongoing investments to expand natural-gas-fueled power generation are continued, but the extension of the lifetime of some coal-fueled blocks is considered as alternative for constructing new natural-gas powered power plants.
[25] Note that "coal mining sector" refers to hard coal and lignite mining activities.
[26] Eurostat, 2020. Indicator: lfsa_egan22d.

hiring freezes, expanded access to early retirement, and – beginning in 1998 – voluntary exits facilitated by a generous Mining Social Package comprising cash benefits (severance pay and allowances), activation instruments (training, scholarships, retraining contracts, support for starting a business) and instruments aimed at employers (contribution refunds, reimbursement of employment costs). By 2002, coal mine jobs had fallen by nearly two-thirds to 164,000. This was followed by a slower pace of contraction, largely due to attrition (Baran et al. 2020). Whereas lignite extraction operated with a relatively stable workforce of around 24,000 until then, it began to decline steadily from 2002 onward, falling below 10,000 by 2015 (see Figure 2). Recent years have seen some limited new hiring, for example during the 2008 economic and financial crisis, and more recently during the 2021 energy crisis.

2.3 Recent estimates put the number of coal-related jobs between 145 and 218 thousand

Two groups of coal-related employment are considered, those directly employed in the mines by the mining companies and mining conglomerates, and those deriving their jobs and incomes from coal-related activities. The number of direct coal jobs can be obtained from the mines with relative precision and is estimated at 87,600 at the end of 2020 (80,000 in hard coal; 7,600 in lignite extraction) (INSTRAT, 2021). But each coal mining job also generates additional jobs in the coal value chain, i.e., in the firms and businesses supplying goods and services to the operations of the mines. Coal mines further provide the inputs for coal-fired power stations. Finally, much of the demand for locally provided goods and services in the local communities (and the related jobs) is financed by the salaries of the coal and coal-related workers (the so-called induced effects). The latter three employment effects (linked to the coal value chain, coal-fired power stations and the induced effects) are much harder to estimate. Appropriate disaggregated data is hard to come by and studies use different methods and different sectoral and geographic coverage, resulting in a wide range of estimates. The results are reviewed briefly here, under the broad umbrella of indirect effects (as opposed to the direct effects).

Recent studies using input-output tables estimate the total number of jobs indirectly linked to Poland's coal mining sector between 57,000 to 130,000 (Figure 3, Box 2). It is common to calculate the number of indirect jobs related to a sector using input-output (IO) tables. IO tables are a set of national (or regional) economic accounts disaggregated by sector. They are a snapshot of flows of products and services in the economy for a single year: they identify and disaggregate all of the monetary flows between industries (inter-industry expenditure flows), between consumers and industries, and between industries and suppliers of factors in the economy. The results suggest that every coal mining job generates between 0.6 and 1.4 additional jobs, or an additional 57,000 to 130,000 jobs indirectly linked to coal mining. This puts the estimated total number of coal-related jobs in Poland today between 144,600, and 217,600 (Figure 3).

Nonetheless, these studies only provide orders of magnitudes at best, and should be treated as such. Estimating the indirect impact of mine closure on employment through IO

models is limited by the simplifying assumptions of the methodology. IO models rely on complicated yet simplified systems of equations, and the emphasis on the product side of the economy doesn't explain why inputs and outputs follow a specific economic pattern. First, the assumption of linear equations relating to one industry's output may not be realistic: since the factors are largely indivisible, it is not always necessary to increase the inputs proportionally to increase the output. Second, IO models do not allow substitution between factors, and in the long-run, replacement potential between inputs may be relatively high. Third, IO models require huge amounts of data, which may not be accurate or up-to-date, and are rarely disaggregated below the national level: IO tables are only available every five years in Poland (the latest year of information published by GUS is 2015[27]). As a result, while providing some benchmarks, the results of IO models can only provide orders of magnitude at best, and should be treated as such, as inputs into a broader debate. Below the report argues that the spatial concentration of coal mines and coal mining related activities in certain municipalities is likely the more important finding, indicating that the effects of coal mine closures will be strongly local.

Additional bottom-up estimates of the indirect effect of mine closure on employment in the coal value chain of Silesia are presented in section 3.5. In addition to national-level estimates, Alves Dias et al (2018) estimate the indirect impact of the transition at NUTS-II level[28]: a total of 34,536 jobs are indirectly linked to coal mining in Silesia, 22,106 of which through intra-regional and 12,430 through inter-regional linkages. This report adds to this using a simple bottom-up approach: data on companies contracted by public mining companies in Silesia through public tenders was obtained through official reporting, data requests and data scraping, and the total workforce of these contracted companies was estimated using administrative data (section 3.5). Final estimates of the workforce indirectly affected by the mines closure were disaggregated between those working on sites located in Silesia, and those working on sites outside of Silesia.

Box 2: Estimating the number of indirect coal-related jobs in Poland

Using IO tables from 2015, Kiewra et al (2019) and Alves Dias et al (2018) estimate that between 57 and 88 thousand persons respectively are indirectly linked to coal mining in Poland.[29] The estimations rely on the use of IO tables and multipliers from the EU Joint Research Center, originally developed for predicting the effects of a change in the final demand in one sector on other related sectors (Thissen and Mandras, 2017). The reasons for the difference in their estimates are not immediately clear. Both Alves Dias et al (2018) and Kiewra et al (2019) use the IO tables from 2015

[27] https://stat.gov.pl/en/topics/national-accounts/annual-national-accounts/input-output-table-at-basic-prices-in-2015,5,3.html

[28] The NUTS classification (Nomenclature of territorial units for statistics) is a hierarchical system for dividing up the economic territory of the EU for the purpose of the collection, development and harmonization of European regional statistics. NUTS-I refers to major socio-economic regions, NUTS-II to basic regions for the application of regional policies, and NUTS-III to small regions for specific diagnoses (https://ec.europa.eu/eurostat/web/nuts/background).

[29] These estimates include power generation, equipment supplies, services, and R&D.

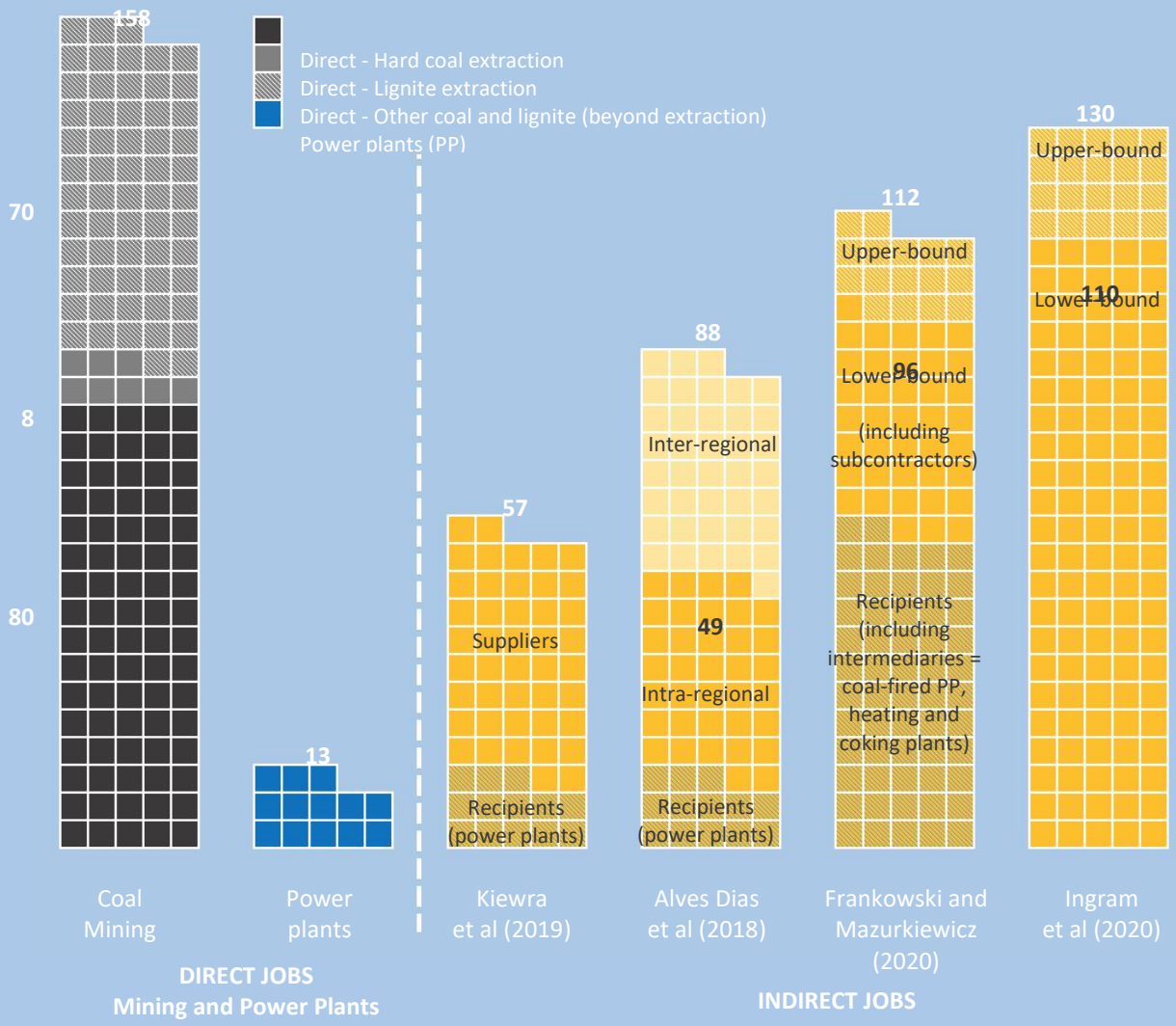
and they both consider employment by coal recipients or users (particularly coal-fueled power plants). To calculate the number of indirect jobs generated in the coal supply chain, they both assume that the ratio of mining-related value-added to mining-value added corresponds to the ratio of mining-related jobs to mining jobs. Kiewra et al apply this ratio to the 2017 number of mining jobs; the base year of mining employment used by Alves et al (2018) is not clear. In terms of reporting, Alves Dias et al report separately also the intra- and inter-regional impacts, respectively 49 and 39 thousand jobs, though both effects should be included by Kiewra as the estimates are national.

Frankowski and Mazurkiewicz (2020) further refine Kiewra et al's work, estimating that Poland's coal mining sector generates between 96 and 112 thousand indirect jobs, 41 thousand of which are generated among suppliers. As in Kiewra et al, indirect jobs are calculated as the share of value added transferred to the mining industry in the total value added generated in a given sector, multiplied by the number of employees in that sector. The paper differs in that employment data was retrieved from Eurostat data for 2018, and that employment among other recipients than coal-fired power plants (in manufacturing, gas, steam, and air conditioning (respectively NACE Rev.2 C and D) were added, proportionally to the share of coal in each sector.

Finally, Ingram et al (2020) provide a slightly larger range of estimates, from 110 to 130 thousand, using a specific survey of 207 companies.[30] This study specifically considers the timeline of mine closure: under an *optimistic* scenario, 26,667 jobs would be indirectly affected by 2030, half of what is estimated under a *plausible* scenario (50,580). The different results, along with estimates of the workforce directly employed in the mining sector and in the power plants, are illustrated in Figure 3.

[30] Unspecified sampling framework.

Figure 3: Polish workforce directly and indirectly employed in mining and power generation



Note: Each square represents 1,000 jobs. All estimates exclude induced jobs. "Hard coal extraction" and "Lignite extraction" estimates are reported by INSTRAT (2021) and refer to administrative data shared by mining conglomerates. However, Eurostat reports a larger number of individuals employed in "coal and lignite" (table lfsa_egan22d), namely 158 thousand: "Other coal and lignite (beyond extraction)" refer to the differential between the two estimates.
Source: Alves Dias et al (2018), Eurostat (lfsa_egan22d, 2019), Frankowski et al. (2020), Ingram (2020), INSTRAT (2021), Kiewra et al (2019).

2.4 Large and increasing wage premia in coal-related jobs, especially for the lower skilled

Wage premia of 50 percent or more are not uncommon for employees in coal-related professions, especially for lower-skilled workers and in state-owned mines or mining conglomerates. Hourly wages in coal-related occupations tend to be substantially higher than wages in other sectors, both on average and when comparing within the same occupational

categories (Figure 4).[31] If coal-related workers were to be in a similar occupation in a sector other than mining or energy production, their average gross salary would be 20 to 40 percent lower. Put differently, most coal-related workers earn at least 50 percent more than those in similar occupations outside the mining sector. The wage premium earned by coal-related workers is particularly high for the lower skilled occupations (craft workers, plant operators and especially elementary occupations) and in public mines and mining conglomerates, where the average sectoral wage gap vis-a-vis other professions was PLN 3,065 in 2018 compared to 1,339 in private mines.[32] When controlling for demographic characteristics such as gender, age, and years of education, in addition to occupation, miners' wage premia are even higher. The logarithm of the earnings regressed by applying the Mincer's Equation (1974), which regresses earnings on the worker's educational attainment, including additional variables indicating sociodemographic (age, sex) and controlling for working time indicates that miners earn 50 to 60 percent more than other workers with similar education and work experience.

Between 2004 and 2018, the wage[33] gap vis-à-vis other sectors generally widened further. The average salaries of mining engineers, technicians and miners' more than doubled over that period: from PLN 4,617 to PLN 8,926 for engineers, from PLN 3,927 to PLN 8,032 for technicians, and from PLN 3,112 to PLN 6,700 for miners. While in 2004 a mining engineer earned PLN 1,563 more than an engineer in another sector, in 2018, the wage gap widened to PLN 4,495. Similar increases were observed for technicians and miners. On the other hand, average salaries of other types of occupations in the mining sector grew at a slower pace, more closely aligned with national wage trends (GUS, 2020).[34] These results are consistent with the World Bank (2018) study which finds that coal wages are not only high but have been rising faster over time, even when comparing coal and non-coal workers with the same demographic characteristics, including educational attainment.[35]

[31] 61 occupations from the International Standard Classification of Occupations (ISCO-08), which are directly affected by the Just Transition, were identified. These occupations, which are directly related to mines and coal-fueled power plants, are listed in different sectors of activity: management of power plants and mines (4 professions), mining in general (24 professions), quarry mining (11 professions), energy production (15 professions), and mining Infrastructure (7 professions).

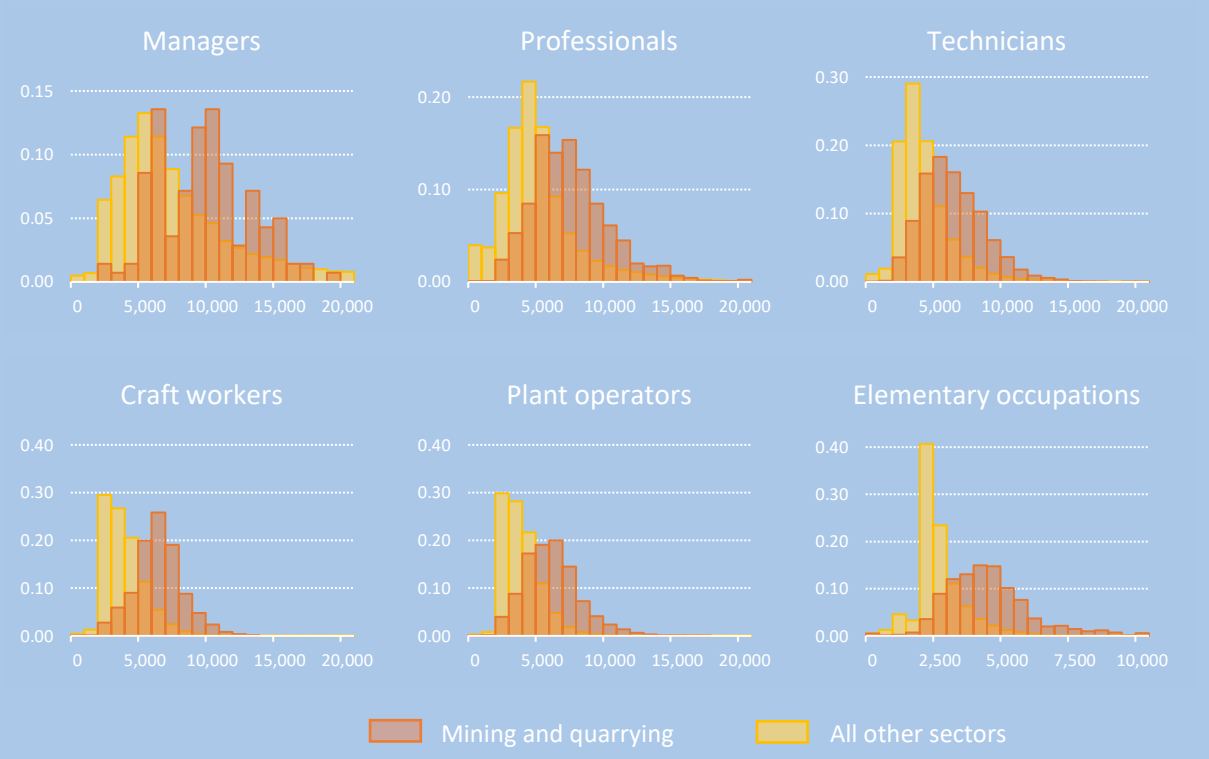
[32] In high-skilled professions in private-owned mines, the premium does not exceed 20% on average, while in the public sector it is similar to this for low-skilled workers

[33] Average gross monthly earnings were calculated as total salaries and benefits for 2018 divided by 12.

[34] The average wage for the Polish economy grew by 100.26 percent between 2004 and 2018 (in nominal terms).

[35] Different factors likely underpin such wage differences. They may simply be compensation for the health hazards and difficult working conditions of coal-related employment. Given high capital intensity of the mining sector, they may also reflect higher labor productivity. Finally, through effective unionization coal-related workers may have more effectively leveraged their bargaining power for faster wage growth, especially the lower-skilled workers in deep mining who are also most exposed to health hazards and difficult working conditions.

Figure 4: Employees in coal-related professions enjoy wage premia of 50 percent or more



Note: Average gross wages. Average monthly earnings were calculated as total salaries and benefits for 2018 divided by 12 and number of hours worked.
Source: Author's computations using Structure of Earnings Data (BDL, access: 1.11.2021).

Finally, the types of occupations, contract terms, compensation and working conditions can vary widely between coal mine workers, and across the coal value chain. Employees of mining conglomerates benefit from the most protective contracts and social packages (in case of dismissal), negotiated by often powerful unions. They enjoy good contract terms (high wages, open-ended contracts, sometimes guaranteed employment within the conglomerate), generous health and unemployment insurance, early retirement eligibility, and pensions indexed to their high wages. They often also benefit from subsidized access to energy (free coal or subsidized heating). Within mining conglomerates, underground miners (hard coal) receive more generous compensation than surface miners (lignite). On the other hand, employees of supporting industries within the coal value chain (suppliers and service providers) tend to have less secure contracts, lower wages, and less protective social insurance than those directly employed by the mining conglomerates, even though their working conditions are on average likely still better than those outside mining and quarrying (Figure 4).[36]

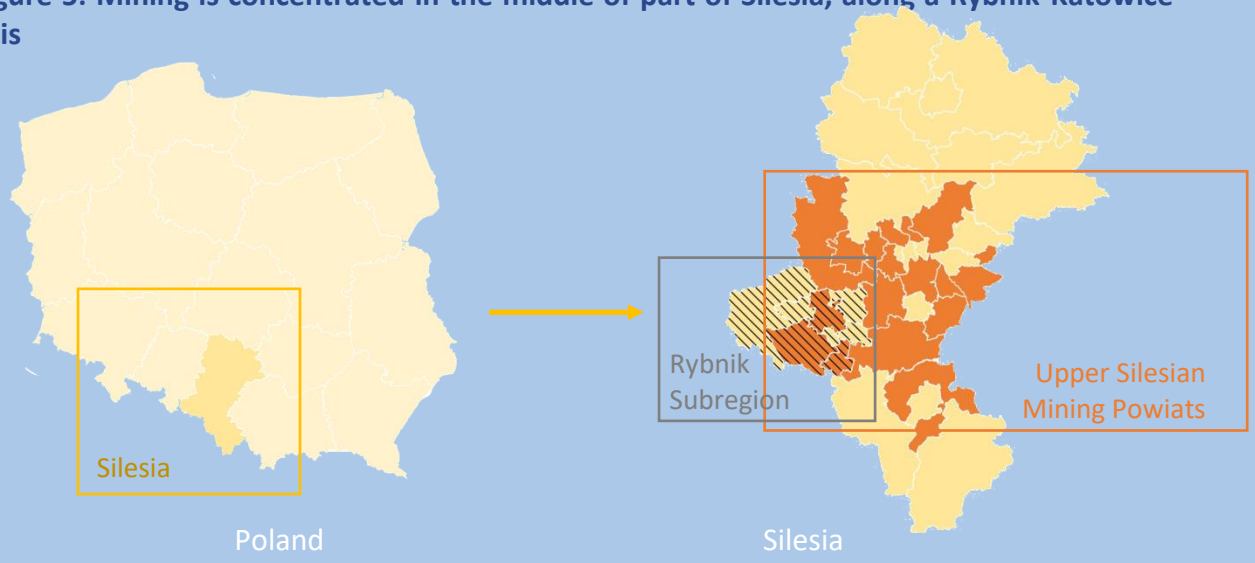
[36] Given definitional issues, the exact wage premium by occupation between those indirectly employed in coal and those employed in other sectors is hard to discern from the Structure of Earnings Data which does not clearly distinguish between those directly employed in mining and those indirectly employed.

3 Silesia has substantial coal-related employment which is geographically concentrated

3.1 Concentration along a Rybnik-Katowice axis

Silesia's coal mining activity is concentrated in the middle of the region. The region of Silesia (*Śląskie Voivodeship*) represents the NUTS-2 administrative level in Poland. It is divided into 8 subregions (NUTS-3 level). Most mining activity is concentrated in the bituminous coalfields of the Upper Silesian Industrial districts (*Górnośląski Okręg Przemysłowy*), and the Rybnik Coal districts (*Rybnicki Okręg Węglowy*). Extraction sites and coal-fueled power plants are found in 17 districts, or powiats, located along a Rybnik-Katowice axis, [37] and most of the coal production is located in the Rybnik subregion (Figure 5).

