Counting and Profiling Coal Mining Industry Jobs: A Guideline to Using Administrative Data

By Haroon Bhorat, Lisa Martin, Jabulile Monnakgotla, and Françios Steenkamp

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Abstract

South Africa is undergoing the early stages of an energy transition away from coal. A planned transition requires social protection policy interventions to mitigate potential negative employment impacts. Crafting a quantifiable transition plan with a comprehensive set of policy measures necessitates robust micro-data-based empirical estimates of the coal mining workforce. In this paper, we use, for the first time, administrative tax data to measure the quantum of employment in the South African coal mining industry. Furthermore, we provide an employment, wage, and inequality profile of workers in the coal mining industry. Subcontracted employment within the coal mining industry has grown, now constituting nearly half of all jobs. The workforce is relatively young, requiring transition policies that prioritise skills development and job placement. Men comprise the bulk share of employees in the coal mining industry, although female participation has risen over time. Coal mining industry jobs are relatively well paid, with the average coal miner wage surpassing that of the average formal sector worker, thus making income support for displaced workers financially burdensome. Wage inequality within the coal mining industry is lower than wage inequality within the broader formal sector economy. Thus, should coal miners transition from jobs in the relatively low inequality coal mining industry to jobs in high inequality industries, then it is possible that overall inequality will rise.

Keywords

Just Transition, coal mining, employment, earnings, South Africa

JEL codes

J21; J31; O13

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1 INTRODUCTION

South Africa is undergoing the early stages of an energy transition away from a coal-orientated energy structure. This transition is being driven by both endogenous and exogeneous forces. The latter set of forces have been bolstered by the Paris Agreement, where the climatic imperative of reducing carbon emissions was agreed upon at a global level. South Africa, being part of this global consensus, has committed to systematically reduce carbon emissions. This in turn has started to drive a shift in South Africa's energy structure away from coal as a source of energy, and increasingly toward low-carbon renewable energy sources.[1] The former set of forces speak to a natural phasing out of coal as an energy source by virtue of South Africa's aging fleet of coal power plants being set for retirement in the coming years. As such, it is stated in the Presidential Climate Commission's (PCC) 2022 report that "the coal value chain in South Africa faces one of the earliest disruptions in the global transition towards reaching net-zero emissions" (PCC, 2022:10).

However, South Africa remains one of the most unequal countries in the world. A transition that ignores the potentially negative implications for workers in affected sectors risks exacerbating existing inequalities. Indeed, the country's high-income inequality is driven primarily by extreme differentials in the labour market, where over 30 percent of the labour force is unemployed and earns zero income (Leibbrandt et al., 2010). Reducing unemployment is therefore at the heart of South Africa's social and economic challenges and is key to lower the level of inequality. In this regard, the potential negative employment impacts of a transition away from the coal value chain, and toward low-carbon energy production, presents a significant socio-economic challenge for a country still dealing with the vestiges of apartheid. It is thus critical that the risks associated with these potential adverse employment effects are managed to ensure that inequality – both national and in coal mining areas in particular – is not deepened by an unplanned transition.

A planned transition requires social protection policy interventions that ameliorate potential negative employment impacts of the transition. The practical process of crafting a quantifiable transition plan that comprises a basket of policy interventions requires rigorous and robust micro-data-based empirical estimates of the size and shape of the coal mining industry workforce. Bhorat et al. (2024) note that while there is an emerging literature examining the potential impacts of South Africa's energy transition, these studies are limited along the following dimensions: first, the focus is primarily on providing aggregate employment estimates for the coal mining industry, as well as other industries linked to the coal value chain; second, and relatedly, there is relatively little in terms of providing a

[1] As we detail in Section 3, coal power stations account for 77 percent of South Africa's energy capacity and, thus, despite increasing renewable energy capacity, the energy structure remains coal intensive.

detailed socio-economic profile of coal sector workers and households. Bhorat et al. (2024) provide a first step toward addressing some of these limitations in the energy transition debate.