Figure 5: Mining is concentrated in the middle of part of Silesia, along a Rybnik-Katowice axis

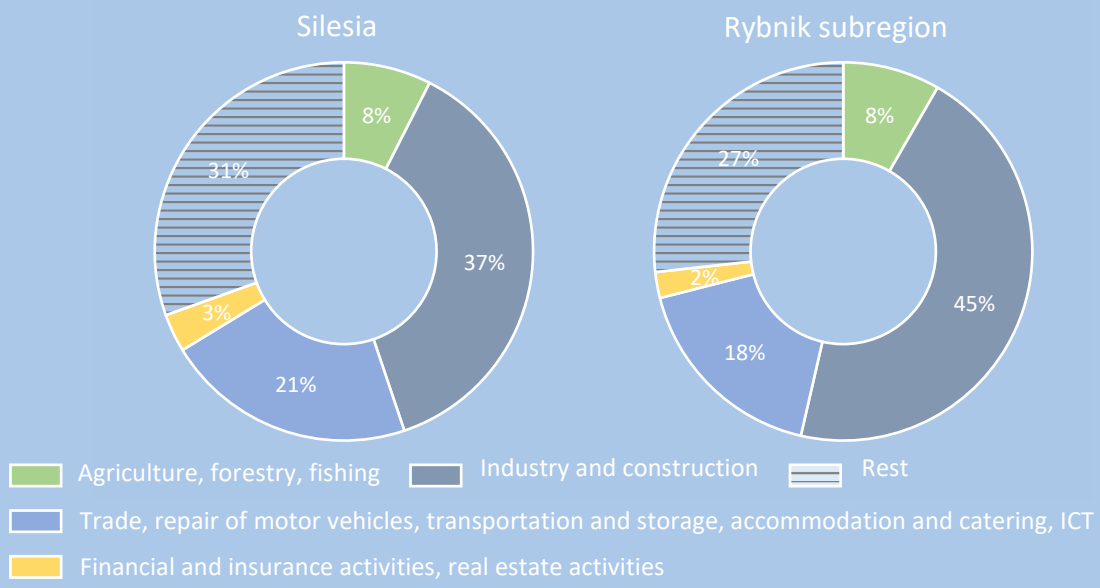


3.2 Rybnik subregion is lagging behind the rest of the region

Silesia is the most urbanized region in Poland and relies heavily on the industrial and construction industry (Figure 6)**.** Three out of four residents of Silesia live in cities, compared to 60 percent for the country as a whole (GUS, 2020). Industry and construction provide 41 percent of the region's gross value added (GUS, 2019). Almost 40 percent of the region's working population is employed in the industry sector, while services and agriculture employ respectively 55 and 8 percent of the population (GUS, 2020). Reliance on industry and construction is even more pronounced in the Rybnik subregion, where they represent 45 and 18 percent respectively.

[37] Employment in the mines is concentrated in 17 districts (powiats): Jastrzębie-Zdrój, Bieruńsko-Lędziński, Rybnik, Ruda Śląska, Katowice, Wodzisławski, Pszczyński, Gliwicki, Mikołowski, Bytom, Mysłowice, Jaworzno, Gliwice, Bielski, Będziński, Zabrze, Piekary Śląskie.

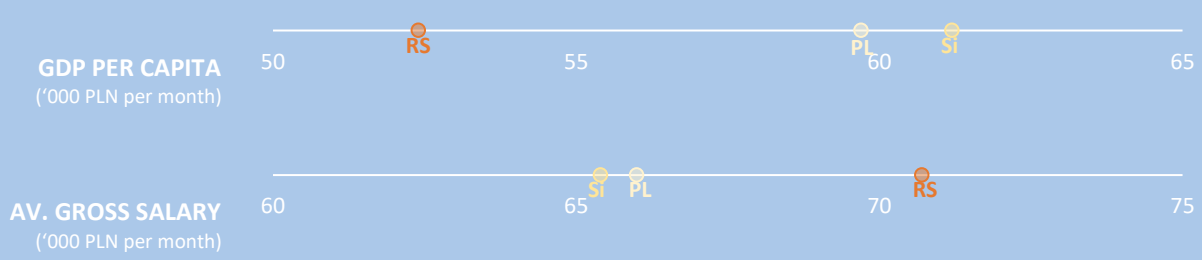
Figure 6: Employment is skewed towards industry and construction

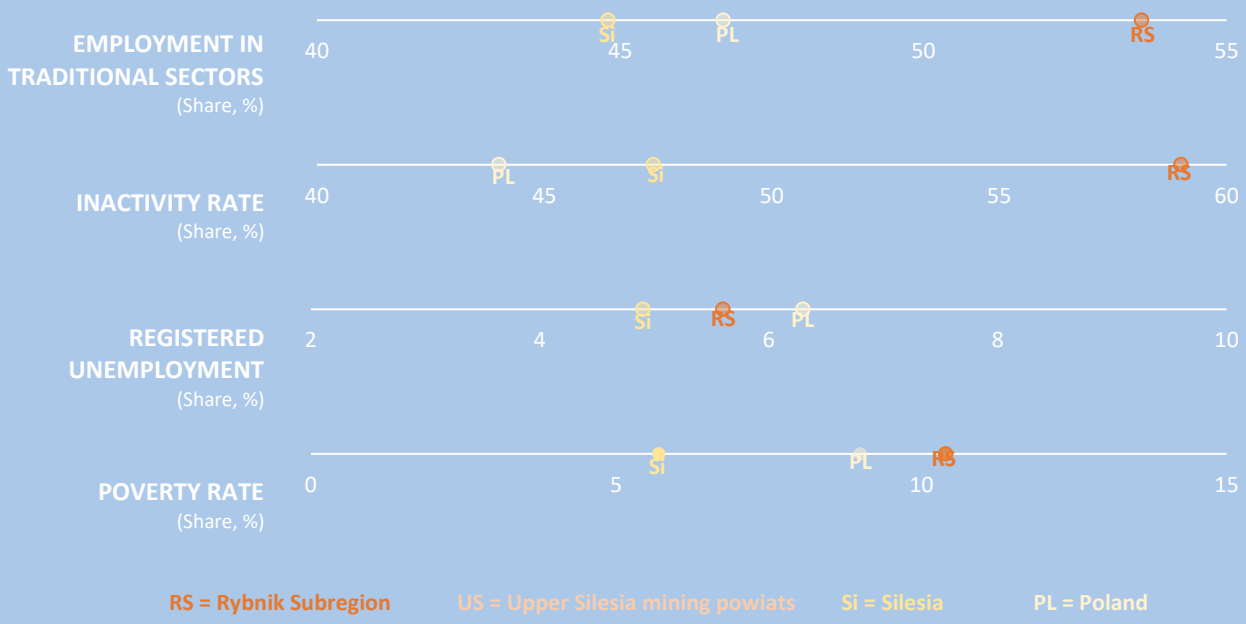


Note: Rybnik subregion is made of the following powiats, Raciborcki, Rybnicki, Wodzisławski, Jastrzębie-Zdrój, Rybnik, and Żory.
Source: GUS, 2020.

The Rybnik subregion, where most of the mining activity is located, lags behind the rest of Silesia (see Figure 7). Average GDP per capita in the Rybnik subregion is low (only PLN 52.4 thousand per month compared to 61.2 and 66 thousand in Silesia and Poland respectively). But average gross salary is quite high, at PLN 70.7 thousand per month, reflecting the importance of mining and associated higher wages in the subregion's average. Inactivity rates are very high: 57 percent of the working-age population is out of the labor market, explaining the lower average GDP/capita – some among those who work earn well, but many are not working or looking for work). Registered unemployment is relatively low, at 5.6 percent of the population, but slightly higher than in Silesia (4.9 percent). These relatively weak labor market indicators translate into above-average poverty rates: 10 percent of the population of Rybnik subregion is poor, which is almost twice the rates recorded in the rest of the region, or 5.7 percent (Szymkowiak et al., 2017).

Figure 7: Rybnik subregion is a lagging subregion within a buoyant region





Source: GUS (2020) excluding GDP per capita (GUS, 2019), and poverty estimates for Rybnik subregion (Szymkowiak et al., 2017).

3.3 Excess labor demand and substantial skills mismatch among the lower skilled

3.3.1 Labor demand is concentrated in lower-skilled occupations

In Silesia, job offers registered with the Public Employment Services (PES)[38] **are concentrated in tertiary activities** (Figure 8)**.** Business administration and support activities, retail, accommodation and other services represent more than 40 percent of the job offers. Scientific activities, education, healthcare and social assistance represent another 9 percent. Traditional sectors of activity represent a third of all PES job offers, with respectively 21, 10 and 7 percent for industrial processing, construction and transportation/warehouse.

Job vacancies in Silesia are concentrated among professions requiring lower skills (Figure 9:)**.** For example, most online job offers in Silesia target low-skilled blue collars, i.e., "workers doing simple jobs," and machine and device operators and assemblers (respectively 35 and 23 percent of all vacancies); and low-skilled white-collar vacancies represent 17 percent of all job offers. On the other hand, only 22 percent of vacancies target high-skilled blue-collars, and 11 percent high-skilled white-collars (Katowice Regional Labor Office, 2020).

[38] Job offers submitted by employers to PES are still a popular recruitment channel in Poland. Past studies show that PES service 1/3 of the labor market, though the network of private employment agencies and internet platforms is expanding, with the latter are extensively used by Silesian employers. The analysis of selected job databases a few years ago shows that the largest number of job offers came from companies from the Mazowieckie voivodeship (16.9%), followed by the Silesia voivodeship (12.4%) (IPISS, 2018). According to the entrepreneurs' declarations, almost 47% of them use the services of the Employment Office to seek employees, 43% post advertisements on recruitment portals, and slightly over 15% use the services of private employment agencies, recruitment agencies, headhunting companies (BKL, 2019).

Figure 8: over 4 in 10 job offers are in services and retail

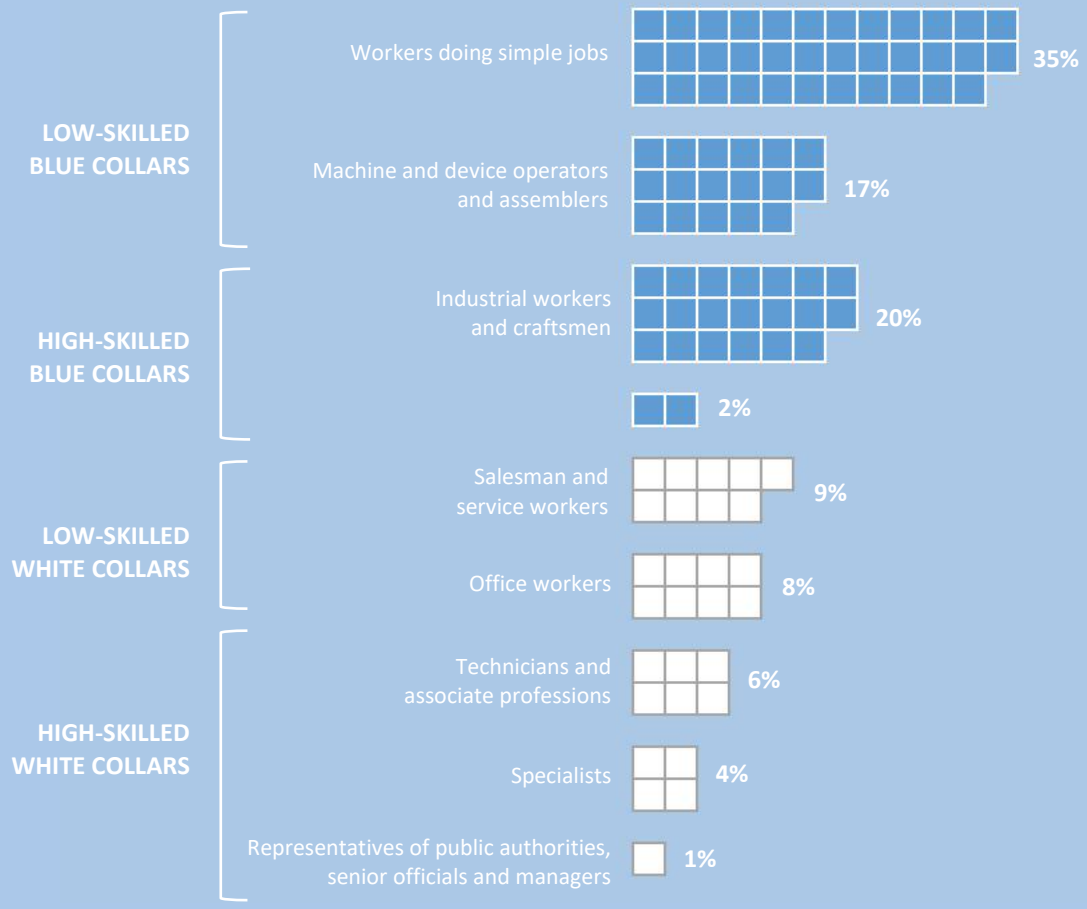
Note: Job vacancies listed by the Public Employment Services (PES).
Source: Katowice Labor Office, 2020. "The Silesian labor market."

Employers demand soft skills, also among lower skilled workers, and digital skills among higher skilled workers. "Psychophysical and psychomotor efficiency" is the most demanded qualification in vacancies targeting low-skilled workers and technicians and associate professionals. On the other hand, digital skills were most demanded for office work, and vacancies targeting other high-skilled white-collars demanded communication, planning and digital skills. [39]

Demand exceeds supply in all professions. In the past, Silesia's labor market has been tight, with job creation far exceeding job destruction: throughout 2019, 81 thousand new jobs were created, and 39 thousand jobs were liquidated (GUS, 2020). At the time of BKL survey in 2019, 18 percent of employers were looking for workers (BKL, 2019), and according to the occupational barometer,[40] employers reported difficulty filling vacancies in most occupations. This situation continues today (post COVID and despite an influx of Ukrainian refugees, some of whom have entered the labor market). The vast majority of employers experiencing a shortage of qualified employees report an impact on the day-to-day functioning of their company. The production, engineering, IT and customer service sectors suffer the greatest shortages. As of 30 June 2022, the unemployment rate in Silesia was 3.8 percent (compared to 4.9 percent nationally), one of the lowest in Poland (Katowice Regional Labor Office, 2022).

[39] Katowice Regional Labor Office, 2021. "Labor Market in the Silesian Region."
[40] Katowice Regional Labor Office, 2020. "Monitoring of Professions in Deficit and Surplus in the Silesian Voivodeship in 2019." Professions in deficit, surplus and balance are identified by a group of experts, which gathers every year. As such, it is not a quantitative comparison of the number of registered jobseekers and registered vacancies.

Figure 9: Most job offers in Silesia are for lower skilled individuals

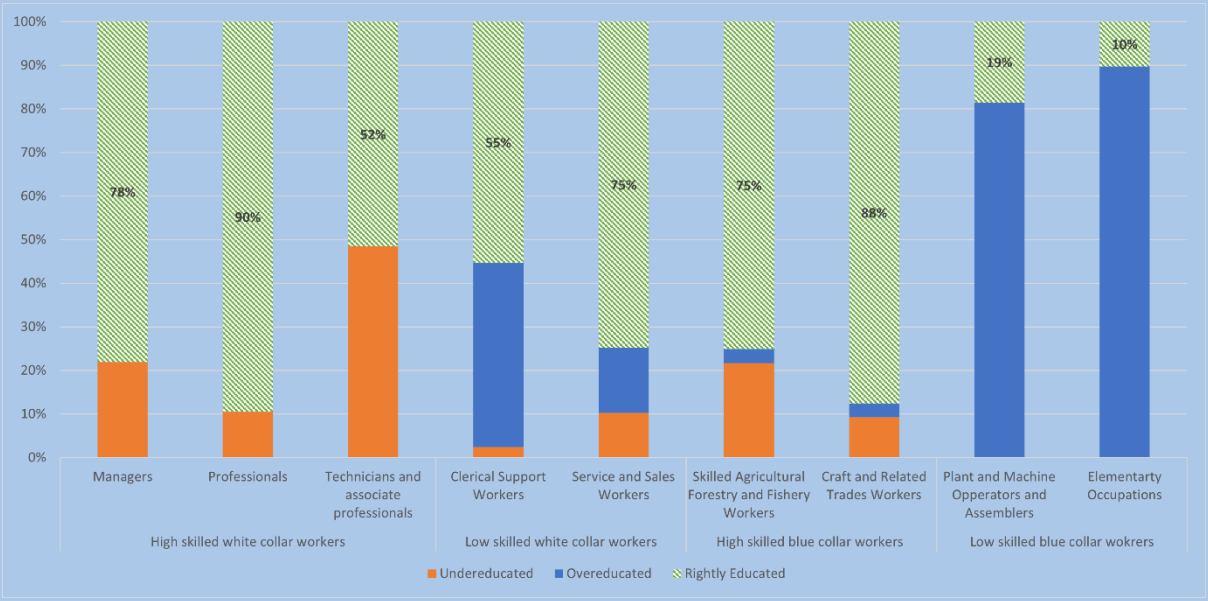


Source: Katowice Regional Labor Office, 2020. "Labor Market in the Silesian Region in 2020."

3.3.2 Skills mismatch is significant, especially among the lower skilled

In Silesia, skills mismatches are especially high among low-skilled blue collar workers (Figure 10)**.** Beyond professionals, whose educational attainments largely match the requirements of their jobs (only 10 percent are undereducated), there are important skills mismatches across the different occupations. Technicians and associate professionals are often undereducated (48 percent), suggesting that the sector fails to attract employees with the right education and employs lower educated workers instead. Skilled agricultural, forestry and fishery workers, service and sales workers, and craft and related trade workers also experience undereducation, but to a lesser extent. On the other hand, low-skilled blue collars are overwhelmingly overeducated, suggesting that skilled blue collars are facing limited work prospects and accept positions below their qualifications. To a lesser extent, clerical support workers, and service and sales workers, also experience overeducation. The situation of Silesia reflects a general situation in Poland, where skill mismatch amounts to 65 percent.

Figure 10: Low skilled blue-collar workers are most often characterized by overeducation



Note: Data for Silesia. The correspondence between occupations and skills is using the ILO nomenclature. High-skilled white collars are expected to have tertiary education (ISCED 5-8), low-skilled white collars and high-skilled blue collars are expected to have more than upper-secondary non-tertiary education (ISCED 3-4), and low-skilled blue collars are expected to have up to upper-secondary education (ISCED 0-2).
Source: Author's computations using Structure of earnings data (BDL, access: 1.11.2021).

3.4 Coal workers represent a substantial share of employment

3.4.1 Mining is important for Silesia, but vital for some municipalities

Despite the significant reduction of mining capacity over almost three decades, Poland remains by far the largest hard coal producer in Europe. 96 percent of EU-27 hard coal production, or 54.4 million tons, is extracted in Poland (EURACOAL, 2020).

Poland's coal extraction is concentrated in the Upper Silesian basin. 79 percent of Poland's hard coal resources are located in Silesia: the region contains some 400 coal seams, half of which are economically viable. 27 percent of the region's reserves is coking coal, a raw material indispensable for the production of steel. Mining is fully mechanized, with over 90 percent of coal produced by longwall systems (EURACAOL, 2020).

Mining represents 1 percent of employment in Poland, but almost 5 percent in Silesia. Since the beginning of the 1990s, employment in the Polish hard coal mining sector decreased from 407 thousand to over 90 thousand employees in 2015 (INSTRAT, 2021). Between 2015 and 2020, employment in the mining industry was further reduced by 12 thousand people due to the closing of mines, transfers to other plants, the natural process of retirement and voluntary exit from the sector. As more than 40 percent of the current mining workforce is expected to

retire by 2030[41], this latter trend will serve as the main channel of employment reductions. Today, 80 percent of Poland's mining workforce is located in Silesia, which represents 5 percent of the region's employment (GUS, 2020).

In Silesia, coal extraction is carried out by 5 large state-controlled mining conglomerates, and 3 private mines. The mining sector is largely run by large state-controlled mining conglomerates: Polska Grupa Górnicza (PGG), Jastrzębska Spółka Węglowa (JSW), Tauron Wydobycie (TWD), and Węglokoks Kraj (WKK). Unprofitable mines or units of integrated mines are transferred to Spółka Restrukturyzacji Kopalń (SRK) for their eventual closure.[42] In addition, 3 private mines, representing less than 5 percent of total employment, continue to operate: PG Silesia, Siltech and Ekoplus.

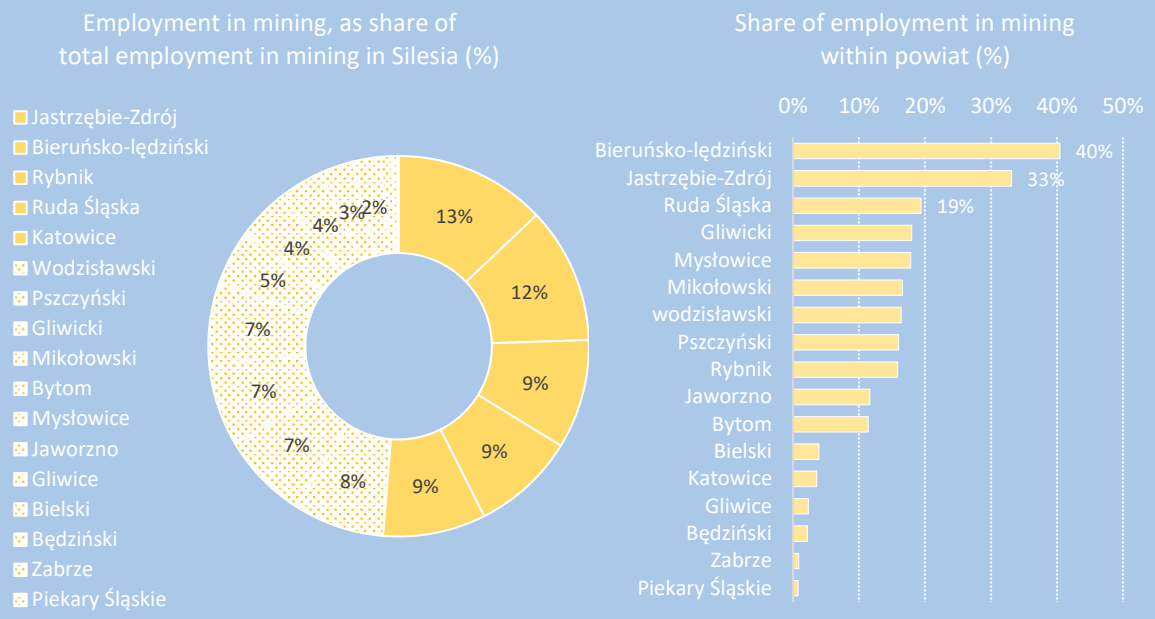
According to the latest figures, 72,000 persons are directly employed in Silesian mining conglomerates.[43] PGG is the largest employer, with 36 thousand employees, followed by JSW, with almost 22,000 workers. The other mines are smaller, with respectively 6.8 thousand employees in TWD, 3 thousand in SRK, 2.3 in WKK, 1.6 in PG Silesia, 400 in Ekoplus, and 100 Siltech.

3.4.2 Direct mining employment is spatially concentrated in the Rybnik subregion

The mining sector plays a dominant role as an employer in several municipalities around the extraction sites (Figure 11)**.** Direct mining employment is spatially concentrated in the Rybnick subregion, around the ROW mining complex operated by PGG (12,000 employees in 4 mines), Borynia-Zofiówka, operated by JSW (almost 8,000 miners). 50 percent of all mining employees live in 5 powiats, namely Jastrzębie-Zdrój, Bieruńsko-Lędziński, Rybnik, Ruda Śląska, and Katowice. In Katowice and Rybnik, they only make up 4 and 16 percent of the working-age population. On the other hand, municipalities located close to the mines are highly dependent on mining for employment: mining represents respectively 40, 33 and 19 percent of total employment in Bieruńsko-Lędziński, Jastrzębie-Zdrój, and Ruda Śląska. Considering that men make up 90 percent of all mining sector employees, about 72 percent of the men living in Bieruńsko-Lędziński are employees of the mining sector (59 and 34 percent for Jastrzębie-Zdrój, and Ruda Śląska respectively).

[41] Sokołowski et al. (2021).
[42] In 2018, there were 14 mines or units of mines managed by this restructuring company (EURACOAL, 2020).
[43] Administrative data from mining companies, as of 12/31/2020 except for TWD and Ekoplus (12/31/2019).

Figure 11: in three powiats at least 1 in 5 working-adult is employed in the mines



Source: administrative data (Frankowski et al., 2021).

3.4.3 The mining sector employs mainly young men with secondary education

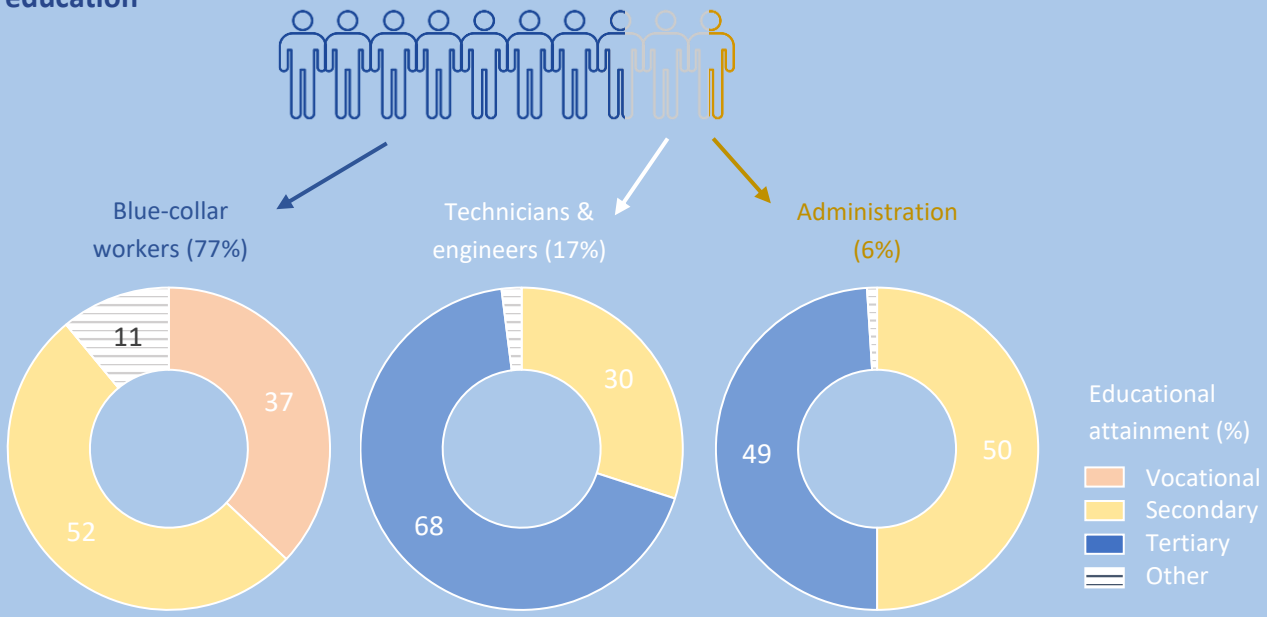
Employees in mining conglomerates are mostly young men. In 2019, the average age of a hard coal mining worker in Silesia was 39 years, with a substantial difference between underground and surface employees (respectively 36 and 48 years old on average). This young age structure is explained by eligibility criteria for retirement: miners can retire as early as 50, or after 25 years working in the mining sector including 15 underground. The vast majority of mining sector workers are men: women make up less than 10 percent of the workforce, the vast majority of which work above ground as blue-collar or administrative staff. [44] Most of them will reach retirement age in the current decade (Frankowski et al., 2021).

8 in 10 employees of the mining sector are blue-collar workers, most of whom have vocational education (Figure 12)**.** The majority of blue-collar workers have secondary or vocational education (respectively 52 and 37 percent). Underground miners mostly graduated from secondary school (55 percent), while surface workers were more likely to have a vocational background (52 percent). The majority of engineering and technical staff have higher or secondary education (respectively 68 and 30 percent): this high level of educational attainment results from the procedures required to be promoted.[45] Finally,

[44] Only slightly over 100 women are working underground, mostly in technical supervision roles.
[45] Professional experience and exams approved by the President of the State Mining Authority (or its subordinate authorities) are required.

white-collar and administration employees, graduated with equal probability from secondary or higher education constituted (respectively 49 and 50 percent).

Figure 12: most employees of the mining sector are blue-collar workers with secondary education



Source: Frankowski et al. (2021).

3.4.4 Relatively high wages

Employees of the coal mining sector enjoy high wages, which are substantially higher than counterparts in Wielkopolska and Lower Silesia (BDL, access: 1.12.2021). Mining engineers and technicians respectively earn PLN 8,383 and PL 7,381 in Silesia, which is about PLN 1,793 and 1,997 higher than in Wielkopolska, and PLN 1,474 and PLN 57 higher than in Lower Silesia.

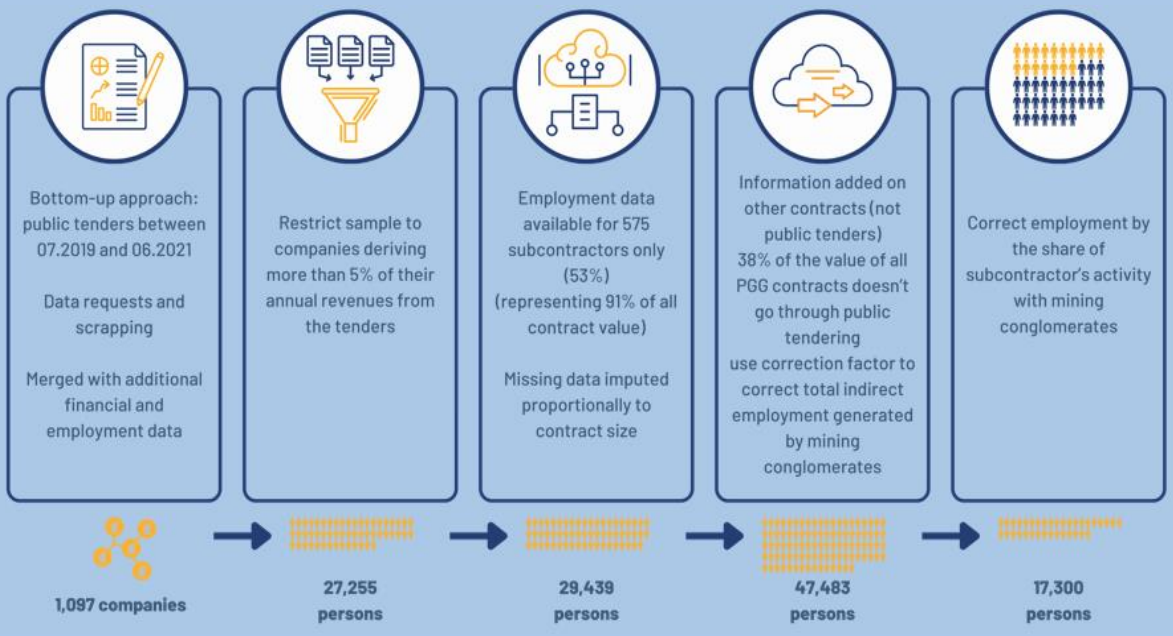
Miner sector employees saw their earnings increase in recent years. Nominally higher-skilled engineers and technicians experienced the largest increase from 2004 to 2018 (by PLN 4,744 and PLN 4,378, respectively), but the greatest percentage gain was noted for miners (125 percent; PLN 3,922) (BDL, access: 1.12.2021).

Mining employees' high wages do not compensate for low earnings from other household members, resulting in lower per capita household incomes on average (World Bank Skills and Preference Survey, 2021). 63 percent of mining sector employees live in double-income households. Nevertheless, 53 percent of mining sector employees have disposable per capita income below the national average. This is particularly true for employees without higher education (below bachelor), 51 percent of whom are below the national average, compared to 38 percent of employees with higher education (World Bank Skills and Preference Survey, 2021).

3.5 17.3 thousand jobs in subcontracting firms are highly dependent on mining

The indirect labor impact of the mine closure was defined as the total number of individuals hired to provide goods and services to the mining conglomerates. Indirect jobs were defined as positions contracted out by mining conglomerates, provided either by companies "associated" with mining conglomerates (often integrated vertically within the broader mining company), or jobs in companies directly subcontracted by mining conglomerates to provide good and services.

Figure 13: 17,300 jobs in subcontracting firms are highly at-risk under coal transition



Source: Frankowski et al. (2021).

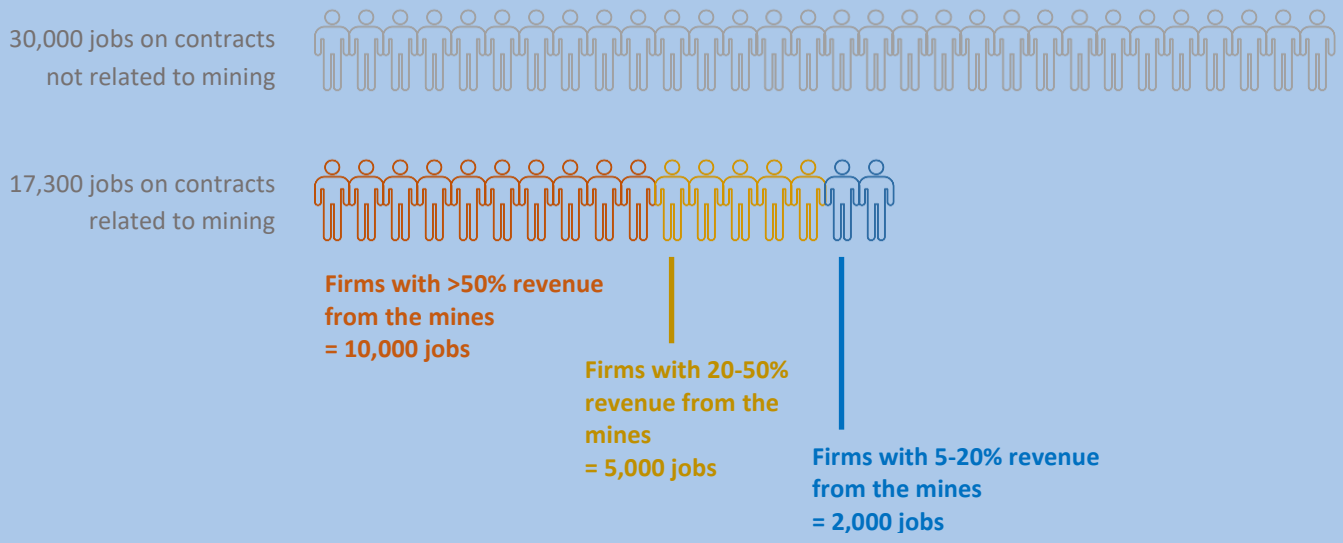
A bottom-up approach was followed to estimate the indirect impact of the mine closure (Figure 13)**.** First, data on companies contracted by mining conglomerates through public tenders between 07.01.2019 and 06.30.2021 was obtained through official reporting, data requests and data scraping, resulting in a list of 1,097 entities for Silesia. Second, the list of subcontractors was restricted to companies with non-negligible business with the mining conglomerates, resulting in 936 entities for Silesia. When available, additional information on subcontracting companies (financial information, structure of labor, etc.) was merged from existing databases, websites, and reports: basic information on employment was retrieved for 52 percent of them, representing 91 percent of all contract value.[46] Third, missing employment data for the remaining 48 percent of public tenders was imputed, in proportion to the tender amount. Fourth, information from the PGG's structure of subcontracting was used to impute the number of individuals indirectly employed by mining conglomerates

[46] More detailed information (age, gender, position, level of education) was retrieved for 33 percent.

through small contracts not required to go through public tendering.[47] Finally, a last correction was applied to the total number of individuals indirectly affected by the mine closure, to only retain employees working on mining contracts. It was assumed that the share of workers likely to be affected by the transition away from coal within a subcontracting company was proportional to the share of revenue derived from the mining sector (see Annex 1 for more details on the methodology).

In Silesia, an estimated 21 thousand jobs, 17,300 jobs among subcontracting firms, and 3,700 among associated subsidiaries, are deemed to be at high risk under a transition away from coal. Subcontracting firms based in Silesia that derive at least 5 percent of their revenues from the mining sector provide 47.3 thousand jobs, 17.3 thousand of which are related to mining contracts. The remaining 30 thousand positions are linked to contracts and activities that these subcontractors may have with other sectors of activity.

Figure 14: 1 in 3 jobs among subcontractors are linked to mining contracts, but only 1 in 10 are within companies highly dependent on the mining sector

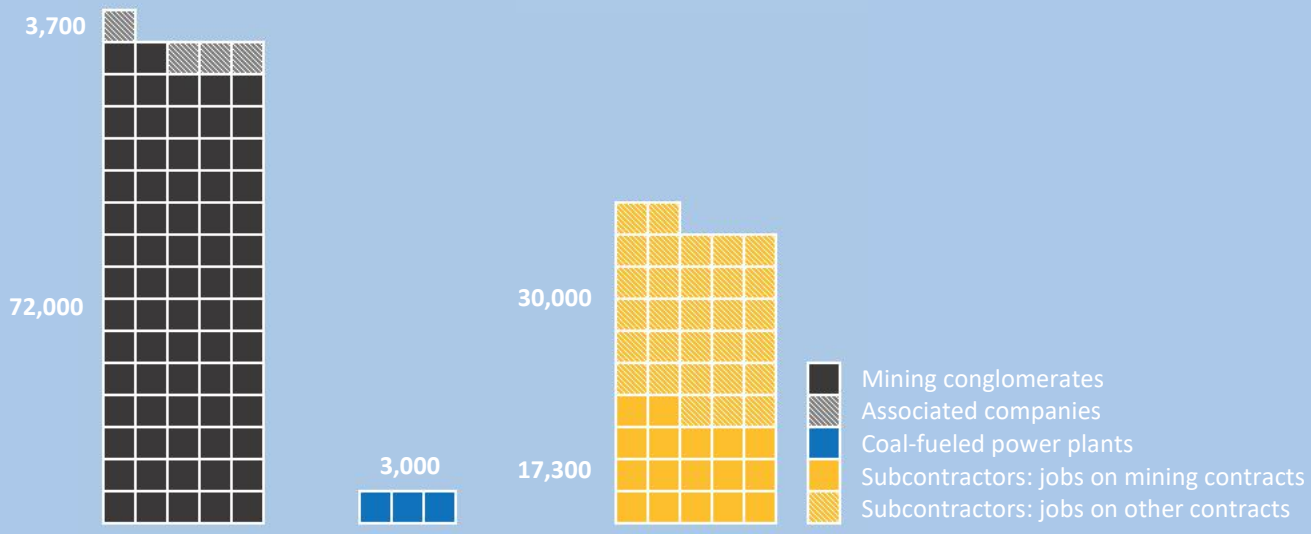


Note: Each person represents 1 thousand jobs.
Source: Frankowski et al. (2021).

The majority of coal-related jobs in Silesia (three in four) are in the mines (Figure 15)**.** In fact, mining workers add up to 72 thousand, and 3,700 employees work in the 8 "associated" subsidiaries that provide support services for mining extraction. Beyond mining conglomerates and associated subsidiaries, subcontractors of the mining conglomerates provide an estimated 17,300 jobs closely on mining-related contracts. Subcontractors located outside of Silesia provide an additional 19 thousand jobs on mining contracts with Silesia mining conglomerates.

[47] The list of tenders used in step 1 only concerned contracts of value of EUR 443,000 in 2019 and EUR 428,000 in 2020, and contracts for smaller amount were not included.

Figure 15: 3 in 4 coal-related jobs in Silesia are in the mines; 1 in 3 jobs provided by subcontractors in Silesia are linked to mining contracts



Note: Each square represents 1,000 jobs.
Source: Frankowski et al. (2021).

The bottom-up approach to estimating the indirect employment effects from coal-mining largely stands up to scrutiny. Overall, the approach puts the estimate at the lower end of the range of indirect employment effects thus far reported in the literature, similar to Diaz et al. (2018), who report 22,106 indirect jobs through intra-regional linkages (based on earlier data when mining was still more widespread) and 12,430 indirect jobs through interregional linkages (see also section 2.3). To further assess the credibility of this report's estimate, it is important to fully understand its coverage and to assess the direction and magnitude of the potential errors introduced by the assumptions made.[48]

Concerning coverage, note that the estimated number of jobs only consider coal-related employment linked to subcontracting by the mining conglomerates in Silesia (i.e., the coal supply chain) and not employment in the coal related sectors (power, coking industry) or the value chains delivering to these sectors. Nor does the estimate consider induced employment effects from broader economic linkages linked to the local spending of the miners' salary mass or the mining-related fiscal revenues from the municipalities. Locally induced employment effects are also notoriously hard to estimate.

Regarding the underlying assumptions, note first that the universe of mining conglomerates is not complete: only tenders from the 5 state-controlled mining companies were looked into: the remaining 3 private mines (Ekoplus, PG Silesia, and Siltech) are not mandated to make their tenders public. However, given the small size of these companies (2,216 workers in

[48] Given methodological and data limitations, assumptions are inevitable in calculating indirect employment effects, irrespective of the approach used.

2019, or 3 percent of the mining workforce in Silesia), the final estimates of the indirectly affected workforce among subcontractors will only marginally increase. Second, there was no direct information on smaller contracts: public tendering only concerns contracts above EUR 443,000 (2019) and EUR 428,000 (2020). Employment among sub-contractors from non-public tendering was imputed using PGG's structure of subcontractors (38 percent of all contract values doesn't go through public tenders). This assumes that the share of smaller contracts is similar across all 5 state-controlled mining conglomerates, and that the relationship between capital and labor is linear, i.e., that the labor intensity (labor/contract value) among smaller contracting firms is similar to this among the larger subcontracting firms. With smaller subcontractors likely more labor intensive, the latter assumption could arguably induce some underestimation of the overall employment effect.

Third, basic data on employment was only available for half of the firms. The results may thus be biased up or downward if labor-intensive subcontractors are more or less likely to report on their employment. A priori, there is no indication either way. Finally, the sensitivity of overall employment among the subcontractor to coal mine closure was calculated using the value of the coal mine contracts over the total sales value. For companies highly dependent on the mining contracts, the overall company (and employment) may be at risk. On the other hand, those lightly dependent on coal-related contracts may be able to diversify quite easily. Applying the ratios thus presents a reasonable approximation.

In conclusion, while the number of affected employees along the coal value chain may be lower than previously reported, this does not exclude severe labor consequences geographically. The bottom-up approach presented here provides a reasonable estimate of the expected employment loss among subcontractors in Silesia, but it does not consider the job loss that may follow from reconversion of the power plants or the coking industry. Yet, the latter is currently also exempt from the transition. As will be highlighted in the subsequent sections, more important, however, is the induced employment loss in the affected communities, given the high concentration of the mining and coal related activities in few communities, which often saw themselves lagging already to begin with.

3.6 Subcontracting concentrated in a few large firms, next to and dependent on the mines

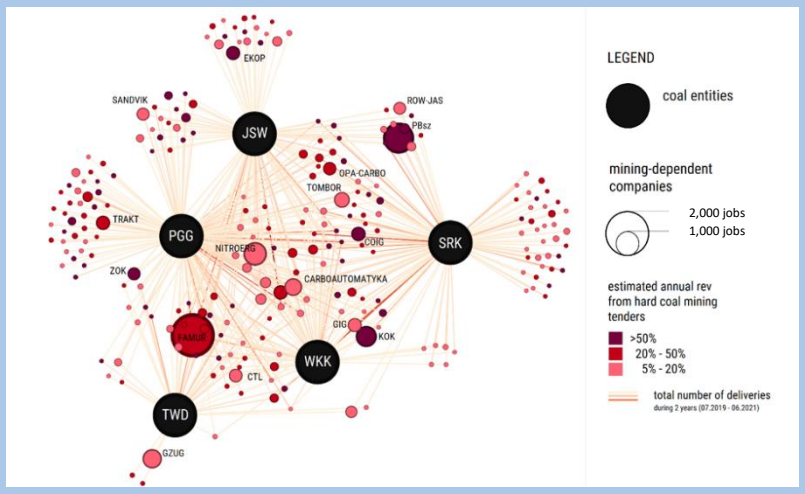
Employment among subcontractors is relatively concentrated (Figure 16)**.** Twenty-four firms provide half of the total contract value and the ten companies employing most of the coal related work force in the coal chain provide one third of the coal value chain jobs. Moreover, apart from Famur and PKP Cargo, most of them are also highly dependent on mining contracts: in PBSz, the largest purveyor of mining jobs among subcontractors, 9 in 10 jobs are related to mining tenders, and all contracts from Zok, Epok or Amar are with the mining sector.

Most indirect jobs among the subcontractors concern blue-collar work in manufacturing and construction, but the share of medium-high tech companies is increasing. Among subcontractors, 45 percent of the employment is in manufacturing; construction represents

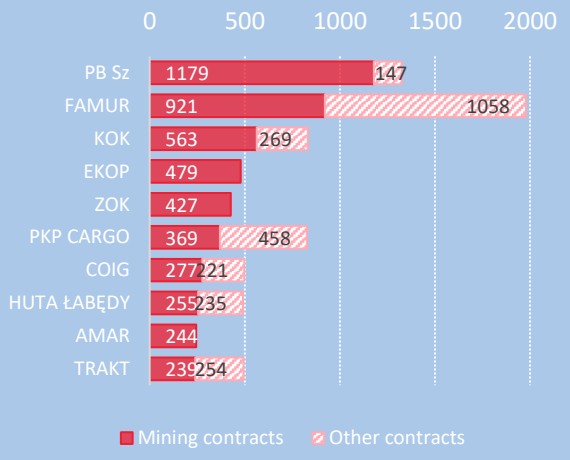
an additional 21 percent. This is in line with the distribution of employment in Silesia. As a consequence, the structure of employment is similar to the mining sector: 7 in 10 employees are blue-collar workers. Almost one third of mining industrial subcontractors are high- or medium-high tech companies, which represents 8,000 jobs in Silesia. The tendency to develop innovative technologies to gain foreign contracts and provide better-paid jobs can be seen with Famur and Joy, which are medium-high tech manufacturers of mining machinery, or Carboautomatyka and Elgór+Hansen, which are medium-high tech electric engineering and automation/control solution providers.

In addition, subcontractors are also spatially concentrated in Silesia, especially around the mining sites. Almost 70 percent of subcontractors are located in Silesia, and those located less than 20 kilometers from the closest active hard coal mine represent 80 percent of the value of all contracts tendered (Frankowski et al., 2021).

Figure 16: Subcontracting employment is concentrated among a few large firms, most of which are highly dependent on mining tenders



Note: The figure represents subcontractors with headquarters in Upper Silesia with at least 5% of their annual revenues from hard coal mining tenders, which provided data about total employment (n=231).
Source: Frankowski et al. (2021).



Note: Ten firms with largest number of employees working on mining tenders. The number of employees working on mining tenders is proportional to the share of revenues from mining tenders on total revenues.
Source: Frankowski et al. (2021).