This paper advances the work by Bhorat et al. (2024) and contributes to this branch of the energy transition literature in South Africa by doing the following: First, we use, for the first time, administrative tax data to measure the quantum of employment in the South African coal mining industry. This analysis augments initial employment estimates generated by Bhorat et al. (2024) who combine a number of publicly available datasets to triangulate an accurate employment estimate for the coal mining industry. The employer–employee-level administrative tax data used in this analysis alleviate some of the key concerns raised by Bhorat et al. (2024) regarding the use of household survey data to measure employment at such disaggregated industry and spatial levels. Second, we provide an employment, wage, and inequality profile of workers in the coal mining industry. Profiling the level and distribution of wages among workers in the coal mining industry is a key contribution to the energy transition discussion in South Africa, as there is a relative dearth of analysis detailing the wage profile of these workers. The administrative tax data provide the gold standard of data for such analysis.

This paper is structured as follows: In Section 2, we review literature that details past energy transition experiences, with specific focus on the labour market outcomes, and applied policy interventions associated with these transitions in other countries. Section 3 contextualises South Africa's energy transition by detailing the economic and spatial footprint of South Africa's coal sector. Section 4 details the administrative tax data used in our analysis, provides a discussion on the advantages and limitations of these data, and discusses our approach to analysing these data. In Section 5, we quantify employment in the coal mining industry. Section 6 profiles coal mining industry employment in terms of the age and gender composition of the workforce. The section also details the wage profile and wage distribution of the coal mining industry workers. Section 7 concludes.

2 LITERATURE REVIEW: INSIGHTS FROM PREVIOUS ENERGY TRANSITIONS

In the literature exploring energy transitions away from fossil fuels, Bulmer et al. (2021) provide an informative framework for categorising coal-producing countries at various stages of their energy transitions. Bulmer et al. (2021) classify these countries into *advanced transitioners*, *partial transitioners*, *expanding exporters*, and *domestic demand accommodators*. We use this framework to structure our review of the energy transition literature applicable to this paper.

Advanced transitioners are countries that have successfully phased out coal mining or have made significant progress towards phasing out coal mining. The labour market outcomes resulting from energy transitions amongst these *advanced transitioners* vary significantly. These variances are a function of differences in approach to social protection and active labour market policies, which are designed to ease the adverse impacts resulting from such a structural change to an economy.

In 2018, after a long decline in coal production, starting with the "coal crisis" in the 1950s, Germany ended coal production (Oei et al., 2019; Wong et al., 2022). German coal mining was concentrated in two regions, the Ruhr and Saarland regions, comprising 155 mines with approximately 665 000 workers employed in 1957. Of these jobs, approximately half were lost during the first decade after the onset of declining coal production. Due to suitable economic conditions in Germany at the time, more than half of these workers were able to successfully shift into metal manufacturing industries where coal was still a key input. The remaining workers were offered either early retirement, redundancy payments, retraining, or pension contributions (Oei et al., 2019; Wong et al., 2022).

Over the course of the transition, Germany's two coal regions had varying labour market outcomes, which Oei et al. (2019) argue stemmed primarily from the fact that the Saarland region's mining operations were majority state-owned. Since the state had more power over decisions in the Saarland region, it was able to more easily implement measures that stimulated the economic reorientation of the region. For example, by encouraging mining companies to sell their land, new businesses settled in the region during the 1960s and 1970s, and approximately 25 000 jobs were created. A key factor driving this job growth was the fact that the new firms that entered the region were from the automotive sector, and that coal mine workers already possessed many of the necessary skills needed to shift into the new industry. However, this did create a new industrial dependency for the region that shifted from coal to the automotive industry.

Within the Ruhr region, there were mixed outcomes between its northern and southern regions. The Southern Ruhr region acted quickly to phase out mining and begin diversifying the region. In the north, coal industry stakeholders slowed transformation efforts, resulting in slightly weaker progress made in this part of the region (Oei et al., 2019, Wong et al., 2022). Overall, structural policies in the Ruhr region were aimed at supporting higher education and innovation, leading to the successful creation of high-wage, high-skilled jobs in new sectors. Unfortunately, due to skills mismatches, ex-miners were unable to benefit from these new jobs, and unemployment in the region remained high (Wong et al., 2022).