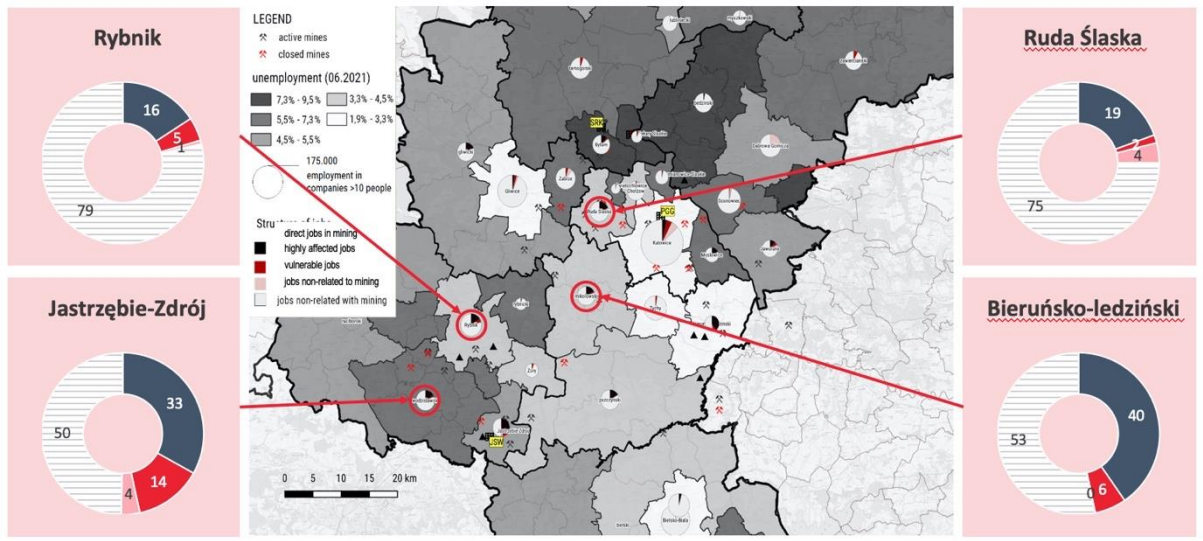
3.7 Coal-related jobs are especially important to the Rybnik subregion

The economy of Rybnik powiat is quite vulnerable to the transition out of coal, given the high concentration of the economy and employment in mining and related activities (Figure 17)**.** The region has the lowest levels of entrepreneurship and the allocation across sectors has not changed much since 2010. Rybnik powiat is in an especially difficult situation as there is a shrinking industrial and service base (Frankowski et al., 2020). This powiat also recorded one of the largest declines in the number of job vacancies and economic activation (-1,952) (Katowice Regional Labor Office, 2021). In 2020, the Rybnik powiat displayed also one of the highest shares of youth unemployment.

The powiats Jastrzębie-Zdrój and Bieruńsko-Iedziński are especially at risk (Figure 17)**.** These two powiats experience an average or lower level of unemployment (in 2020 5.8% and 2.8%)

than other powiats in the regions, but they are highly vulnerable to changes in mining-related labor demand. PGG is the predominant purveyor of jobs in Bieruńsko-Iedziński, with 1 mine and 2 factories: 40 percent of the working population is directly employed by PGG, and an additional 6 percent are employed by mining subcontractors. Similarly, JSW provides one in three jobs in Jastrzębie-Zdrój, where its headquarters are located, 2 mines and a factory. An additional 14 percent of the workforce is employed by subcontractors on mining-related contracts. More generally, in these powiats, female unemployment rates exceed male unemployment rates, with elderly persons (45 years old or more) especially affected by unemployment, constituting one third of the registered unemployed).

Figure 17: Four powiats display a combination of high dependency on mining



Note: total employment on firms with more than 10 employees. Highly vulnerable and indirect jobs only include public tenders (and not the correction factor for small subcontractors).
Source: Frankowski et al. (2021).

3.8 Indirect impact of the mines closure beyond Silesia

The economic fortunes of Western Małopolska are highly linked to the mining activities in Upper Silesia. This follows from the dependence of several companies in Western Malopolska on mining activities (one located in Upper Silesia and one located in Western Malopolska). Historically, two of the powiats of Western Malopolska were also part of Silesia.[49] Particularly, two large hard coal subcontractors, are operating in Małopolska: WITMET (producer of angular connectors, stirrups, based in Kęty, Oświęcimski powiat – where Brzeszcze coal mine is located) and WOLBROM Conveyor Belt Factory (the oldest Polish manufacturer of rubber, with a plant located in Małopolska). Wolbrom, a small-sized city of 8,500 people, houses two other important rubber industry subcontractors – Met-Roll (producer of idles for conveyor

[49] Two powiats located in Lesser Poland (olkuski and chrzanowski) used to be a part of old province of Katowickie (where all the hard coal mines were located).

belts) and FAGUMIT (largest producer of middle and low-pressure hoses in Poland), together with Wostal – a recognized producer of elements of suspended monorails. Together, these companies employ more than 900 workers, making the local labor market particularly vulnerable to a decline in orders from the coal mines. While the mining industry is not the only client for these companies, especially the rubber companies, its orders are sizeable.

Apart from Western Poland, there are a couple of other geographical clusters spilling over into spanning neighboring regions. Dremex – one of the largest hard coal mining subcontractors – has their headquarters in Podkarpackie Region along with smaller wood suppliers for mines. Also, almost 4% of total revenues from hard coal and more than a half of the revenues from lignite mining are channeled to Warsaw.

4 The type of jobs coal-related workers can and would like to do

4.1 Local understanding of coal-related workers' skills and job preferences is needed

The coal-related workforce displays little mobility traditionally. Mining activities are by nature location-bound, with coal-based industries (coal-fired power stations, coking and steel industries) typically also establishing in the vicinity of the mines, given the bulkiness and cost to transport coal. This has often generated a strong attachment of coal-related workers to the local community and low geographical mobility (the Ruhr valley in Germany, the Nord-Pas-de-Calais basin in France, the Upper-Silesian basin in Poland). Beyond limited geographic mobility, employees of the mining sector usually also display little cross-sectoral mobility. Many spend their entire career working for one employer, the mining conglomerate, which typically also dominates the local labor market. Coal mining jobs often involve semi-skilled production and machine operation occupations, which have limited immediate transferability to other sectors. As they are usually better paid than others holding similar jobs in other sectors, employees in the mining sectors also have high wage expectations (section 3.3.4). As a result, even employees with skills that are easily transferable (e.g., electricians, drivers) have limited incentive to look for work elsewhere. These social and economic forces driving the limited geographic and intersectoral mobility of coal-related workers are compounded by a deeply felt cultural identity, rooted in mining.[50] Reasons for this could be traced to the communities' historical contribution to their nations' early industrialization and energy security, the emergence of social rights and workers' movements around mining-related activities, and strong group solidarity and work ethics in general.

Does limited mobility of the coal-related workforce across space and sectors still hold today? Low worker mobility limits the pool of potential job opportunities, exacerbating the challenge of a just coal transition. This holds especially when the surrounding districts or regions are economically vibrant, as in many regions in Poland (especially in Lower Silesia, but to a lesser extent also in Silesia and Wielkopolska). Yet, whether workers in Silesia value mine related work and job opportunities locally to the same extent as has been historically observed in Poland and elsewhere, is an empirical question. Mining has mechanized and automatized over the past decades. Along with it, the skill profile of its workers, and possibly also the link of their identity to mining and the mining community, may have changed.[51] Given the different health hazards involved, the mining related identity may also be stronger among deep-coal mining communities than among lignite workers (as in Wielkopolska and Lower Silesia). To inform policymakers and investors regarding the potential and desirability of different mine repurposing activities and economic diversification strategies, the skills profile

[50] Carley, et al., 2018, Mayer, 2018, Robertson (2006).

[51] Findings from the UK, however, suggest that the new technologies in mining that have intensified workplace monitoring and surveillance, have not changed mine workers' unique sense of identity as coal miners, given their continuing role as autonomous workers that mediate the impact of technology on their working practices (Allsop and Calveley, 2009).

and job aspirations of the directly and indirectly affected workforce of Silesia must be better understood. This also helps develop tailored training and job transition programs and policies for the affected workers and informs other labor market transitions affecting Silesia, such as the ongoing digitization of the economy and workplace and the transition to more environmentally sustainable economic activities.

A new skills and worker job preference survey among Silesia's coal-related workers helps shed light. During 2021, a skills and job preference survey was conducted among workers directly affected by the coal phase-out, at PWD, PGG, and SRK, across 16 branches, and covered 3,030 employees. The partners controlled the sample structure in relation to the desired population due to the sensitivity of the data. Partners assured that the sample reflected the targeted population. The results are presented jointly for these three groups of individuals and were not reweighted.[52]

The survey consisted of two parts: a skills and employment questionnaire and a Discrete Choice Experiment (DCE). It measured a range of transversal hard and soft skills and identified how respondents value different job characteristics, such as job location, job security, and job compensation, through a discrete choice experiment (DCE). The questionnaire also included detailed questions to determine the respondents' employment status and socio-economic situation to identify potential differences in skills and job attribute preferences across different socio-economic groups. The questionnaires were field tested and fine-tuned accordingly. They are in Annex 2.

4.2 Higher skilled coal workers skilled as others; lower skilled coal workers lag behind

4.2.1 Skills measurement and scales

The focus is on transversal skills. ILO (2004) shows that individuals are most employable when "*they have broad-based education and training, basic and portable high-level skills, including teamwork, problem solving, information and communications technology (ICT) and communication and language skills. This combination of skills enables them to adapt to changes in the world of work*." The better equipped the affected workforce in Silesia is with these "transversal" skills, the easier the transition to other jobs will be. The skills questionnaire thus focuses on core transversal skills that are not exclusively related to any particular sector or occupation.

The analysis is comparative. Rather than assessing the skill profile of the coal-related workers in absolute terms, the report compares them with the rest of the labor force in Poland to assess their comparative (dis)advantage vis-à-vis other workers. Information on universal competencies among workers in Poland has been annually collected through the Polish Human Capital Balance (*Bilans Kapitału Ludziego*, BKL) survey. It is the largest cross-sectional

[52] For confidentiality reasons, the structure of employment within each of the mining conglomerates was not disclosed, and it was impossible to reweight the final sample, which may have been subject to self-selection, despite instructions to each company to maintain a representative sample.

panel study monitoring the Polish labor market from 2010 to 2022. Self-assessment scales are used, going from 1 (very poor) to 5 (very developed), which will serve as a benchmark for our analysis. Self-skills assessments are easier and less expensive to administer than test-based skill measurement, though the findings on whether they are a good proxy for test-based skill measurement are mixed. By taking a comparative perspective, lingering doubts about the accuracy of self-assessed skills are mitigated.[53] The transversal skills of the coal-related workforce are thus assessed by comparison to those of the broader regional and national labor pool, using the same questions and similar survey settings as in the BKL survey.

Following skill domains were adopted. They were also queried in the BKL survey and relate to: self-organization and initiative taking, communication with other people, organizing and conducting office work, managerial abilities and organization of other people's work, fluency in Polish language (oral and written), ability to search for and analyze information and draw conclusions, capacity to maintain assemble and repair technical devices, ability to perform simple calculations, willingness to travel frequently, knowledge of specialized computer programs, ability to code and create websites, artistic and creative abilities, and physical strength.

4.2.2 Similar skills for higher skilled coal workers; lower skills for lower skilled coal workers

Tertiary-educated PGG, SRK and TWD employees display on average similar skills as other Poles (Figure 18)**.** Overall, higher skilled employees score similarly to other Poles in Silesia and Poland, for most skills, but substantially higher for maintenance and repair skills (+0.7 points), and somewhat lower for advanced digital skills (-0.9 point).[54] On the other hand, they show higher ability in group work and willingness to travel, though the differences are minor (+0.02 and +0.03)[55].

Among PGG, SRK and Tauron employees, less educated workers, i.e., those with at most upper-secondary education, display the lowest transversal skills, but they score better on technical skills (Figure 18)**.** Within mining conglomerates, miners have the lowest skill profile, far below managers and professional technicians, power plant employees, administrative and repair staff. The skills gap is largest for organization at work, digital skills, and simple calculus. On the other hand, miners feel more confident about maintenance, assembly, and repair of technical devices (respectively +0.6 and +0.7 points compared to Silesian and national

[53] Research by Allen & Van Der Velden (2005), Brown et al. (2015) and Davis et al. (2006) shows mixed conclusions as to whether self-skills assessments can be a good proxy for test-based skill measurement The comparison of the skill profiles among different groups holds, however, as long as potential biases in the self-assessments are unrelated to the group defining features. The report thus mainly operates on the differences in self-assessment, treating them as a relative measure and refraining from treating them as indicators of competencies in absolute terms.

[54] Both differences are statistically significant.

[55] The differences are insignificant.

Figure 18: Similar skills for higher skilled employees; lower skills for lower skilled miners

Source: World Bank Skills and Preference Survey (2021), BKL (2017).

averages)[56]. Miners are a substantial part of the total workforce: to the extent that the self-assessed transversal skill scores provide a good approximation of their skill levels in absolute terms, this suggests that they will face more difficulties in transitioning to other jobs, thus requiring special policy attention.

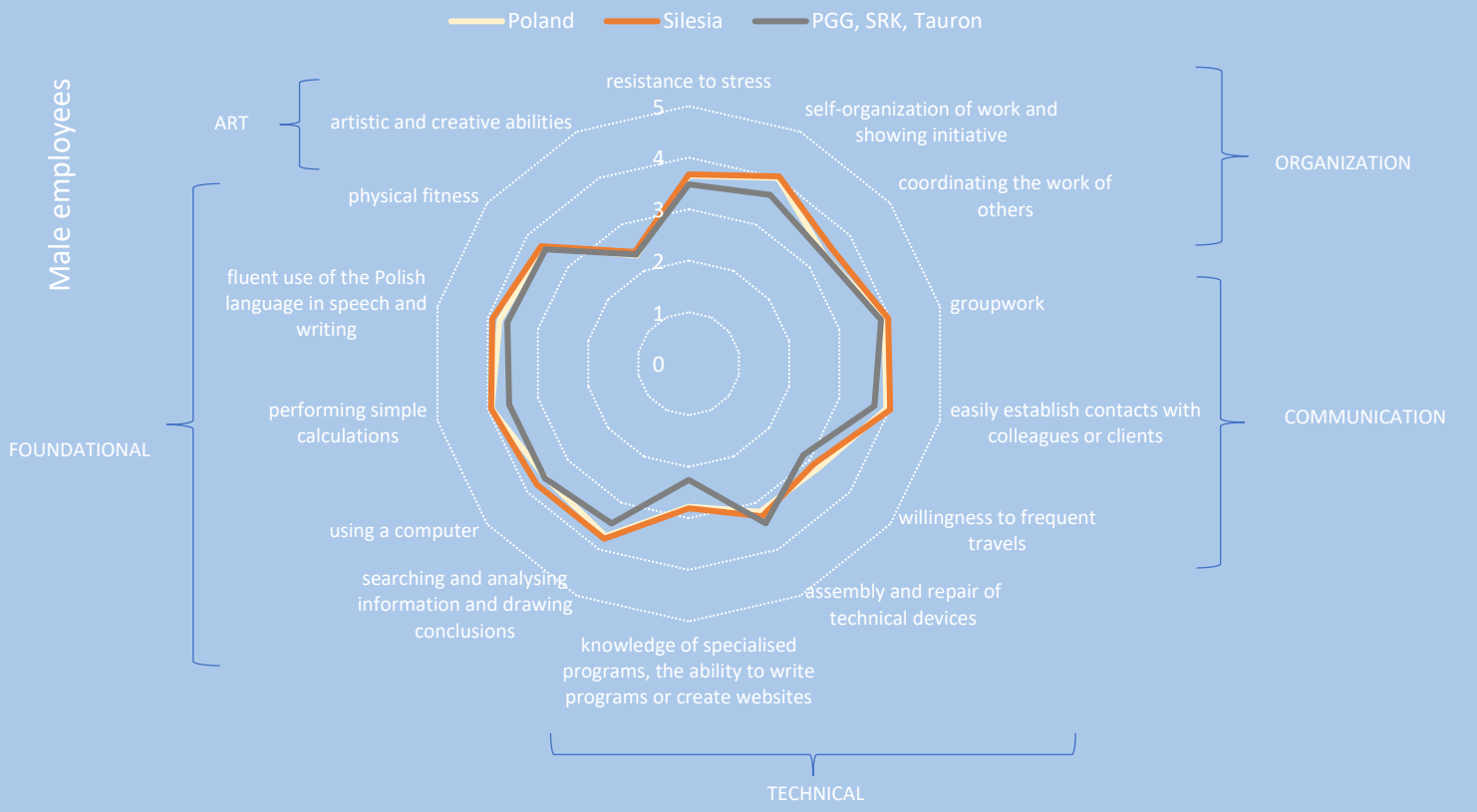
4.2.3 Men are more technical; women are better organized and more creative

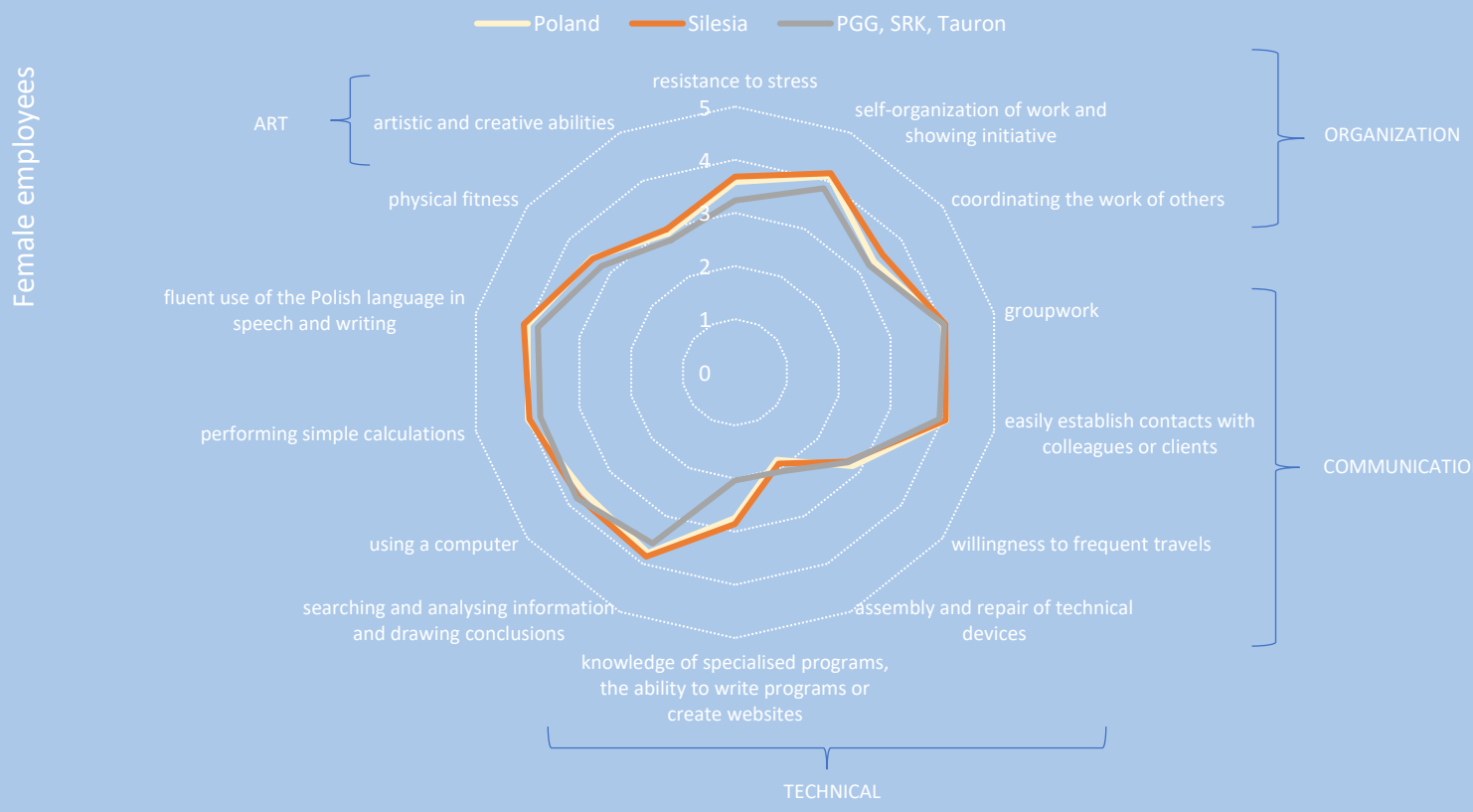
Male employees of the mining conglomerates display better technical and managerial skills and physical strength; female employees display higher creative abilities and have better cooperation and communication skills (Figure 19**).** Compared to national and regional averages, male respondents from PGG, SRK and Tauron display the lowest skills set, especially digital skills. The only exception lies in skills related to the assembly and repair of technical devices. Female employees of the mining conglomerate on the other hand show higher computer, group work, and technical skills than their counterparts in Silesia and Poland. Finally, within the mining conglomerates, men appear to be better managers, have higher technical skills, and physical strength, and are more willing to travel frequently; women report higher artistic and creative abilities, communication and cooperation with other people, and basic digital skills.

Finally, age matters, and younger cohorts are lagging behind their peers elsewhere in the region or Poland. Older workers (over 45 years of age) are on par with regional and national averages for technical skills and simple computer use and report higher communication skills than Silesian older workers. Younger workers on the other hand (below 45 years of age), report higher skills gaps compared to Polish and Silesian workers from the same age groups.

[56] The differences are statistically significant.

Figure 19: Male employees report better technical and managerial skills, while women are better at organization, coordination and creation





Source: World Bank Skills and Preference Survey (2021), BKL (2017).

4.2.4 Overall willingness to reskill to get a new job, especially for hard skills

Most workers feel that their skills are suited to their jobs. This holds for 66 percent of mining employees; 26 percent of PGG/SRK/Tauron workers feel that they have the skills to handle more demanding duties. 15 percent of women and 12 percent of men indicate that they need further training to do their current job well. For 39 percent of employees, the job performed in the mining conglomerate is inconsistent with their education and skills, particularly among younger workers (aged 45 or less).

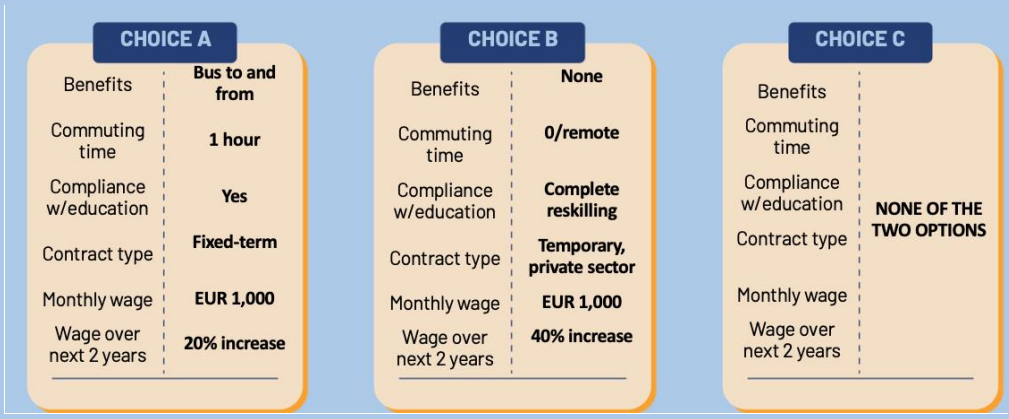
The majority of workers (76 percent) would be willing to reskill or acquire new competencies when looking for another job. Consistent with a more traditional learning environment, PGG/SRK/Tauron employees are primarily interested in training that develops hard competences. 61 percent of respondents would be interested in upskilling in hard skills, and almost 53 would like to upskill in soft skills (assertiveness, communication, etc.) and job search methods. Language courses were the most sought-after training, suggesting that workers are looking to more nationally or globally competitive sectors as a potential source of good-quality jobs. Workers also underlined their willingness to participate in training focused on digital skills – the field where the respondents rate their abilities especially low.

4.3 Job attributes coal-related workers value

4.3.1 The valuation of job attributes requires comparing job packages

To properly assess people's valuation of different jobs and job attributes, they need to be confronted with a clear (discrete) choice between different job packages with clearly defined attributes. Oftentimes, respondents do not or cannot know what future situation they prefer, either because they don't have an answer, or because they do not have enough information to make an informed decision. For example, one may be willing, or not, to move regions for a job, but the answer will depend on many other characteristics of the job offer such as the position, the wage, the type of contract, the benefits, the availability of childcare etc. Hence, instead of asking separately direct questions, such as one's willingness to move regions, or to change sectors, or to accept a pay cut, the DCE methodology reveals these preferences by asking the participant to choose several times, between two hypothetical options, each of which includes a significant set of characteristics, or *attributes*. This methodology follows a selection process of probabilistic nature, as described by McFadden (1974). The choice of an alternative that seems more attractive to respondents is determined by a utility that depends on individuals' observed characteristics and unobserved idiosyncrasies. This process allows modeling respondents' decision processes and extracting information about preferences (individual utility function parameters) based on pre-composed successive choices in a controlled environment.

Figure 20: Example of a choice card



Source: World Bank Preference Survey, 2021.

The DCE consisted of six choice sets, each of them offering two different job descriptions to choose from (Figure 20)**.** These two offers included detailed job characteristics or *attributes*: alignment with educational specialization, type of contract, a monthly wage, wage increase over the first two years of work, benefit levels, commuting time. The attributes and their levels were based on the literature review and preliminary qualitative work, including focus groups with local stakeholders (including PGG, SRK and PWD human resource department and trade unions). The choice experiment was divided into two designs (DCE 1 and DCE 2) with seven attributes each to prevent cognitive overload. See Annex 3 for more detail on the choice cards and their attributes and the econometric procedures applied to estimate the value attached to the different job attributes.

4.3.2 Strong preference for stability

DCE queries about workers' disposition towards job alternatives indicate travel time to work as one of the most important attributes when choosing a job, and even more so among women, higher educated and older workers. Reducing the travel time to work by one hour (each way) is valued at PLN 1,148 overall. This means that respondents would agree to sacrifice on average PLN 1,148 of their monthly salary if work commute is reduced by one hour each way - which is equivalent, on average, to one-fifth of a mining employee's monthly salary. Women are more sensitive to shorter commuting times, along with more educated and older workers.

Similarly, mining industry workers have a strong preference against relocating, and even more so among female, lesser educated and older workers. They evaluate the financial compensation justifying moving abroad for work at PLN 2,448 per month and moving to another region within Poland at PLN 1,651. Females display much higher WTP in order not to relocate (twice as high as the average), and the situation is similar for older workers, and those with lower education.

The second most important characteristic when choosing a new job is employment security as measured by an open-ended contract. Indeed, the preference goes to a permanent

contract, for which they would be willing to forego PLN 2,251, or two fifth of a monthly wage, as compared to a temporary contract. These preferences are particularly strong among women and older workers (above 45 years of age) and those with lower education. In addition, respondents reveal a strong aversion towards self-employment, which should be taken into account when projecting Active Labor Market Policy needs (ALMPs). Interestingly, employees prefer private employers or NGOs over public ones (WTP = PLN 150), and for being self-employed, they would require a monthly compensation of about PLN 1,400.

Finding a job in line with one's educational specialization is also important, especially for women and older workers. The average substitution rate was estimated at PLN 1,150 PLN. Women, older workers (above 45 years of age), and more educated workers value this attribute more strongly, and would be willing to sacrifice relatively more of their monthly earnings to ensure they can utilize their current set of skills and knowledge. In addition, women, older and more educated workers are more averse to positions involving dangerous conditions.

These results are corroborated by respondents' strong preference to remain in the mining sector. Respondents' disutility to change sector of employment is worth PLN 768 to PLN 1,935. Among non-mining options, renewable energy (RE) is the preferred sector of activity: employees would require a monthly compensation of only PLN 768. The preference for RE is particularly strong among younger cohorts and higher-educated workers, in line with recent trends and the change of attitudes towards greener energy sources among these two groups. The latter (highly educated) would prefer working in RE over working in the mining sector. The least preferred employment sectors are industrial processing, agriculture, and administration (office work): for these sectors, employees would request a monthly compensation of almost PLN 2,000. These findings could also be seen as an expression of the strong and intricate link between miners' identity and their work in the mines.

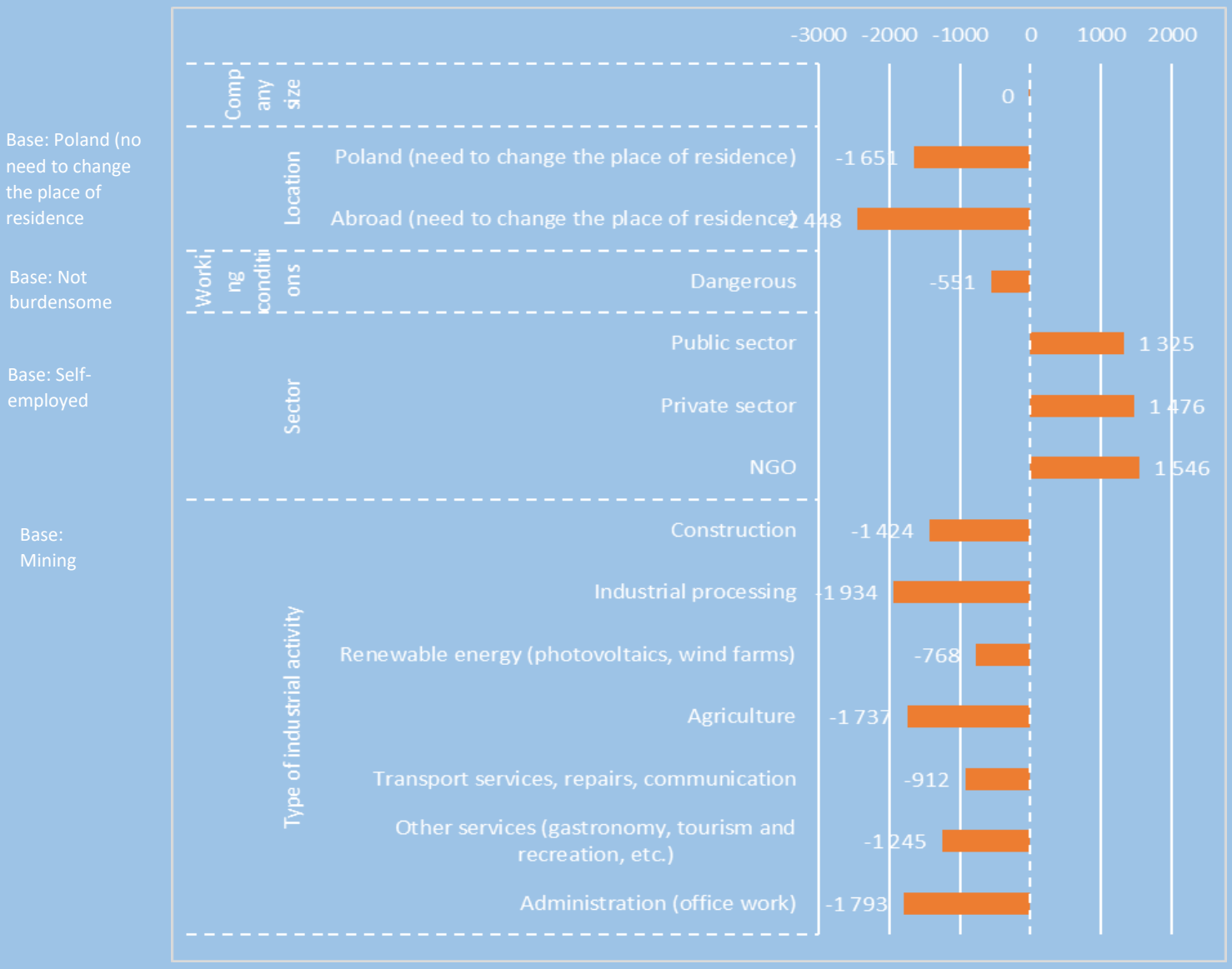
Workers are ready to accept lower job entry conditions if prospects for good progression are held. Employees of conglomerates strongly prefer a job that would guarantee a steep wage increase: when searching for a job, the development path and projection of income is particularly important: the prospect of a 40 percent earnings growth is valued at PLN 1,001.

Most of the workers would agree to substitute a part of the salary for some of the fringe benefits. They are willing to pay PLN 471 to have transport to- and from- work, PLN 440 to attend certified professional courses, PLN 332 to have private medical care, and PLN 332 to enjoy flexible working time. At the same time, they do not value in kind advantages such as a mobile phone or a computer, or childcare services. In his case, education and age do not seem to influence the set of employees' preferences.

Figure 21: Employees' preferences – DCE 1

Note: except from Mobile phone or computer (benefits) all attributes are significant at 10 percent.
Source: World Bank Skills and Preference Survey, 2021.

Figure 22: Employees' preferences – DCE 2



Note: except for Company size all attributes are significant at 10 percent.

Source: World Bank Skills and Preference Survey, 2021.

These findings give important voice to the affected workforce and help steer repurposing plans and investments to generate attractive employment and develop viable job transition paths. Understanding the strong aversion towards relocation and commuting time and the attachment to the mining sector, especially by the underground workers, the need for utilizing competencies, which are similar to the rest of the Silesian workforce for highly educated workers, but less for lower educated municipality workers, and the overall willingness to retrain, allow to better identify viable transition pathways compatible with the affected workforce's skills and job-related preferences.

5 The identification of viable job transition pathways for coal-related workers

5.1 Ingredients needed to assess the viability of individual job and labor force transitions

The (local) availability of jobs, workers' job preferences, and the extent of skills' (mis)match, determine the viability of job transitions for Silesia's coal-related workforce. Section 4 shows that most PGG/SRK/Tauron workers have lower transversal skills as other workers in the region (recall that the majority of the workers are among the lower educated). At the same time, they are also more competent technically, but less skilled digitally. All workers put a high value on being able to work nearby, in positions that provide job security. They prefer jobs that match their skills, but they are open to re/up-skilling. Assessing the extent of the coal transition challenge for laborers thus requires assessing the spatial, expectations and skills mismatch, i.e., 1) assessing the availability of alternative job opportunities and their location, 2) determining their attributes (salary, contract type, sector, benefits, …), and 3) identifying the skills required and the workers' ability and attitude towards re/up-skilling.

Trade-offs across these dimensions further complicate the assessment. Most jobs, whether currently available or only available in the future, are unlikely to score equally well on all three dimensions (local availability, job preferences, skills (mis)match). Systematically mapping out the trade-offs will be equally important to assess the individual and overall labor transition challenge. A job may be available, for example, but only in another region, or only under a self-employed as opposed to a salaried contractual arrangement. The better a job scores on each of the three dimensions, i.e. the smaller the spatial, expectations and skills mismatch, the more viable is the transition. At the aggregate or regional planning level, the more well matching jobs that there are already available or will be generated through appropriate repurposing of the mines or economic diversification, or that could be filled through well designed and well targeted re/up-skilling programs, the smoother will be the overall labor transition. Yet, as highlighted in Box 1 and illustrated in detail for the Appalachia region in the

United States, in the past, the labor transition has proven to be an uphill battle for many mining communities.[57]

Seemingly intuitive job transition pathways often prove unsuccessful. Job transitions considered by stakeholders are regularly restricted to different occupations within the same sectors of activity (e.g., reskilling a belt maintenance technician into a photovoltaic installer), or similar occupations in another sector of activity (e.g., offering a school bus position to a dismissed shuttle car operator). In Wielkopolska, ZE PAK's recent experience of reskilling workers within the energy sector from brown to green jobs has shown limited take-up, however, mostly due to the reluctance to commute, the limited ability of older displaced workers to retrain in a new occupation, and limited career prospects in the medium-to-long term (see Box 3). Such experience is not uncommon. As Michael Bloomberg said at the 2014 Bloomberg Energy Summit: "*You're not going to teach a coal miner to code. Mark Zuckerberg says you teach them [people] to code and everything will be great. I don't know how to break it to you . . . but no.*" [58]

Box 3: Retraining ZE PAK workers for opportunities in Renewable Energies (RE)

ZE PAK started its process of collective redundancies in 2020. To facilitate the transition of dismissed ZE PAK workers to RE opportunities, two three-days specialized trainings were organized to provide participants with photovoltaic installation fitter qualifications. Over 300 workers about to be dismissed were offered the training, 50 registered. They all graduated from the course and 21 graduates were short-listed for a position. In the end only 14 ended up accepting a job offer: 5 as photovoltaic systems electricians, 6 as photovoltaic installers, and 3 as construction engineers.

Although the training quality was high, few displaced workers transitioned to photovoltaic installers. Part of the reasons why the installer job offers were not appealing is because of the long distance (up to 120 km from Konin) to reach the photovoltaic installations every day. Second, trained employees were too old to work as installer in a photovoltaic farm. Finally, the photovoltaic sector does not offer long-term sustainable job opportunities: job demand is high at the beginning to build the infrastructure, but then the market and job demand disappear, as maintenance requirements are limited.

Source: Honorati (2022).

Obtaining timely and systematic information on the spatial, expectation and skills mismatch of alternative jobs and adjudicating potential trade-offs is challenging. Hiring intentions of employers captured through national employer surveys are frequently used to assess labor demand trends across occupations, sectors and locations (the number and types of jobs). They provide a powerful source to assess employment opportunities in the nearby future (typically the next 6-12 months), complementing the job vacancies published by public

[57] In Appalachia, a longstanding coal mining region in the United States, only 4 out of the 420 coal counties covered by the Appalachian Regional Commission managed a successful socio-economic transition out of coal (Labao et al., 2021).
[58] https://gigaom.com/2014/04/09/michael-bloomberg-you-cant-teach-a-coal-miner-to-code/

and private employment services. Yet not everywhere are employer surveys implemented on a regular basis, and when administered, the results may overlook employment opportunities provided by micro and small enterprises, they may not be representative at local/district level, or they are not publicly available. Employer surveys also give little guidance regarding future job emanating from mine repurposing or regional diversification strategies, either directly, but also indirectly in the supply chains, or through consumption linkages in the broader community. This further complicates proper tailoring of re/up skilling programs to the needs of the local labor market, while generic re/upskilling programs (unlinked to particular job opportunities) often prove to be rather ineffective (European Commission, 2012).

Second, to assess job preferences regarding different job attributes, DCEs can be used, but they are typically not widely or systematically applied. The potential of the DCE technique to assess job-related preferences/expectations has been illustrated in the context of coal-related workers in section 4. How these insights can then be used to help delineate the set of viable job alternatives is elaborated further in this section. Such information is, however, typically not readily available to policymakers, while the more widely used direct questions about attitudes towards different job attributes are deficient. As a result, worker preferences regarding job attributes are often insufficiently accounted for, neither in the planning of re/upskilling programs, nor in the development of repurposing activities or regional diversification strategies, burdening their chances of success as illustrated by the limited job placements following ZE PAK's renewable energy retraining program (Box 3).

Thirdly, and most challenging, is to assess the extent of skills (mis)match across jobs. It has also attracted a great deal of attention among policymakers. A pre-condition for a viable job transition is the worker's capacity to execute the tasks required (with or without re/upskilling). While this may be easier to assess on a case-by-case basis, from a planning perspective, it is also important to know how the skills of the workforce at risk of dismissal, match with the skills needed in currently available or future alternatives. To assess this requires having a similar skills metric that can be used to both describe the skills profile of the current labor force and the skills needed to perform the currently available or future jobs. This is data and computationally intensive. New artificial intelligence (AI) text mining algorithms are now starting to be used to do so. WEF (2018) and OECD (2021), for example, used online job postings collected by Burning Glass Technologies (BGT) and artificial intelligence (AI) text mining algorithms to analyze similarities between pairs of occupations, respectively in the US (WEF, 2018), and in EU-27 Member States, Australia, Canada, the United Kingdom, the United States, and New Zealand (OECD, 2021). Using online job postings has the advantage to use real time data and the most up-to-date vacancies description (tasks and skills requirements, location, contract type, salary, etc.), but it may skew the analysis towards higher skilled occupations and sectors, both of which are more likely to use online job postings.

5.2 Towards a "viable-job-matching" decision tool tailored to the Polish labor market

Publicly available Polish and location specific data on occupations and new jobs, DCE information on job preferences for coal-related workers and big data techniques are used to assess the extent of viable job transitions for the coal-related work force as present in the current labor market. Particularly, the section develops and illustrates how a new job matching decision tool anchored in location specific data can help individual case workers, mining conglomerates, public employment services (PES) and local authorities prioritize their actions, time and investments, including to develop tailored re/upskilling programs. It maps out job transitions opportunities for workers at-risk of losing their jobs in the mining and energy sectors, but the methodology can be applied to anyone looking for another job, looking to upskill and/or improve their wage prospects and job satisfaction. The method can also be readily adapted to different contexts and demand projections, including those of new investors or related to repurposing activities.

In particular, to identify viable job transitions, the following three constraints were considered: (i) the amount of reskilling due to the transition between two occupations was minimized, (ii) only occupations in growing demand on the local labor market were considered, and finally (iii) potential candidates were further screened using the results of the preference survey described in the previous section.

First, to assess the skills (mis)match across positions, the task-similarity between all professions was first assessed. Job descriptions (including those held by workers at risk through the coal transition) were extracted from the Polish Labor and Labor Offices Job Postings Office using the Selenium web scraper. This resulted in a list of 2.7 thousand key occupations. Occupations were then compared one by one based on their task content, using Latent Semantic Indexing (LSI), and a (task) similarity score (between 0 and 1) was constructed for each pair of occupations (yielding a 2.7k by 2.7k similarity score matrix). A similarity score close to zero signifies two occupations with very little overlap in terms of tasks demanded; a similarity score close to one signifies two occupations with large overlap in terms of tasks to perform. A career switch between two occupations with a low similarity score is likely to require substantial reskilling, or may be even impossible, while a career switch between two positions with a high similarity score may require limited retraining and may also be much more feasible, at least from a technical capacity point of view. The similarity score index thus allows to identify occupations which are very similar in task content to those currently conducted by the coal-related workforce, suggesting a high probability of a good match, provided that they meet the expectations of the workers and that they are available on the (local) labor market.

For robustness and refinement, an additional metric to assess skill similarity across occupations was introduced. In particular, the types of tasks required by each position were divided into five skills groups: non-routine manual (NRM), non-routine interactive (NRI), routine manual (RM), non-routine manual (NRM), routine cognitive (RC). This classification builds on the measure of routine and non-routine task content developed by Mihaylov and

Tijdens (2019), who provide a measure of the Routine and Non-Routine Task Content of 427 Four-Digit ISCO-08 Occupations. Each task in an occupation is assigned to one of the 5 groups (NRM, NRI, RM, NRM, RC). The indexes are created by dividing the number of tasks belonging to a given category by the number of all tasks performed in a given occupation. Then, the occupation is classified to one of the 5 skill groups, i.e., the skills group whose tasks accounts for the largest share in that occupation. The results are reported at the 4-digit level and were integrated in the dashboard, defining the top similar professions across those five dimensions. In what follows below, the job with the highest similarity score in each of the 5 skill groupings will be featured and its viability discussed further based on its availability in the local market and the wage such a job earns on average (as reported in Labor Force Survey, 2018).

Second, job transitions were restricted to positions with excess demand on the local labor market. Poland does not administer an employer survey on a regular and highly disaggregated basis that could be used to locally investigate labor demand. Yet, it annually produces a more qualitative assessment of labor demand through the so-called occupational barometers. These are developed by the powiat labor offices and used here to identify jobs with excess demand,[59] in order to restrict job transitions to occupations in growing demand, or with high potential (Górna – Kubacka, Komasa and Rybak, 2020).[60]

Finally, the viability of the options is further checked against the value assigned to different job attributes as revealed through the DCE. The DCE results of Section 4 were used to further scrutinize the opportunities short-listed by the similarity scores and the occupational barometers. For instance, PGG/SRK/Tauron workers display a strong aversion to commuting or moving regions. The subset of job offers that were not present locally and implied moving to another part of the country were scrutinized: if the wage increase was below PGG/SRK/Tauron employees' willingness to pay, the option was discarded.

For more detail on the method and application, see Annex 4, which also provides screenshots of the data presented in the designed online tool used to develop the different pathways.

5.3 Five transition pathways relevant to the mining and energy sector

Five positions typically found in the mining and power sector were selected, five associated transition pathways identified, and their viability discussed. Using the methodology described in Section **Error! Reference source not found.**, five potential transition pathways a re each time identified for each position, one for each of the 5 skills grouping discussed (non-

[59] Occupational barometers of occupations in surplus, balance or deficit, produced by local Labor Offices were used here to identify occupations in excess demand. The occupational barometers represent a qualitative consensus view of local labor market stakeholders, including local labor offices, the industry and their chambers of commerce, and civil society (labor unions, academics, etc.). The methodology can be adapted to use other sources of labor market forecasting

[60] https://barometrzawodow.pl/#wielkopolskie

routine manual, non-routine interactive, routine manual, non-routine manual, routine cognitive) and implying different reskilling efforts needed. Within each skill group, the occupation with the highest task similarity score was retained to capture the most similar job. The potential wage differential associated with the career change, and the availability of those jobs locally are also discussed. Most trajectories imply reskilling and some involve pay cuts, in the short-term, but wages should increase in the longer-term given that all occupations are in growing demand.

Most trajectories do not point to retraining and upskilling in renewable energies, the focus of much of the regional diversification efforts, or in digital jobs, often considered the jobs of the future. In fact, the transition from coal-based energy production to renewable energy can often be complicated by the complexity of retraining and upskilling (can dismissed workers be reskilled, and are they willing to?), fundamental differences between workplace characteristics (is the nature of the work aligned with displaced workers' expectations and preferences), and/or lack of such opportunities on the local labor market (especially in the case of dismissed workers with low geographic mobility). The transition from a *mechanic of opencast mining machinery and equipment* to *fitter of renewable energy devices* displays a score of 0.54, which is relatively low. Similarly, the transition from a *mining engineer – lignite mining* to an *engineer of equipment and renewable energy systems* displays an even lower similarity score of 0.36, suggesting limited overlap of skills (at least as captured by task similarity). Finally, the transition from a *technician of opencast mining and equipment* to a *technician of renewable energy systems* displays a similarity score of 0.26, suggesting that this option would not utilize most of the skills and experience acquired by the displaced workers.