Although Germany has phased out hard coal mining, lignite mining, and lignite- and coal-powered power plants are still operational.[2] Oei et al. (2020) study the impact of the energy transition on workers at coal-fired power plants according to various potential decommissioning pathways. First, they estimate that due to demographic and technological changes, the number of workers employed in the lignite coal industry should naturally decline from 16 500 in 2014 to 9 100 in 2040. The authors use an input–output model and a regional macroeconomic model to estimate employment effects

[2] Lignite (also called 'brown coal') is lower-quality coal that is typically mined from surface mines, while hard coal requires more intensive, underground mining.

under 'Fast', 'Moderate A', 'Moderate B' and 'Flex' scenarios. Though the methods used are only able to estimate a broad interval or range of job losses, the results do indicate that faster pathways to decommissioning should result in a faster recovery.

Similar to the German case, Poland's coal sector has undergone a long and gradual decline since 1990 due to increasing financial difficulties resulting from inefficiencies in the sector (Zinecker et al., 2018; Bulmer et al., 2021). Out of a total of 70 mines in 1990, 40 mines were closed by 2014, with seven more mines scheduled for liquidation by 2016 (Zinecker et al., 2018). Employment in hard coal and lignite declined from 444 000 workers in 1990 to fewer than 100 000 in 2019 (Bulmer et al., 2021; Baran et al., 2020).

According to Sokolowski et al. (2022), Poland's transition experience can be divided into two main regional cases. Between 1990 and 1996, the coal basin of the Walbrzych region was shut down, resulting in the dismissal of 10 000 workers. Due to an absence of appropriate remedial social protection and active labour market policy being put in place, workers were unable to adjust and, consequently, unemployment rose from 11 to 17 percent in the region over a six-year period. The second case occurred between 1998 and 2002, when employment in hard coal mining in the Silesia region decreased by more than 100 000 individuals. However, in this case, the broader "Mining Social Package" was implemented. The Polish government offered generous incentives to leave mining jobs (Bulmer et al., 2021). However, unlike in the German case, lower labour force participation was observed among many of those who left these jobs, as the measures in place failed to maintain economic activity among former mine workers (Bulmer et al., 2021; Sokolowski et al., 2022). Bulmer et al. (2021) suggest that this was partly the result of an early retirement policy offered to workers, which was taken up by many workers over the age of 45.

The case of the Polish energy transition reveals several key policy considerations, namely: worker education levels, worker age, the coal industry's relatively high wages and benefits, and a developed mining culture (Baran et al., 2020). At the end of 2019, 83 000 workers were employed in hard coal mining, with 89 percent of this employment falling within the Silesia region, and 94 percent of these workers working directly in mines (Sokolowski et al., 2022). As a result of the age distribution of the workforce, more than 40 percent of the current mining workforce are expected to retire by 2030, which makes a retirement policy an important approach to naturally reducing employment in the industry (Christiaensen et al., 2022). With regards to reskilling or retraining policies, Polish coal employees are typically semi-skilled (Bulmer et al., 2021) and have a basic vocational or secondary education (Baran et al., 2020), which may limit their ability to easily shift into employment opportunities in other more skill-intensive sectors. Furthermore, coal miners earn relatively high wages compared to lower-skilled workers in other industries and enjoy additional benefits that have resulted from the influence of unionisation in the industry (Baran et al., 2020). This may make them less likely to want to shift into other industries, even if they were able to find a job match in another industry.

Given the lack of research on indirect coal phase-out effects, Frankowski et al. (2022) attempt to estimate a measure of the indirect employment effects of hard coal mining in the Upper Silesia region of Poland. They state that it is insufficient to calculate only the number of direct coal mining jobs. Indirect (mining-related) employment is defined as "*people employed at companies that produce goods or deliver services directly to coal enterprises*". The authors estimate that the coal phase-out will potentially impact an additional 51 200 indirect jobs[3] in the Upper Silesia region, mainly in manufacturing and construction companies.

The post-transition outcomes emerging from the United Kingdom's energy transition were mixed (Beatty et al., 2007). Despite worker contestation in the form of strike action, the United Kingdom (UK) began coal mine closures during the 1980s, with 90 percent of the coal mining labour force losing their jobs within the first decade of mine closure (Beatty et al., 2007). Total coal employment in the English and Welsh coalfields declined from 221 000 workers in 1985 (of which 171 000 were miners) to fewer than 7 000 workers by 2005 (4 000 miners), with the majority of mine workers being male workers in manual occupations. By 2011, only four collieries remained open, and the number of mining employees declined further to 6 000 workers (Aragón et al., 2018). In 2015, the last large deep mine closed (Fothergill, 2017).