5.3.1 Underground miners will not be able to maintain their salaries

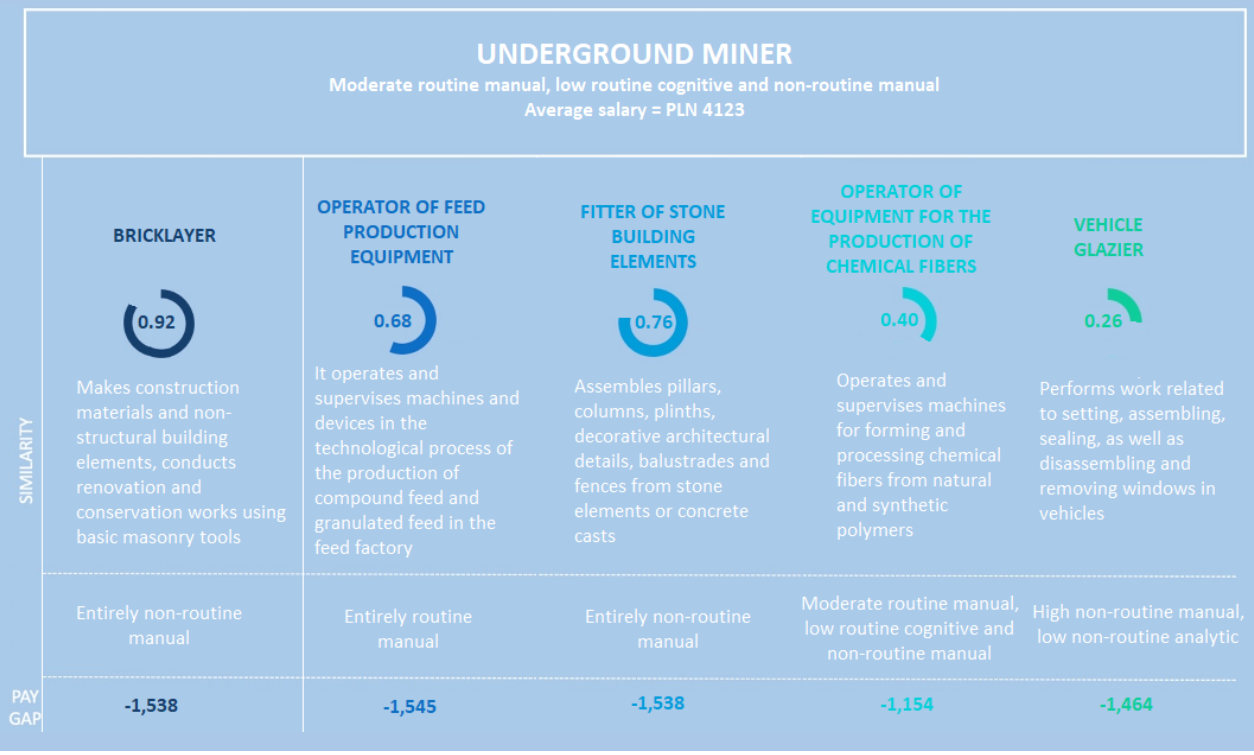
For an underground miner, all optimal transition pathways entail a wage decrease, **irrespective of their similarity score** (Figure 23)**.** An underground miner carries out activities that mostly require moderate routine manual skills and low routine cognitive and non-routine manual skills, for an average monthly salary of PLN 4,123. The closest transition pathways display a wide range of similarity scores, from low (0.26) to very high (0.92), and a wage reduction of PLN 1,154 to 1,545, or a 30 to 40 percent drop.

The closest profession is that of a bricklayer (similarity score of 0.92). Switching to this profession would cause a loss in salary equal to more than PLN 1,500, as well as a substantial change in the types of skills involved on the job: a bricklayer performs entirely non-routine manual activities, as opposed to the mostly routine manual of an underground miner.

The smallest wage loss would be when switching to an operator of equipment for the production of chemical fibers (equal to PLN 1,154). The types of activities performed are of the same type as an underground miner, but the two positions show a significantly lower similarity score (equal 0.40). The other two positions show high similarity indexes (respectively equal to 0.76 and 0.68) but involve a considerable loss in the salary of more than PLN 1,500.

The most viable transition pathway seems to be to a bricklayer. Nonetheless, such transition would generate an income drop of almost 40 percent, and the switch from routine to non-routine manual activities. While other proposed pathway transitions may exhibit better fit of activities, there are larger differences in the overall similarity index.

Figure 23: Examples of pathway transitions for an underground miner



5.3.2 Operators of machines for coal processing can easily find similar positions, with a substantial salary increase

Operators of machines for coal processing have a choice between transition pathways which entail higher salaries, and high similarity indexes (Figure 24)**.** An operator of machines for coal processing mostly uses routine-manual skills and sometimes routine-cognitive and non-routine manual skills, for an average monthly salary of PLN 823 per month.

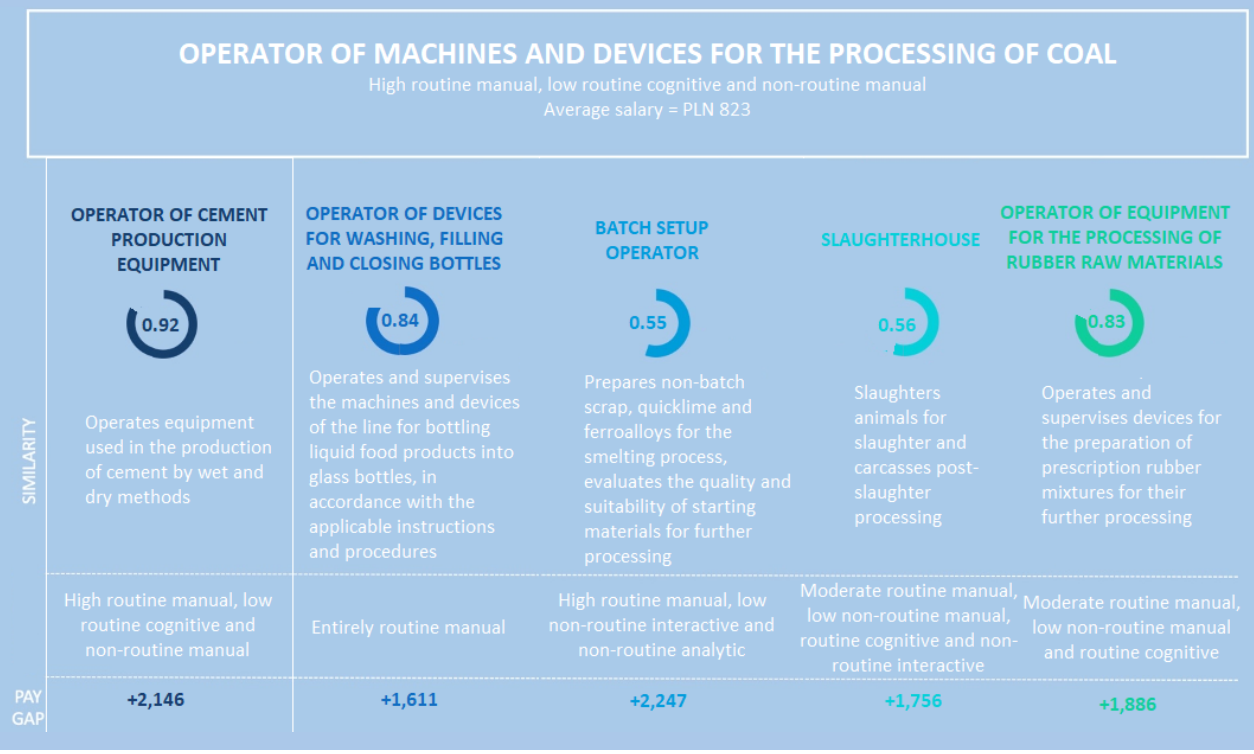
The closest position in terms of task similarity is that of an operator of cement production equipment (similarity index of 0.92). Two other transition pathways also display high similarity scores: 0.84 for an operator of devices for bottling, and 0.83 for an operator of equipment for rubber processing. These three positions would generate substantial salary increases (equal to PLN 2,146, PLN 1,611, and PLN 1,886, respectively). Generally, activities performed in these professions overlap or are of the same type as those performed by an operator of machines for coal processing.[61]

[61] Some reskilling may be required to switch to operating devices for bottling and operating equipment for the processing of rubber.

The profession with the highest salary increase is a batch setup operator. With a monthly increase of PLN 2,247, an operator of machines for coal processing would earn almost 4 times as much in this new position. But the low similarity score of 0.55 suggests that substantial reskilling would be required.

The most reasonable transition pathway is thus to switch to operating cement production equipment. The position has a high similarity score and a substantial increase in salary. While other professions may entail even higher wage increases, operating cement production equipment would involve little-to-no reskilling due to the high similarity between professions. The new salary would be more than 3.5 times the previous one.

Figure 24: Examples of pathway transitions for an operator of machines for coal processing



5.3.3 Drivers of mining hosting machines can switch to jobs with no reskilling nor wage loss

For drivers of mining hosting machines, most transition pathways show high similarity indexes and comparable salaries (Figure 25). A driver of mining hosting machines performs exclusively non-routine manual tasks, for an average monthly salary of PLN 3,602 per month.

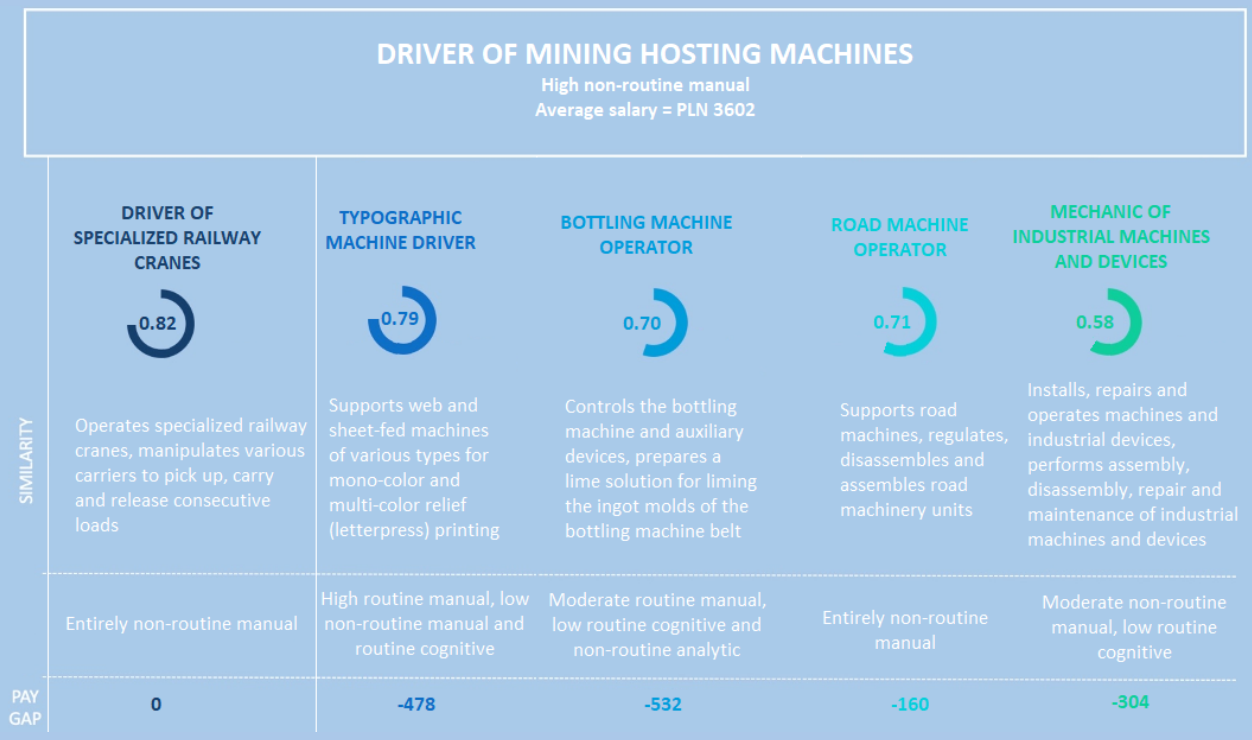
The closest position in terms of task similarity is that of driver of specialized railway cranes (similarity index of 0.82). This transition pathway would not entail any income loss, and the activities to be performed by the worker would be of the same type as those performed as a driver of mining hosting machines, thereby requiring no reskilling.

Two other transition pathways display high similarity scores: typographic machine driver and road machine operator, equal to 0.79 and 0.71, respectively. Nevertheless, choosing one of these professions would entail a wage loss of PLN 478 and PLN 160, respectively. In

addition, the differences in the activities performed would require some reskilling, although minor.

The most reasonable transition pathway is thus to switch to driving specialized railway cranes. This transition pathway displays high similarity score, little-to-no reskilling, and no wage loss.

Figure 25: Examples of pathway transitions for a driver of mining hosting machines



5.3.4 Fitter of vehicles and transport devices can switch to jobs with no reskilling nor wage loss

For fitters of vehicles and transport devices, most transition pathways show high similarity indexes and comparable salaries (Figure 26). A fitter of vehicles and transport devices performs mostly routine cognitive tasks, and sometimes routine manual tasks, for an average monthly salary of PLN 2,995.

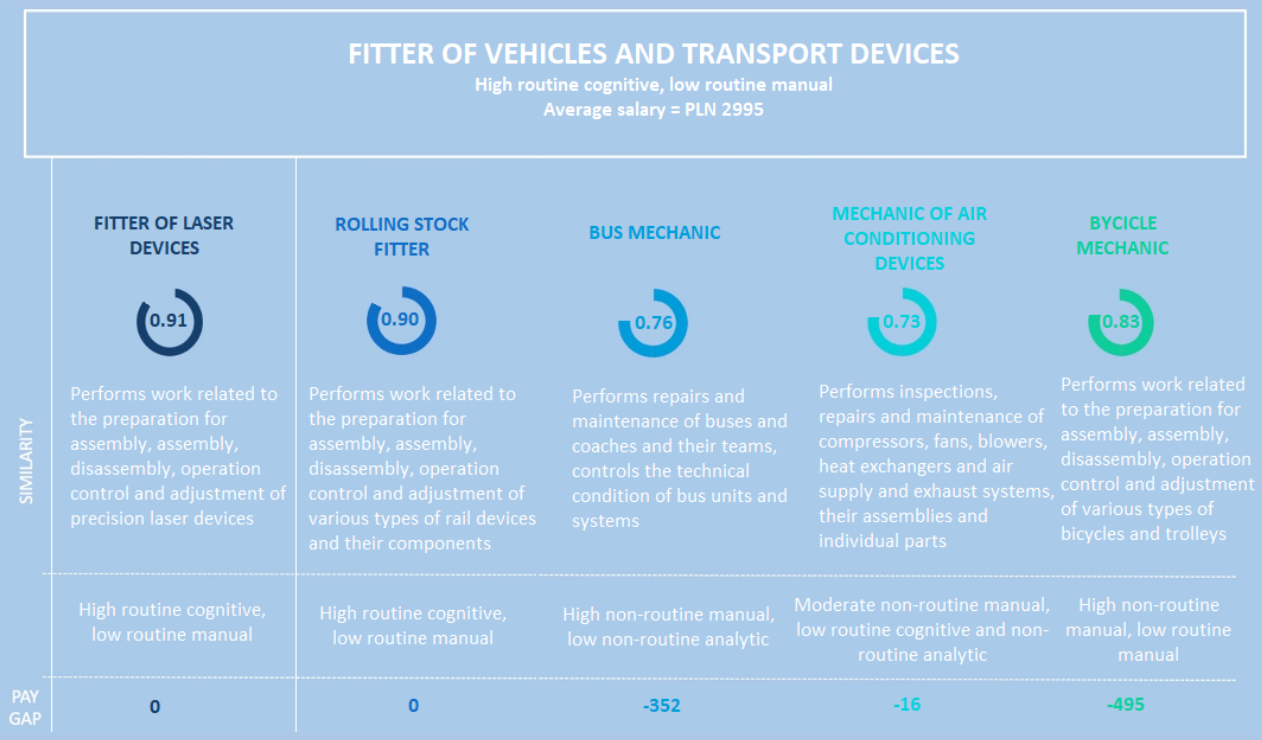
Two transition pathways require little-to-no reskilling with no wage loss: fitter of laser devices and rolling stock fitter. These positions display similarity score of 0.91 and 0.90, respectively. In both cases, the need to reskill is limited. The positions also entail no change in monthly salary. These two professions are highly comparable, both with the fitter of vehicles and transport devices, and between themselves.

Switching to a bicycle mechanic would require some reskilling and would entail a wage loss. This transition would generate a monthly salary drop of close to PLN 500, or almost 17 percent. Furthermore, the profession would require reskilling, as the activities performed

would be mainly non-routine manual, instead of routine cognitive that are usually executed by fitters of vehicles and transport devices.

The transitions to the positions of fitter of laser devices, or rolling stock fitter, are the soundest alternatives. Neither is associated with the need for reskilling, nor a change in salary. Moreover, for both professions, the similarity index is remarkably high.

Figure 26: Examples of pathway transitions for a fitter of vehicles and transport devices



5.3.5 Conveyor belt operator

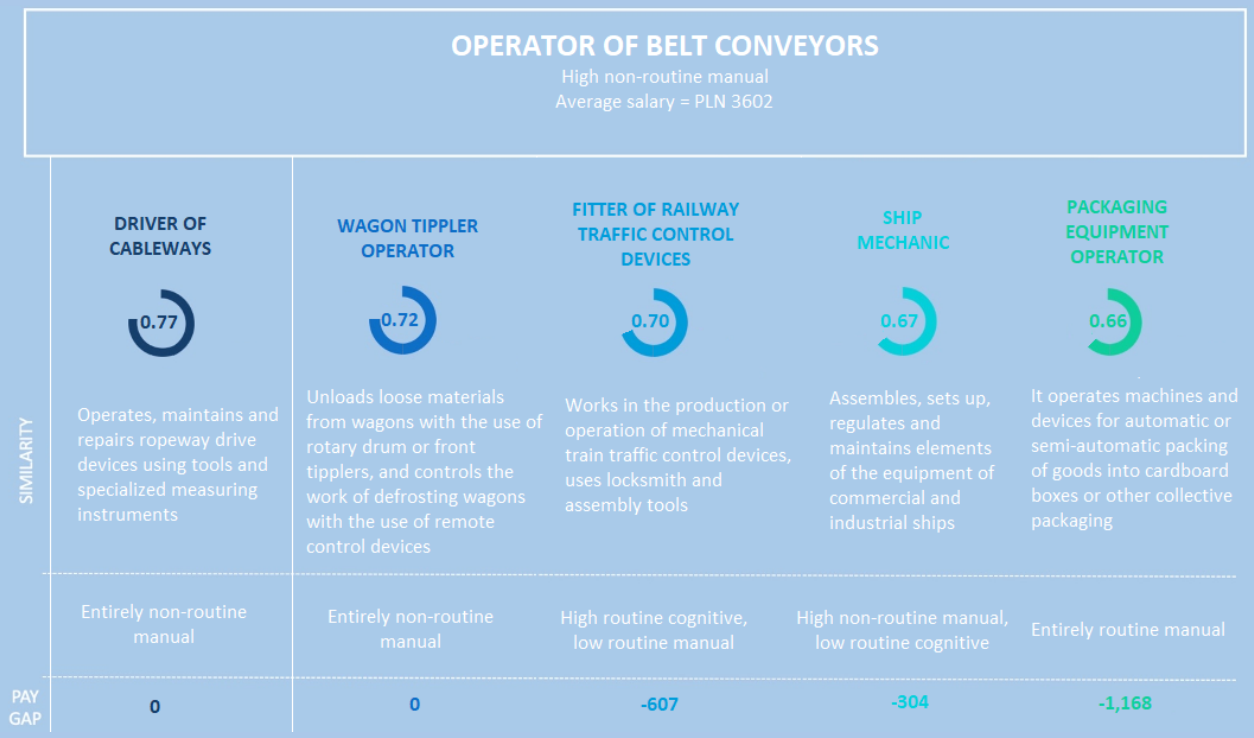
Conveyor belt operators can switch to jobs with limited reskilling and no income drop salary (Figure 27). A conveyor belt operator carries tasks based on non-routine manual activities, for a monthly salary of PLN 3,602.

Two transition pathways require little-to-no reskilling with no wage loss: driver of cableways and wagon tippler operator. Both show high similarity indexes, of 0.77 and 0.72 respectively, and would not require any significant reskilling given that both jobs are also based on non-routine manual activities. Moreover, both transitions would maintain similar monthly salaries.

The other alternatives present lower salaries and require different skills. In particular, fitting railway traffic control devices, and operating ship mechanic and packaging equipment show lower (although still high) similarity indexes – between 0.66 and 0.70 – and would generate a loss in salary, up to PLN 1,168 for the latter. All the three would also involve some reskilling, given the different type of activities to be performed.

The most viable transition pathway would be driving cableways: the new position would offer the same average salary and the conveyor belt operator would perform tasks similar to what he did in the past. The required skills also overlap with previous skills: both professions are based on non-routine manual skills. Switching to operating wagon tipples is also a feasible alternative, even though with a slightly lower similarity index.

Figure 27: Examples of pathway transitions for a conveyor belt operator



6 Conclusions

A geographically focused, or local economic development approach to just coal transition, rather than a sectoral approach, is called for. Climate change is forcing a transition to carbon neutrality, putting many jobs at risk in and especially around the mines. As Europe's largest coal producer, Poland is at the forefront of the European coal transition. Within Poland, Silesia is the region most dependent on coal; 80 percent of Poland's mining workforce is located there. More specifically, according to the latest figures, 72,000 persons are directly employed in Silesian mining conglomerates, and an additional estimated 17.3 thousand jobs are in subcontracting firms in Silesia, most of them within 20 kilometers of the mines. More important than this large number of coal-related jobs is their spatial concentration. In Silesia, coal-related jobs are especially important to the Rybnik subregion, where they can account for up to 50 percent of total employment in some of the powiats. These communities, which are often already lagging, are likely to be hit particularly hard; these circumstances call for a locally-focused economic development approach to just coal transition.

The energy sector can potentially be a catalyst for future regional development and employment, but the path to achieving this economic stimulus role is not certain. At the global level, new jobs in transition-related technologies and sectors are expected to outweigh job losses in fossil fuels and nuclear energy (IRENA, 2021). Conversion into wind or solar parks, for example, could provide re-employment opportunities for some coal workers after an adjustment of skills, since electrical and mechanical skills, experience of working under difficult conditions and sophisticated safety experience are in demand in the wind and solar energy industries. Similarly, the re-use of closed mines for geothermal energy or hydropower applications could also provide jobs and socioeconomic benefits to post-mining communities. However, the distributional impact of the transition may not guarantee successful job transitions across all skill sets: medium-skilled occupations display the highest opportunities for retraining and upskilling measures for the green transition, but low- and high-skilled workers are likely to find fewer opportunities (ILO, 2018). The success of transitions within the mining and energy sectors will also be subject to the jobs-related aspirations of the dismissed workforce and their willingness to participate in retraining and upskilling programs. More broadly, the availability of viable job alternatives will depend on the extent to which new economic activities can be developed that make maximum use of the existing skill pool, including through appropriate re-purposing of the mines and their assets.

Analysis combining large and representative datasets, econometric techniques, and machine learning can be used to develop well-tailored, realistic and acceptable retraining and reskilling programs.

Firstly, the discrete choice experiment (DCE) showed how voice can be given to displaced workers, whose preferences are typically ignored, partly because it is challenging to capture these preferences adequately and systematically. Workers likely to be affected by the coal transition express strong mobility aversion (both to relocation and longer commuting time),

consistent with the strong preference for in situ job creation, a sentiment also voiced during stakeholder consultations. The DCE results also showed that workers' relatively high reservation wages may need to be addressed by offering jobs with a set of desired non-pecuniary benefits such as a clearly defined career development path (with earnings increases) and jobs compatible in skills and education, or employment sector and type of contract. Despite significant heterogeneity in terms of job attribute preferences, the vast majority of affected workers demonstrate an overall willingness to work and reskill as needed.

Secondly, leveraging machine learning and online job descriptions allowed to identify *plausible* transition pathways for workers affected by the transition. Incorporating the DCE results further helped to narrow down *available and acceptable* options that not only imply good matches in terms of skill and task similarity but that are also in excess demand in the local labor market and within the range of desired job attributes. Oftentimes, job transition pathways considered by stakeholders are unrealistic. The possibility of a transition from brown jobs to green occupations, for example, is often treated overly optimistically in the transformation process, but trajectories to retrain and upskill the dismissed workforce to renewable energy jobs display low similarity scores, suggesting that displaced workers would not utilize most of the skills and experience they had acquired pre-transition. Most viable transition pathways identified for typical occupations at PGG/SRK/Tauron are in fact in technical operators, with easier transitions for non-sector-specific workers, and more difficult transitions for higher-skilled specialized employees.

The discrete choice experiment (DCE) run for miners and other workers in the mining towns will be essential to design tailored coal transition policies that leave no one behind.

More broadly, the methodologies and techniques presented above could be used to assist public officials in designing effective labor market transition plans during factory closure in single employer dominated labor markets.

The techniques and findings that emerged from the DCE on mine-sector workers can also be used to inform other labor market transitions, such as the ongoing digitization of the economy and workplace and the transition to more environmentally sustainable economic activities. Doing so requires further ground-truthing and operationalization of the tools. More broadly, the DCE and job matching tool illustrated here in the context of the just coal transition are just an example of the type of methodology that could be used in similar contexts of large-scale lay-offs in areas with single employer dominance.

The identification of viable job transition pathways demonstrates the potential power of data-driven approaches for finding solutions to job disruptions, including reskilling opportunities that might not be immediately apparent. Job opportunities were mapped out for workers at-risk of losing their jobs in the mining and energy sectors, but the methodology can be applied to anyone looking to upskill and improve their wage prospects and job satisfaction: the methodology is not limited to the geography and sector presented here, and can be adapted to different contexts and demand projections. Instead of matching displaced workers with

current opportunities as identified by local Labor Offices, labor market forecast, development strategies, or investors' interest in moving to the region (including Special Economic Zones) can be fitted in the job transition pathway tool developed.

Despite potential delays in the closure of Poland's coal mines in the short run, in view of the Russian invasion of Ukraine, the diagnostic and methodology developed for this report remain valid. The transition away from coal is as relevant as ever. With Poland already importing a fair amount of coal from Russia, the Russian invasion is likely to accelerate the development of carbon neutral energy sources in the medium run, while securing energy supplies with the use of coal in the near-term.[62] In the short-run, the European Commission proposed to reduce Poland's dependence on natural gas and coal imports from Russia, extending the lifetime of coal-fueled blocks, while accelerating the rollout of renewable energy sources.[63] The changes in energy policy as well as the influx of Ukrainian refugees may have an impact on an already tight labor market.[64] The key findings emerging from the skills and preferences survey are expected to remain unchanged in the near term: skills similarity, reluctance to commute or relocate, preference for job security, willingness to switch sectors if employees can keep deploying their skills, willingness to take up lower paying job when there are credible wage growth prospects, etc. The matching tool developed to identify optimal transition pathways can be adapted to include new occupations that may arise in the near future, or otherwise respond to changing labor demand. Overall, the imperative to take a local economic development perspective as opposed to a sectoral perspective will remain unchanged.

[62] https://www.iea.org/news/how-europe-can-cut-natural-gas-imports-from-russia-significantly-within-a-year
[63] https://www.politico.eu/article/coal-not-taboo-as-eu-seeks-russian-gas-exit-says-green-deal-chief/
[64] The initial wave of refugees, constituted mainly of women and children, is concentrated in the capital city of Warsaw.

Bibliography

Alves Dias, P., K. Kanellopoulos, H. Medarac, Z. Kapetaki, E. Miranda Barbosa, R. Shortall, V. Czako, T. Telsnig, C. Vazquez Hernandez, R. Lacal Arantegui, W. Nijs, I. Gonzalez Aparicio, M. Trombetti, G. Mandras, E. Peteves, and E. Tzimas, 2018. "EU Coal Regions: Opportunities and Challenges Ahead," JRC 112593, Publications Office of the European Union, Luxembourg.

Baran, J., A. Szpor, J. Witajewski-Baltvilks, 2020. „Low-carbon transition in a coal-producing country: A labour market perspective," *Energy Policy*, *147*, 111878.

Barometr zawodów, https://www.barometrzawodow.pl/#wielkopolskie, access: 1.12.2021.

Brown, G. T., Andrade, H. L., & Chen, F. (2015). Accuracy in student self-assessment: directions and cautions for research. *Assessment in Education: Principles, Policy & Practice, 22(4)*, 444-457.

Churski P., R, Perdał, M. Burchardt, 2021. Czasoprzestrzenna analiza zmian lokalnego rynku pracy podregionu konińskiego w konsekwencji sprawiedliwej transformacji," Uniwersytet im. Adama Mickiewicza w Poznaniu, Poznań.

Daly, A., S. Hess, K. Train, 2012. "Assuring finite moments for willingness to pay in random coefficient models," *Transportation*, *39(1):* 19-31.

Davis, D. A., Mazmanian, P. E., Fordis, M., Van Harrison, R. T. K. E., Thorpe, K. E., & Perrier, L. 2006. "Accuracy of physician self-assessment compared with observed measures of competence: a systematic review," *Jama, 296(9)*: 1094-1102.

EBRD, 2020. "Insights from Historical Cases of Transition". Background Paper for the EBRD Just Transition Initiative.

EURACOAL, 2020. "Country Profile – Poland," https://euracoal.eu/info/country-profiles/poland [accessed on 11/29/2021].

Deville, J.C., and C.E. Sarndal, 1992. "Calibration Estimators in Survey Sampling," Journal of the American Statistical Association 87: 376–382.

Frankowski, J., J. Mazurkiewicz, J. Sokołowski, and P. Lewandowski, 2020. „Zatrudnienie w górnictwie węgla kamiennego w Zagłębiu Górnośląskim," IBS.

Frankowski, J., J. Mazurkiewicz, J. Sokołowski, and P. Lewandowski, 2021. „Labour Force Affected by Coal Mine Closures in Three Phasing-out Polish Regions: Upper Silesia, Lower Silesia and Greater Poland," IBS.

Górna – Kubacka A., M. Komasa, M. Rybak, 2020. "Barometr zawodów 2021," Wojewódzki Urząd Pracy w Krakowie. https://arrtransformacja.org.pl/wp-content/uploads/2021/09/Raport-Barometr-Zawodow-2021.pdf

BDL, https://bdl.stat.gov.pl/bdl/start, access: 1.12.2021.

Hołub-Iwan J., I. Orsa-Chomiak, T. Michał, K. Gutta, T. Gutta, P. Gozdek, 2019. „Stan i perspektywy rozwoju inteligentnych specjalizacji w subregionie konińskim," EU-Consult sp. z o.o., http://iw.org.pl/stan-i-perspektywy-rozwoju-inteligentnych-specjalizacji-w-subregionie-koninskim-raport/

Honorati, Maddalena, 2022. Options to support workers through a transition away from coal in Eastern Wielkopolska. World Bank Group, Jobs Group. Mimeographed.

ILO (2004). R195 - Human Resources Development Recommendation (no. 195). https://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:12100:0::NO::P12100_INSTRUMENT_ID:312533

Ingram, T., K. Bartuś, M. Baron, and Ł. Bielecki, 2020. "Ekspertyza Dotycząca Konsekwencji Likwidacji Kopalń Węgla Kamiennego dla Sektora Okołogórniczego oraz Sytuacji Społeczno-Gospodarczej w Polsce," Centrum Badań i Rozwoju, Uniwersytet Ekonomiczny w Katowicach, Katowice.

IRENA, 2020. "Global Renewables Outlook: Energy Transformation 2050," International Renewable Energy Agency, 212.

IRENA and ILO, 2021. "Renewable Energy and Jobs – Annual Review 2021," International Renewable Energy Agency, International Labor Organization, Abu Dhabi, Geneva.

Katowice Regional Labor Office, 2022. "Registered Unemployment in the Silesian Voivodeship at the end of June 2022," Katowice, https://wupkatowice.praca.gov.pl/documents/162604/893121/Informacja%20kwartalna%20-%20ANG/68a9f51b-6322-4e6d-95fe-e670765dd305

Kiewra D., A. Szpor, and J. Witajewski-Baltvilks, 2019. "Sprawiedliwa Transformacja Węglowa w Regionie Śląskim. Implikacje dla Rynku Pracy," IBS Research Report 02/2019.

Lancaster, K. J., 1966. "A new approach to consumer theory," Journal of political economy, 74(2), 132-157.

Martinez-Fernandez,C., N. Kubo, A. Noya and T. Weyman, 2012. "Demographic Change and Local Development: Shrinkage, Regeneration and Social Dynamics," OECD, Paris.

McFadden, D.,1974. "Conditional Logit Analysis of Qualitative Choice Behavior," in P. Zarembka (editor), Frontiers in Econometrics, New York: Academic Press.

McFadden, D., 2001, "Economic choices," American economic review, 91(3), 351-378.

McFadden, D., K. Train, 2000. "Mixed MNL models for discrete response," Journal of applied Econometrics, 15(5), 447-470.

Mihaylov, E., K. G. Tijdens, 2019. "Measuring the Routine and Non-Routine Task Content of 427 Four-Digit ISCO-08 Occupations," Tinbergen Institute Discussion Paper 2019-035/V, http://dx.doi.org/10.2139/ssrn.3389681

OECD, 2021. “OECD Skills Outlook 2021: Learning for Life,” OECD Publishing, Paris. https://doi.org/10.1787/0ae365b4-en.

Pacifico D., 2014. “Sreweight: A Stata Command to Reweight Survey Data to External Totals,” The Stata Journal. 14(1):4-21.

Piggot, G., M. Boyland, A. Down, and A. Raluca Torre, 2019. “Realizing a Just and Equitable Transition away from Fossil Fuels,” Stockholm Environment Institute, Stockholm.

Revelt, D., K. Train, 1998. “Mixed logit with repeated choices: households' choices of appliance efficiency level,” Review of economics and statistics, 80(4), 647-657.

Ruppert Bulmer, E., K. Pela, A. Eberhard-Ruiz and J. Montoya, 2021. “Global Perspective on Coal Jobs and Managing Labor Transition out of Coal: Key Issues and Policy Responses,” Job Groups, The World Bank.

Strietska-Ilina, O., K. McCoshan, A. McCoshan, G. Montt, M., Harsdorff, B. Tumurchudur-Klok, A. Podjanin, S. Broek, M. Hudepohi, T. Mahmud, 2019, Skills for a greener future: A global view. Geneva: International Labour Organisation. https://www.ilo.org/wcmsp5/groups/public/---ed_emp/documents/publication/wcms_732214.pdf

Szymkowiak, M., A. Młodak, Ł. Wawrowski, 2017. „Mapping poverty at the level of subregions in Poland using indirect estimation,” STATISTICS, 609.

Thissen, M., G. Mandras, 2017. “The importance of network: Consistent Interregional Trade and Transport flows between European NUTS 2 regions,” JRC. IPTS Working Papers.

Train, K., M. Weeks, 2005. “Discrete choice models in preference space and willingness-to-pay space,” In Applications of simulation methods in environmental and resource economics (pp. 1-16). Springer, Dordrecht.

Valliant, R., J.A. Dever, 2018. “Survey Weights: A Step-by-Step Guide to Calculation,” College Station, TX: Stata Press.

Wirth, P., B. Mali, and W. Fischer, 2012. “Post-Mining Regions in Central Europe. Problems, Potentials, Possibilities.”

White, I.R., P. Royston, and A.M. Wood, 2011. “Multiple Imputation Using Chained Equations: Issues and Guidance for Practice,” Statist. Med., 30: 377-399.

World Bank, 2018. “Poland Energy Transition: The Path to Sustainability in the Electricity and Heating Sector,” The World Bank.

World Economic Forum (WEF), 2018. “Towards a Reskilling Revolution - A Future of Jobs for All,” World Economic Forum, Geneva.

Annex 1: Methodology to estimate the indirect impact of mines closure

A simple bottom-up approach was followed to estimate the indirect impact of the mines closure (see Frankowski et al., 2021).

Indirect jobs are those contracted out by mining conglomerates

Indirect jobs are defined as positions contracted out by mining conglomerates. These include (i) jobs provided by companies "associated" with mining conglomerates, providing material and analytical support, and often vertically integrated within the mining conglomerate; as well as (ii) jobs in companies that are directly subcontracted by mining conglomerates, often providing good and services. On a case-by-case basis, jobs were carefully mapped to the mining conglomerate (direct employment), subsidiaries (companies "associated" with the conglomerates), or subcontractors (entities which won public tenders, even when they were subsidiaries) – see Table 1.

Table 1. Number of indirect jobs in associated companies

Company	Companies classified as associated	Number of jobs
PGG	Synercom Usługi Wspólne	3,684
JSW	Jastrzębska Spółka Kolejowa, JSW Logistics, JSW Szkolenie i Górnictwo, JSW Shipping, Jastrzębskie Zakłady Remontowe, JSW IT Systems, Centralne Laboratorium Pomiarowo-Badawcze, JSU, Przedsiębiorstwo Gospodarki Wodnej i Rekultywacji, Przedsiębiorstwo Budowy Szybów	
TWD	Spółka Usług Górniczych	
WKK	Węglokoks Kraj Serwis	
SRK	SAG	

Note: underlined companies were excluded from associated companies and incorporated to the group of subcontractors, as they won tenders for mining conglomerates. Also "Śląsko-Dąbrowska Spółka Mieszkaniowa" and Przedsiębiorstwo Produkcyjno-Usługowo-Handlowe Labor from SRK were excluded as these companies are not connected with extraction activity.
Source: Frankowski et al. (2021) on the basis of rejestr.io.

Retrieving information on mining conglomerates' subcontractors

In a first step, data on companies contracted out by mining conglomerates between 07.01.2019 and 06.30.2021 was obtained through official reporting, data requests and data scrapping, resulting in 1,097 entities for Silesia. The complete list of tenders from July 2019 to June 2021 was requested from all major mining conglomerates in Silesia, including information on the winner, and net contract value.[65] Polska Grupa Górnicza (PGG),

[65] According to Polish regulation, tenders must be made public for contracts above EUR 443,000 in 2019 and EUR 428,000 in 2020.

Jastrzębska Spółka Węglowa (JSW), and Tauron Wydobycie (TWD) shared their information. The dataset was complemented by online data scrapping in the case of Węglokoks Kraj (WKK) and Spółka Restrukturyzacji Kopalń (SRK), as they did not share the requested information directly. [66]

In a second step, and when available, additional information on subcontracting companies was merged from existing databases, websites, and reports. Information on subcontractors' activity (legal form, sector of activity, ownership structure, location, annual revenues, etc.) and the structure of employment (number of employees, gender and age structure, educational attainment, etc.) was obtained directly from the companies, or indirectly through the registry of national economic entities (*Rejestr Gospodarki Narodowej*, REGON), the Ministry of Finance (MoF), the National Court Register (KRS), and other sources using Open Source Intelligence and Social Media Investigations (OSINT) techniques.

Detailed information on employees was retrieved for 52 percent of the firms shortlisted in step 2. Information was available for the larger subcontracting firms: 565 subcontractors shared information on the total number of employees, representing 91 percent of the total value of tenders. The rest were mostly sole proprietorships, i.e. mostly microenterprises. In addition, more detailed data on the structure of employment was extracted for 363 firms, including age and gender structure, position, and highest level of education achieved. For the purpose of the analysis, data were divided into underground and surface workers, and then broken down further into three subcategories: (i) mining, or blue-collar workers, (ii) engineering and technical supervision, and (iii) administration.

In a third step, missing employment data for the remaining 48 percent of public tenders was imputed, proportional to the tender amount. The estimated number of individuals employed by the remaining 48 percent of subcontractors with no information on the employment structure, was imputed in proportion to the total estimated revenues from mining tenders, or 0.8 percent in Silesia, excluding foreign companies from the sample.

Estimating the workforce dependent on mining contracts, within subcontracting firms

In a fourth step, employment derived from smaller contracts was imputed using information from the structure of subcontracting from PGG. The list of tenders used in step 1 only concerned contracts of value of EUR 443,000 in 2019 and EUR 428,000 in 2020, and contracts for smaller amount were not included. The structure of PGG spending is however available publicly: in its 2020 annual report, the mining conglomerate reports that 62 percent of the total value of contracts was advertised through public tendering, the remining 48 percent being contracted out with no obligation by Polish regulators to be recorded. The additional employment generated by these smaller contracts was imputed, assuming that (i) the share of total tender value represented by smaller contracts within PGG is similar for the

[66] WKK and SRK reported all of their tenders on-line, but WKK did not report any financial information (total/net value) on the contracts, just the identity of the winner.

other 4 mining conglomerates, (ii) there is no overlap between companies included in public tenders and those bidding on smaller contracts, and (iii) the total number of employees is proportional to the estimated values of these smaller tender.

In a fifth step, the list of subcontractors was restricted to companies with non-negligible business with the mining conglomerates, resulting in 936 entities for Silesia. A number of public tenders were won by very large companies with very limited dependency on the mining sector, and for which the prospect of discontinuing work with the mining conglomerate is not expected to have any impact on the employment structure of the company.[67] As a consequence, the final list of subcontractors includes only companies deriving at least 5 percent of their annual revenues from the mining tenders.

Finally, a correction factor was applied to estimate the total number of employees within subcontracting firms, who are dependent on mining contracts. Companies deriving less than 5 percent of their revenue from mining were already excluded from the analysis in step 5, assuming that if these companies lose their mining clients, their workforce will either not be affected, or they will be able to reallocate their employees to other clients. Similarly, contractors that are more dependent on mining contracts also derive income from non-mining contract: a last correction was applied to the total number of individuals indirectly affected by the mines closure, to only retain employees working on mining contracts. It was assumed that the share of workers likely to be affected by the transition away from coal within a subcontracting company was proportional to the share of revenue derived from the mining sector.

Table 2. 93 thousand coal-related jobs in Silesia and an additional 19 thousand jobs in the rest of Poland related to coal extraction in Silesia

DIRECT (SILESIA)	INDIRECT (SILESIA)		INDIRECT (rest of Poland)
Mining conglomerates	Associated subsidiaries	Subcontractors	Subcontractors
71,808	3,684	17,273	19,487

[67] For instance, Deutsche Bahn Cargo is transporting goods for PGG, WKK and SRK, which represents 0.34 percent of its activity in Poland; Wasko provides IT services to SRK, which represents 0.05 percent of its activity; F/X provides furniture to SRK, which represents 0.16 percent of its activity.

Table 3: Previous estimates of indirect impact of mines closures

Study	Authors	Year	Methodology and assumptions	Estimations
Joint Research Centre (JRC)	Alves Dias et al.	2018	I-O (Eurostat)[68]. The estimation of indirect employment in the coal sector relied on the use of input-output tables and multipliers developed by the EU Joint Research Center, originally, for predicting the impacts of a change in the final demand of one sector on other related sectors (Thissen and Mandras, 2017). Indirect employment was estimated by applying the same multipliers to the number of coal direct jobs. The indices used, besides extending the supply-chain coverage to all sectors that might be impacted by changes in coal mining and coal power plants activities, are assessed at intra-regional level, and also consider spill-over effects at inter-regional level.	Poland: 48,746 (intra-regional). 87,760 (inter-regional) Upper Silesia: 22,106 (intra-regional), 34,536 (inter-regional) Lower Silesia: 1,698 (intra-regional) 3,045 (inter-regional) Wielkopolska: 3,447 (intra-regional); 8,090 (inter-regional) note: Inter-regional figures include Intra-regional effect and, therefore, differences are due to the inter-regional trade between NUTS 2 regions.
Institute for Structural Research (IBS)	Kiewra, Szpor, Witajewski-Baltvilks	2019	Input-Output (Central Statistical Office, base year 2015) Indirect jobs are calculated as the share of value added transferred to the mining industry in the total value added generated in a given section multiplied by the number of employees in this sector (according to data for 2017)	56,700 – suppliers 13,000 – recipients (coal-fired power plants)
	Frankowski, Mazurkiewicz	2020	Input-Output (Central Statistical Office; base year 2015) Indirect jobs are calculated as the share of value added transferred to the mining industry in the total value added generated in a given section multiplied by the number of employees in this sector (according to Eurostat data for 2018) + additions of employment in Section C and D, proportionally to the share of coal in a given sector	96,000 – 112,000 subcontractors 41,000-56,700 intermediaries 55,300 (coal-fired power plants, heating and coking plants)
University of Economi	Ingram et.al.	2020	Survey (207 companies; sampling frame not specified)	The total number of indirect jobs: 110,000 – 130,000 Number of affected indirect jobs (until 2030):

[68] The share of added value associated with mining to the mining added value is the same as the share of mining-related jobs to the number of mining jobs.

cs in Katowice	Optimistic scenario: 26,667 Plausible scenario: 50,580 Pessimistic scenario: 75,876

Table 4: JRC (2018) Estimates

	Direct Impact	Indirect Jobs		Direct jobs impacted by coal PP retirement	
		Intra-regional	Inter-regional (total)	2025	2030
Poland	112,500	48,746	87,760		
mines	99,500			2,077	5,276
power plants	13,000				
Silesia	82,459	22,106	34,536		
mines	79,548			315	1,558
power plants	2,911				
Lower Silesia	1,926	1,698	3,045		
mines	1,108			480	102
power plants	818				
Wielkopolska	3,400	3,447	8,090		
mines	2,079			748	321
power plants	1,306				

Source and methodology: JRC (2018), using EURACOAL database.

Annex 2: Skills and preference survey questionnaires

The World Bank Skills and Preference Survey consisted of two parts: a skills and employment questionnaire and a Discrete Choice Experiment (DCE). The questionnaire included detailed questions to determine the respondents' employment status and socio-economic situation. Questions were grouped into thematic blocks, consisting of (i) general information, (ii) employment characteristics, (iii) job search, and (iv) self-assessment of competencies. For the municipalities, the blocks consisted of (i) general information, (ii) professional situation, and (iii) self-assessment of competencies.