During the early transition years, redundancy payments were offered to workers, while those who chose to stay were transferred to other mines (Fothergill, 2017). There was a clear difference in worker response by age. Older workers were more willing to take the benefits and become economically inactive, while younger workers remained at coal mines until, eventually, they attempted to shift into other – often lower paying – industries. This pattern in miner behaviour seems to have persisted. However, the key issue has been a shortage of new jobs for miners (production) and non-miners (non-production) alike (Fothergill, 2017).

Findings by Aragón et al. (2018) suggest that workers who found alternative employment typically shifted to manufacturing, construction, transport, and services industries. Their findings also indicate that the shift of male mine workers into the non-primary sectors crowded out women employed in these sectors. In manufacturing, the number of male employees increased, while the number of female employees decreased. A similar effect was observed in the services sector, although this negative displacement effect was smaller than that observed in manufacturing.

[3] The authors calculate an indirect-to-direct jobs ratio of 1:0.71. Given the figure of 51 200 indirect jobs that are impacted, this would mean approximately 72 100 direct jobs impacted.

Despite the UK government's policies designed to support workers, limited alternative employment opportunities in English and Welsh coal regions have resulted in persistent negative labour market outcomes for those remaining in the labour market (Beatty & Fothergill, 1996). While some regions saw partial economic recovery, others continued to struggle with high levels of economic inactivity and poverty, indicating that the long-term outcomes of the transition remained challenging for many former coalfield communities.

In contrast to the UK case of targeting mine closures despite striking workers, Ukraine decided against explicitly reducing coal production due to political and social concerns (Zinecker et al., 2018). However, driven by economic factors, such as high production costs and safety issues resulting from the country's geological conditions, Ukraine's coal sector began declining during the1980s and 1990s. Coal extraction halved from the sector's peak production level of 152.6 metric ton (Mt) in 1976, to 87 Mt in 1990 (Zinecker et al., 2018). By 2016, production had declined even further to 23 Mt. The number of jobs provided by the industry declined from 870 000 in 1991 (511 000 direct workers in coal mining) to 122 000 in 2016 (Savitsky, 2015; Zinecker et al., 2018).

Ukraine's coal deposits and mining sites are concentrated in the Donets Basin, or Donbass (Savitsky, 2015). Due to the development of single-industry satellite towns around the coal mines in this region, households were highly dependent on mining jobs. Given the concentrated nature of the local economies surrounding mining towns, mine closure over time resulted in significant socio-economic problems. Limited alternative employment opportunities resulted in growing unemployment levels, with unemployment rates reaching between 1.5 to 3 times that of the average unemployment rates in other non-mining towns in the same region (Savitsky, 2015; Zinecker et al., 2018).

Due to social and political pressures, government funds have been aimed at continued maintenance of unprofitable mines, rather than sufficiently supporting mine workers (Zinecker et al., 2018). Furthermore, where measures have been aimed at workers, these efforts have suffered poor coordination and misuse of funds. Still, support of ex-miners, such as retraining, redundancy payments, and the development of regional infrastructure, has been included in future planning (Zinecker et al., 2018). However, the current conflict with Russia largely affects the mining regions, stalling any progress.

In 1991, environmental motivations caused the adoption of a coal phase-out in the Czech Republic (Lehotský & Cernik, 2019). The government set out various restrictions, such as limited spatial boundaries where mining would be permitted, and filters were required to be installed at power plants. However, these restrictions were not strong enough to encourage the desired phase out (Lehotský & Cernik, 2019). Nonetheless, between 1990 and 2001, mining employment in the country's Ostrava region declined from 62 087 to 21 482 (Bruha et al., 2005). Over the same period, the region's unemployment rate increased from 1.2 percent in 1990 to 20.2 percent in 2001. Bruha et al. (2005) argue that two factors that eased the labour market impact of this transition were co-operation and consultation between the miner's union and the government, and that miners proactively sought out alternative employment opportunities. However, the latter was possible because the Ostrava region was relatively diversified and thus able to provide alternative employment pathways for former coal sector workers.