Survey questionnaire

Good morning! You are about to start the survey on work and professional preferences, carried out at the request of the World Bank Group in order to support the transformation of the labor market related to the Just Transition process. All Any of your statements will be kept in complete confidence and will only be used anonymously, along with other people's responses. We are counting on your honest answers.		
MODULE G: GENERAL INFORMATION		
G1	**Please indicate your age category.**	1. Poniżej 25 lat 2. 25 - 29 lat 3. 30 - 34 lat 4. 35 - 39 lat 5. 40 - 44 lat 6. 45 - 49 lat 7. 50 - 54 lat 8. 55 - 59 lat 9. 60 - 64 lat 10. 65 i więcej lat
G2	**What is your gender?**	1. Woman
		2. Man
G3	**What is your marital status?**	1. Married
		2. Divorced or separated
		3. Widowed
		4. Single
G4	**Do you have children?**	1. Yes
		2. No
G5	**Please indicate your level of education**	1. Primary
		2. Vocational
		3.Secondary(high school or technical college)
		4. Post-secondary
		5. BA/BSc/Engineering degree
		6. Master's degree
		7. Tertiary education with at least a Ph.D. degree

G6	**How many people are in your household, including you?**	……
G7	**What range is your total monthly net income (per month) for you and all people in your household from all sources? Please include both your earnings and any other income such as pensions, scholarships, alimony, benefits, rental income, etc.?**	1. PLN 1201–1500
		2. PLN 1501–1800
		3. PLN 1801–2100
		4. PLN 2101–2500
		5. PLN 2501–3000
		6. PLN 3001–4000
		7. PLN 4001–5000
		8. PLN 5001–6000
		9. PLN 6001–7000
		10. PLN 7001–8000
		11. PLN 8001–9000
		9. PLN 9001–10 000
		10. above PLN 10 000
		11. Refuse to answer -> *go to G9*
G8	**How many people does this income come from?**	a) …… b) Not applicable
G9	**How many members of your household, apart from you, work in the Tauron/SRK/?**	a) …… b) Not applicable
G10	**How many of your household members, apart from you, work in a company that is the main partner of the fuel and energy company?**	a) …… b) Not applicable
G11	**To what extent is your household income dependent on the fuel and energy sector?**	1. 0%-20%
		2. 20%-40%
		3. 41%-60%
		4. 61%-80%
		5. 81%-100%
G12	**To what extent do you feel that the process of just transformation may a negatively impact your life?**	1. At all 2. A bit 3. Moderately 4. Very 5. Incerdibly
MODULE P: EMPLOYMENT CHARACTERISTICS		
P1	**What is your total work experience in years (consider all your employers)?**	……
P2	**Please indicate the number of all your past employers (i.e., places where the employment period was at least 3 months)**	……
Now, we would like to ask about your main workplace		
P3	**What professional group do you represent?**	Tauron: 1. Office administrative employee

		2. Engineering and technical worker 3. Blue collar worker
		SRK: 1. Technical worker (underground) 2. Blue collar worker (underground) 3. Technical worker (on the surface) 4. Engineering and technical worker (underground) 5. Blue collar worker (on the surface) 6. Administration worker
		PGG: - **Underground:** 1. Miner 2. Locksmith 3. Electrician 4. Engineering and technical worker underground 5. Others working underground - **Surface:** 1. Employee - worker position - Coal Mechanical Processing Plant 2. Worker - worker position - remaining area 3. Engineering and technical worker - Coal Mechanical Processing Plant 4. Engineering and technical worker - remaining area 5. Office administrative employee
P5	**You job is:**	1. Permanent, for an indefinite period
		2. Fixed-term work
P6	**Do you supervise or manage the work of other people?**	1. Yes
		2. No
P7	**In your opinion, what level of education is the most appropriate for the work you do in your place of work?**	1. Tertiary education with Ph.D. degree
		2. MSc degree
		3. BA/BSc degree
		4. Engineering
		5. Post-secondary
		6. Secondary general education
		7. Secondary vocational
		8. Lower than secondary
		9. The level of education does not matter
P8	**In your opinion, which field of study is the most appropriate for your current main job?**	1. Field of study that I am studying/graduated from
		2. Related to the field of study, I am studying/graduated from
		3. Different field of study from the one I am studying/graduated from
		4. The field of study does not matter
		5. I do not know; I cannot define

P9	**Which of the following best describes your skills in relation to the current job in your place of work?**	1. I need further training to do my job well.
		2. My current skills are well suited to my responsibilities/duties.
		3. I have the skills to handle more demanding duties.
P10	**Referring to your competencies related to the job you currently perform, please indicate which of the following two statements better describes the nature of your current job.**	
	It does not require any additional competencies	**It requires many additional competencies**
	1 2 3 4 5	
MODULE Q: JOB SEARCH		
Now, we would like to ask about your future work.		
Q1	**In the last 12 months, have you considered changing your job?**	1. Yes
		2. No
Q2	**Have you recently been looking for a job / participated in the recruitment for the new job?**	1. Yes
		2. No
Q2a	**If yes, please indicate when**	
Q3	**Do you know institutions or organizations that support job search?**	1. Yes,
		2. No
Q3a	**If yes, please provide examples**	
Q4	**How do you assess your chances of finding a job outside the fuel and energy sector (mining sector)?**	1. Very high
		2. High
		3. Moderate
		4. Low
		5. None
		6. I do not know
Q5	**Which of the following factors may be an obstacle for you in the process of looking for a job? (Many answers are possible)**	1. Child care
		2. Taking care of another family member
		3. Taking care of the house
		4. Taking care of a farm
		5. Poor health
		6. Age
		7. Lack of appropriate certificates and authorizations
		8. Level of education
		9. Insufficient experience
		10. Study or training
		11. There are no job offers in the area
		12. Lack of appropriate contacts, acquaintances
Q6	**Please rate how prepared you are (on a scale from 1 to 5, where 1 means very bad, 2-bad, 3-average, 4 -good, and 5-very well) to:**	

	a) search for and select job offers	1 2 3 4 5
	b) prepare application documents	1 2 3 4 5
	c) participate in interviews	1 2 3 4 5
Q7	**Would you like to undertake training in the area of:**	
	a) Job search	1. Yes
		2. No
	b) Soft skills (such as assertiveness, communication, etc.)	1. Yes
		2. No
	c) Hard qualifications	1. Yes
		2. No
	d) Other (what kind?)	.....
Q8	**What kind of training do you find the most useful for you?**	1. Job search
		2. Soft skills (such as assertiveness, communication, etc.)
		3. Hard qualifications
		4. Other (what kind?) .....
Q8a	**If other is marked, please indicate which other training you find most useful for you.**	
Q9	**After the end of your current employment, do you intend to look for a job and take up a new job?**	1. Yes
		2. No
Q10	**Which form of employment would you be interested in if you were looking for a new job?**	1. Only part-time job
		2. Depending on the offer, a part-time or full-time job
		3. Only full-time job
		4. Not applicable
Q11	**When looking for a job, would you be willing to learn a new job/reskill?**	1. Definitely not
		2. Rather not
		3. It's hard to say
		4. Rather yes
		5. Definitely yes
		6.Not applicable
Q12	**Would you be willing to take up employment in Turek?**	1. Yes
		2. It depends on the job offer
		3. No
		4.Not applicable
Q13	**Given that many jobs offer lower wages than your current employment sector, what net monthly salary (in hand) for a**	1. PLN 1201–1500
		2. PLN 1501–1800
		3. PLN 1801–2100
		4. PLN 2101–2500

	full-time job would be satisfactory for you / would you agree to accept?	5. PLN 2501–3000
		6. PLN 3001–4000
		7. PLN 4001–5000
		8. PLN 5001–6000
		9. PLN 6001–7000
		10. PLN 7001–8000
		11. PLN 8001–9000
		12. PLN 9001–10 000
		13. above PLN 10 000
		14. Not applicable
Q14	**Have you ever considered the possibility of starting your own business?**	1.Yes
		2.No
Q14a	**If yes, what kind of business did you consider establishing?**	.....

MODULE K: COMPETENCIES

Different types of work require different skills and abilities. It is often the case that our capabilities are relatively high in one or two areas, while in others, they are much lower.
Below is a list of the various skills. For each of them, I will ask you to assess the level of your own skills in this respect on a 5-point scale, where 1 is low, 2 is basic, 3 - medium, 4 - high, and 5 - very high.

Competencies		How do you rate your skill level?				
		Low	Basic	Average	High	Very high
1	self-organization of work and showing initiative (Planning and timely implementation of activities at work, effectiveness in achieving the goal)	1	2	3	4	5
1.1	independent decision making	1	2	3	4	5
1.2	entrepreneurship and showing initiative	1	2	3	4	5
1.3	creativity (Being innovative, coming up with new solutions)	1	2	3	4	5
1.4	resistance to stress	1	2	3	4	5
1.5	timely implementation of planned activities	1	2	3	4	5
2	contacts with other people, both with co-workers as well as clients and subordinates.	1	2	3	4	5
2.1	cooperation in a group	1	2	3	4	5
2.2	easy contact with colleagues or clients	1	2	3	4	5
2.3	being communicative and communicating clearly	1	2	3	4	5
2.4	solving conflicts	1	2	3	4	5
3	organizing and conducting office work	1	2	3	4	5
4	managerial abilities and organization of work of others	1	2	3	4	5
4.1	coordinating the work of other employees	1	2	3	4	5

4.2	disciplining other employees - bringing them to order.	1	2	3	4	5
5	availability	1	2	3	4	5
5.1	willingness to travel frequently	1	2	3	4	5
5.1	willingness to work flexible hours	1	2	3	4	5
6	fluent use of the Polish language in speech and writing (linguistic correctness, rich vocabulary, ease of expression).	1	2	3	4	5
7	searching and analyzing information and drawing conclusions	1	2	3	4	5
7.1	quick summarizing a large amount of text	1	2	3	4	5
7.2	logical thinking, fact analysis	1	2	3	4	5
7.3	constantly learning new things	1	2	3	4	5
8	maintenance, assembly and repair of technical devices	1	2	3	4	5
9	Skills necessary for physical work	1	2	3	4	5
9.1	Manual skills	1	2	3	4	5
9.2	Operation of technical equipment and devices	1	2	3	4	5
9.3	Installation and repair of technical devices	1	2	3	4	5
10	performing calculations	1	2	3	4	5
10.1	performing simple calculations	1	2	3	4	5
10.2	performing advanced mathematical calculations	1	2	3	4	5
11	computer operation and use of the Internet	1	2	3	4	5
12	basic knowledge of the MS Office type package	1	2	3	4	5
12.1	knowledge of specialized programs, the ability to write programs or create websites	1	2	3	4	5
13	artistic and creative abilities	1	2	3	4	5
14	physical fitness	1	2	3	4	5

MODULE D: JOB CHARACTERISTICS		
Finally, we would like to ask about your job characteristics.		
D1	**Please indicate which answer best describes the compliance of your work with your education.**	Work inconsistent with your education and skills
		Work related to your education
		Work matches your skills and education
D2	**Please indicate which of the following non-wage benefits you receive in your current workplace. (Many answers are possible)**	Flexible working time
		Certified professional courses
		Transport provided to and from work by bus
		Private medical care
		Childcare services (kindergartens close to the workplace, financed by the employer)
		Mobile phone or computer
		I am not getting any of the listed non-wage benefits
D3		Up to 15 min

	Please indicate which time of the following is the closest to your commuting time to work (one way).	15 min – 30 min
		30 min – 1 hour
		1 hour – 1.5 hour
		1.5 hour – 2 hours

Annex 3: Skills and preference survey methodology

DCE methodology

To analyze preferences towards the workplace, a Discrete Choice Experiment (DCE) was applied. The concept of discrete choice methods is derived from the theory of economic value (Lancaster, 1966) and random utility theory (McFadden, 1974; McFadden, 2001). The utility refers to the level of satisfaction a person achieves with a particular consumption structure – here the consumed good is defined as the workplace.

In the discrete choice method, respondents select an alternative that seems to be more attractive to them or decide not to make a choice. This selection process is of probabilistic nature (McFadden, 1974). The choice is determined by a utility that depends on the observed characteristics (attributes) and unobserved idiosyncrasies and for individuals. This process allows modeling worker's decision processes and extracting information about preferences (individual utility function parameters) based on pre-composed successive choices in a controlled environment.

The design of choice situations (composition of attributes) is based on an effective Bayesian method that allows obtaining the most accurate estimates with minimal respondents' choices (utility balance). The designing process is done using the simulation with obtained priors from the pilot study. Over the study, the design is optimized several times to minimize D-error (scaled measure of the determinant of the Fisher Information Matrix, summarizing how good a design is at extracting information about preferences).

The choice of attributes and levels was based on the preliminary qualitative work and literature review. Prior pilot-testing enabled researchers to refine the attribute levels and their wording. To avoid cognitive overload resulting from too many attributes, two DCE designs with two overlapping attributes were prepared. To estimate the monetary equivalents of a change in job components a monetary attribute (monthly net salary) was included. The designs prepared for ZE PAK employees and municipality residents differed slightly.

Table 5: Job attributes – DCE design 1

Attribute	Levels of attributes
Net monthly salary	• PLN 3000 • PLN 4000 • PLN 5000 • PLN 6000 • PLN 7000 • PLN 8000
Contract	• Labor code based (permanent) • Fixed-term employment • Temporary (contract of mandate)

	• Apprenticeship / internship
Change in financial conditions within the next 2 years from starting work	• No change • 20% increase over initial salary • 40% increase over initial salary
Non-wage benefits	• No • Flexible working time • Certified professional courses • Transport provided to and from work by bus • Private medical care • Childcare services (kindergartens close to the workplace, financed by the employer) • Mobile phone or computer
Compliance of work with education	• Job incompatible with skills and education (requires complete reskilling) • Related workplace (requires entry training) • Job corresponds to your skills and education
Travel time to work (one way)	• 0 (remote work) • 15 min • 30 min • 1 hour • 1.5 hour2 hours

Table 6: Job attributes – DCE design 2

Attribute	Levels of attributes
Net monthly salary	• PLN 3000 • PLN 4000 • PLN 5000 • PLN 6000 • PLN 7000 • PLN 8000
Contract	• Self-employed • Public • Private • Non-governmental organization
Company size	• Employing 10 people • Employing 100 people • Employing 250 people • Employing 500 people

Industry sector	• Mining • Construction • Industrial processing • Renewable energy (photovoltaics, wind farms) • Agriculture • Transport services, repairs, communication • Other services (gastronomy, tourism and recreation, etc.) • Administration (office work)
Compliance of work with education	• Job incompatible with skills and education (requires complete reskilling) • Related workplace (requires entry training) • Job corresponds to your skills and education
Working conditions	• Not burdensome • Burdensome (physically strenuous or dangerous)
Job location	• Poland (no need to change the place of residence) • Poland (need to change the place of residence) • Abroad (need to change the place of residence)

Econometric model

The choice is determined by a utility which depends on the observed characteristics (attributes) and unobserved idiosyncrasies and for individual, i, resulting from choosing an alternative, j, in the situation, t, can be expressed as:

$$U_{ijt} = \mathbf{X}_{ijt}\boldsymbol{\beta} + e_{ijt} \,. \tag{1}$$

Where $\mathbf{x}_{ijt}$, corresponds to observed job attributes with the vector of parameters, $\boldsymbol{\beta}$, and e_{ijt}, refers to the stochastic component, standing for the unobservable factors. Assuming that the stochastic component (e_{ijt}) follows an independent and identical extreme value (type I) distribution, the probability of, *i*, respondent selecting an alternative, *j,* from set of ,*J,* alternatives takes the form of conditional logistic regression:

$$P(j|J) = \frac{\exp(\mathbf{X}_{ijt}\boldsymbol{\beta})}{\sum_{k=1}^{J}\exp(\mathbf{X}_{ikt}\boldsymbol{\beta})}, \tag{2}$$

which, depending on the selection and levels of attributes, enables to derive the maximum likelihood estimator of the utility function. As the respondents want to maximize their utility while making a choice, this probability represents an optimization problem. The designated formula 3 is known as the multinomial logit model (MNL).

Train (2003) proved that choice behavior logit models have several limitations. Namely, MNL express the preference variation that relates to observed characteristics of the decision-maker - this is so-called in literature *the systematic taste variation* but not random taste variation. The second limitation is that logit cannot handle situations where unobserved factors are internally correlated over time.

One of the ways to relax these restrictions is to allow for preference heterogeneity and, possibly, correlations between the alternatives and choices across time. This can be done by including the individual-specific parameters, $\boldsymbol{\beta}_i$, which leads to more general models. (McFadden and Train, 2000).

To account for these limitations in addition to the MNL the data will be analyzed with a random parameter logistic regression called as mixed logit model (RPL or MIXL). Mixed logit is expressed as the integrals of standard logit probabilities over a density of parameters, where n is an individual and i is an alternative.

$$P_{ni} = \int \frac{e^{\beta_n' x_{ni}}}{\sum_j e^{\beta_n' x_{nj}}} \phi(\beta | b, \Omega) d\beta, \tag{3}$$

Here in the random parameter model we will use the panel specification formulated by Revelt and Train (1998).

In the baseline assumption all non-price coefficients will be assumed to follow a normal distribution but the coefficients related to income will be assumed to follow a log-normal distribution. In this case, assuming lognormal distribution for the income coefficient is plausible from a behavioral perspective and the model accountability. Assuming log-normal distribution restricts respondents to have positive income sensitivity, in addition, this assumption guarantees that the resulting distributions of WTP are useful and meaningful i.e. have finite moments (Daly et al., 2012).

Given the above it is convenient to introduce modification of the basic utility function defined above which is to use the so-called estimation in WTP space (Train and Weeks, 2005):

$$U_{ijt} = \alpha\left(p_{ijt} + \mathbf{Y}_{ijt}\,\boldsymbol{b}/\alpha\right) + e_{ijt} = \alpha\left(p_{ijt} + \mathbf{Y}_{ijt}\boldsymbol{\beta}\right) + e_{ijt}\,. \tag{4}$$

Where e_{ijt} is the stochastic component, p is the time attribute, and the vector of parameters β is a vector of implicit prices for the non-monetary attributes Y_{ijt}.

In the survey, respondents were asked to choose between two hypothetical alternative job offers described by several attributes or decide not to make a choice. This selection process is of probabilistic nature (McFadden, 1974). The choice of an alternative that seems to be more attractive to respondents is determined by a utility that depends on individuals' observed characteristics and unobserved idiosyncrasies. This process allows modeling workers' decision processes and extracting information about preferences (individual utility function parameters) based on pre-composed successive choices in a controlled environment.

Annex 4: The viable job matching tool - methodological considerations

The extent of skills' (mis)match, the availability of jobs, and workers' preferences determine the viability of transiting to future jobs. Whether the path to an alternative job for a worker is viable depends on 1) whether the worker has the capacity to do the job, 3) whether the job attributes (salary, benefits, contractual arrangements, etc.) live up to the expectations of the worker (and compared to the value and compensation received when not working), and 3) whether the job is available locally or not. Most jobs are unlikely to score equally well on all three dimensions. The job may be available, for example, but only in another region, or only under a self-employed as opposed to a salaried contractual arrangement. The better a job scores on each of these dimensions (matching skills, attribute preferences, and local availability), the more viable is the transition.

In particular, in identifying matches, the following three constraints were considered: (i) the amount of reskilling due to the transition between two occupations was minimized, (ii) only occupations in growing demand on the local labor market were considered, and finally (iii) potential candidates were further screened using the results of the preference survey described in the previous section.

The technical feasibility of an alternative job in terms of skills was first assessed based on task-similarity between professions (as a proxy for skills) using artificial intelligence (AI) text mining algorithms. Job descriptions were extracted from the Polish Labor Office and Labor Offices Job Postings using Selenium web scraper and resulting in a list of 2,700 key occupations. Occupations were then compared one by one, using Latent Semantic Indexing (LSI), and a similarity score (between 0 and 1) was constructed for each pair of occupations.

Latent semantic indexing (LSI) is an indexing and retrieval method that uses a mathematical technique called singular value decomposition (SVD) to identify patterns in the relationships between the terms and concepts contained in an unstructured collection of text. LSI is based on the principle that words that are used in the same contexts tend to have similar meanings. A key feature of LSI is its ability to extract the conceptual content of a body of texts by establishing associations between those terms that occur in similar contexts. Applying LSI model with 100 topics (number established using trial and errors approach), we were able to describe each job/occupation in our corpus as a mixture of topics.

Using standard distance metrics, we calculated the similarity of all vs all pairs of jobs/occupations – in other words similarity of vectors containing information about topics mixtures. We used cosine distance to create a 2.7k/2.7k (rows/columns) similarity scores matrix. The score could take values bounded between 0 and 1, going from least to most similar.

To complement and refine the task-based pairing and ranking of jobs, the types of tasks required by each position were further divided into five groups: non-routine manual, non-routine interactive, routine manual, non-routine manual, routine cognitive. This classification builds on the measure of routine and non-routine task content developed by Mihaylov and

Tijdens (2019), who provided a measure of the Routine and Non-Routine Task Content of 427 Four-Digit ISCO-08 Occupations. The indexes are created by dividing the number of tasks in a given category by the number of all tasks performed in a given occupation. The results are reported at the 4-digit level and were integrated in the dashboard, defining the top similar professions in each of five categories of occupations.

Table 7: Identification of similar professions with the designed tool

Related professions and competences

Lignite miner

Occupation	ISCO-08	Potential of the profession	NRA	NRI	RC	RM	NRM	TRI	Average monthly salary (PLN)	Median monthly salary (PLN)	Similarity score
Lignite miner	8	-	0.0	0.0	0.2	0.6	0.2	Routine+	4,123	4,000	1
Opencast miner	8	-	0.0	0.0	0.2	0.6	0.2	Routine+	4,123	4,000	0.94
Bricklayer	7	High	0.0	0.0	0.0	0.0	1.0	Non-routine+	2,585	2,500	0.92
Fitter of stone building elements	7	High	0.0	0.0	0.0	0.0	1.0	Non-routine+	2,585	2,500	0.76
Operator of feed production equipment	8	High	0.0	0.0	0.0	1.0	0.0	Routine+	2,585	2,500	0.68
Aggregate and clay extractor	8	-	0.0	0.0	0.2	0.6	0.2	Routine+	4,123	4,000	0.60

Second, job transitions were restricted to positions with excess demand on the local labor market. The occupational barometers developed by the powiat labor offices were used to identify jobs with excess demand, in order to restrict job transitions to occupations in growing demand, or with high potential.

Finally, using the results of the preference survey it can further be determined whether jobs fall within the realm of the job attribute preferences expressed by the coal-related workers. For instance, PGG/SRK/Tauron workers display a strong aversion to moving regions. Job offers that are good matches, but imply moving to another part of the country, would thus be discarded if the wage increase was below the expressed welfare loss from taking up job in another location. The option was then discarded from the viable set.

The proposed method of identifying possible transition paths and similar professions can be used as a tool supporting the activities of labor offices (e.g., in providing career consultations). Its ease of use allows employees to make a preliminary overview of possible career paths

themselves and allows employers to identify employees who may be placed in newly created positions, e.g., as part of creating new economic zones.

Most Recent Jobs Working Papers:

69. Towards a Just Coal Transition Labor Market Challenges and People's Perspectives from Lower Silesia. (2022)
Luc Christiaensen, Céline Ferré, Tomasz Gajderowicz and Sylwia Wrona.

68. A Tale of Two Countries: Labor Market Profiles of Youth in Urban and Rural Cameroon. (2022)
Ioana Botea and Mitja Del Bono

67. Improving Smallholders' Jobs Through Agribusiness Linkages : Findings of the Mozambique Agricultural Aggregator Pilot (MAAP). (2022)
Michael Baxter,Christopher Brian Delgado, Jose Romero and David Ian Walker.

66. Rural Employment in Africa: Trends and Challenges. (2022)
Luc Christiaensen and Miet Maertens

65. Understanding and Predicting Job Losses Due to Covid-19: Empirical Evidence from Middle-Income Countries. (2021)
Maho Hatayama, Yiruo Li, and Theresa Osborne

64. Revisiting Labor Market Regulations in The Middle East and North Africa. (2021)
Maho Hatayama.

63. Migrants, Markets and Mayors Rising above the Employment Challenge in Africa's Secondary Cities – Key Insights. (2021)
Christiaensen, Luc and Lozano Gracia, Nancy.

62. What was the Impact of Creating Better Jobs for more People in China's Economic Transformation? What we know and Questions for Further Investigation. (2021)
Merotto, Dino and Jiang, Hanchen

61. Opportunities for Youth and Women's Participation in Ghana's Labor-Intensive Public Works Program (2021)
Dadzie, Christabel E. and Ofei-Aboagye, Esther.

60. How Did the Covid-19 Crisis Affect Different Types of Workers in The Developing World? (2021)
Maurice Kugler, Mariana Viollaz, Daniel Duque, Isis Gaddis, David Newhouse, Amparo Palacios-Lopez and Michael Weber.

Click here for full Jobs Paper Series

Address: 1776 G St, NW, Washington, DC 20006
Website: http://www.worldbank.org/en/topic/jobsanddevelopment
Twitter: @WBG_Jobs
Blog: https://blogs.worldbank.org/jobs/