While hard coal production has been steadily declining in the Ostrava region (Northern Moravia), brown coal (lignite) mining in the Northern Bohemia region has only experienced a slight downturn. Lehotský & Cernik (2019) highlight that the brown coal mining regions are relatively underdeveloped and coal dependent, which may cause some opposition to a continued coal phase-out. They stress the importance of policy focused on a fair distribution of the costs and benefits of the phase-out, referring here to a previous episode in which a coal mining company went bankrupt, and workers shouldered the reduced wages and job losses while the company received support from the state.

Unlike *advanced transitioners*, *partial transitioners* are countries that have experienced a decline in the demand for coal, and transitions towards cleaner energy production have taken place more recently, or are underway (Bulmer et al., 2021). However, progress in these countries may be slowed, or stalled, due to economic, political, and social challenges. Although discussions around a transition may occur, significant portions of the coal industry are still operational and communities reliant on coal-based employment remain vulnerable.

As the country transitioned to a market economy in the 1990s, Russia's coal production started declining, and continued on this downward trend until 1998 (Overland & Loginova, 2023). Between 1992 and 2001, coal industry employment decreased from 900 000 to 328 000 (Haney & Shkaratan, 2003). During this restructuring period, the government provided several social programmes for workers, including support for relocation, assistance for purchasing housing, and support for generating new jobs and small businesses (Korppoo et al., 2021). Since 2001, despite declining domestic consumption of coal that resulted from a decreasing share in Russia's energy mix, Russian coal production and exports continued increasing and peaked in 2019 (Overland & Loginova, 2023). In 2020, the international demand for Russian coal started to decline. Furthermore, Russia announced an emissions target of 70–75 percent of its 1990 levels by 2030 (Korppoo et al., 2021).

In 2019, coal employment stood at 133 000 employees (Korppoo et al., 2021), with most of this employment within the Kuzbass region where the coal industry accounts for 30 percent of the industrial production and 96 percent of the region's fuel (Safonov, 2021). As a precaution against the coal sector becoming less competitive as a result of global energy transitions, the state has requested that regional governments and companies in coal-producing regions use coal export revenues to stimulate regional diversification (Safonov, 2021). In 2021, projects adopted by the federal government of the Kuzbass region included the development of a new plant for the manufacture of ammonia and urea production, a hydro-plant, and a logistical centre for a large retailer (Safonov, 2021). The projected number of non-coal employment opportunities created by these regional diversification strategies is estimated to be over 13 000 jobs (Safonov, 2021).

In line with the European Union target to reduce coal-derived energy by 2030, the regional government of Western Macedonia in Greece has started working towards an energy transition in its coal and lignite dependent regions (Christiaensen & Ferre, 2020). Western Macedonia is already the poorest region in Greece and, therefore, requires careful planning with regards to its transition. Coal mining and energy production do not account for a large proportion of Greece's employment. However, mining and power generation account for between 22 and 33 percent of all employment in the municipalities of Florina, Amynteo, Eordea and Kozani in the eastern parts of Western Macedonia (Christiaensen & Ferre, 2020).

As is the case with the relatively poor mining regions in other countries, mining and quarrying and energy production has provided a reliable source of employment and income for households within these key municipalities. Christiaensen & Ferre (2020) estimate that the closure of mines could affect 16 000 jobs, with approximately 70 percent of these jobs being indirect beyond mining and power generation. Pavloudakis et al. (2020) estimate the job losses between 2013 and 2028 – the target date for zero lignite production – to be 21 000 jobs, corresponding with a 24 percent reduction in employment in the region. Without appropriate support policies in place, the unemployment and poverty already present in the region will not only persist but grow.

An important factor in the decisions of policymakers is the age distribution of the mostly male workforce. Christiaensen & Ferre (2020) note that the permanent workers are primarily men older than 50 years of age, with primary or secondary levels of education, working as technicians. Although they may be relatively well skilled, having worked at the mine or power plant for many years, their level of education may limit their ability to shift into alternative employment opportunities in other industries. However, because many of these workers are nearing retirement, they may be more willing to accept a retirement package. In this case, it should be noted that mine workers earn higher salaries than power plant workers (Christiaensen & Ferre, 2020), which may have implications for the total cost of support provided to each group in the event of closures.

In terms of policy approaches to the region itself, Pavloudakis et al. (2020) notes that the European Commission proposes a Just Transition Mechanism as a tool to help transitioning countries that are most impacted and generate the regional investments that they require. The proposed mechanism consists of a Just Transition Fund for the provision of grants; InvestEU to manage private investments; and a public sector loan facility for supplementary investments to be leveraged by the European Investment Bank. While all transitioning regions will require general funding, Pavloudakis et al. (2020) highlight that those especially hard hit by transitions will need to restructure their local economies, ensuring the development of new business activity and creation of skills. These region-specific needs may require additional, focused investments.

The United States of America (USA) is a special case for the *partial transitioners* as the country has experienced a separation between coal production and coal employment. In the US, growth in surface mining and improvements in mechanisation resulted in coal production seeing a steady increase from the 1950s until the 2010s, while coal mining employment declined over the same period. Employment declined from over 200 000 coal workers at the end of the 1970s to less than 50 000 in 2021 (Bulmer et al., 2021). During the 2010s, as a result of clean energy policies and shifts to other fuel sources, US coal production and coal power plant capacity began to decline. Almost one fifth (18 percent) of coal power plant capacity was retired in 2020 (Hearer & Pratson, 2015; Weber, 2020). Due to changes in electricity generation, Hearer & Pratson (2015) estimate that around 49 000 direct and indirect jobs in the coal-powered electricity supply chain were lost between 2008 and 2012 (a rate of -5 percent per annum). These include jobs in coal mining, mining support, rail transport, and power generation and supply. Weber (2020) estimates that, between 2011 and 2016, the number of coal mining jobs lost was 43 467 (approximately 45 percent of the national coal mining workforce).

Similar to the other cases, coal-related activities were regionally concentrated in the Appalachian region, which over time became dependent on the coal economy (Bulmer et al., 2021; Greenspon & Raimi, 2022). This region is historically poorer than most of the United States. However, in the US, coal jobs are highly unionised and high paying relative to other jobs (Carley et al., 2018). This partly explains the concentrated nature of these regional economies as workers enjoy the security provided by relatively high paying mining jobs, and businesses are not incentivised to diversify. This results in individuals who live in these regions having limited alternative employment options.

It is often contended that the phase-out of jobs linked to coal energy will be compensated for by new jobs in the renewable energy sector. In the US case, Hearer & Pratson (2015) estimate an increase of 125 000 new jobs in alternative energy sectors such as wind, solar and natural gas. While this may hypothetically be enough job creation to cancel out the estimated 70 000 workers in coal-powered electricity generation in 2022 (Hanson, 2023), these types of jobs are not necessarily available in the regions where fossil fuel extraction takes place. The implication being that, assuming fossil fuel workers can seamlessly match to jobs in the renewable energy sector, these workers leaving mines and coal-fired power plants would need to be both willing and able to relocate (Hanson, 2023; Greenspon & Raimi, 2022).

This willingness to relocate is an important consideration for policymakers. Greenspon & Raimi (2022) find that fossil fuel workers are less likely to have relocated within the past year compared to the national average. However, the study results also identify substantial regional differences in relocation rates. For example, the fossil fuel workforce in the Appalachian coal region has lower moving rates than the US average compared to those in the Permian Basin region, who have higher moving rates than the national average.

Furthermore, Greenspon & Raimi (2022) contend that although new energy jobs in renewables may be available, policymakers need to be aware of the skills required for different roles, as well as the potential skills mismatch between job leavers from the fossil fuel industry and the new job opportunities in renewables. Greenspon & Raimi (2022) perform an analysis where they compare the attained skills of fossil fuel workers in relation to the required skills of in-demand jobs that pay at least 90 percent of their current wage. For workers in Appalachia, they find relatively high skills gaps. They find that the skills contributing the most to these skills gaps (for fossil fuel workers as an aggregate) are social, content (foundational skills needed to acquire more skills), and problem-solving skills. They further note that these patterns in skills gaps are consistent across regions. However, in all regions, fossil fuel workers exceed at technical skills such as operations and monitoring, or equipment maintenance skills.

Weber (2020) estimates that for every one coal job lost in the US between 2011 and 2016, unemployment increased by 0.32 unemployed people, which equates to approximately 14 000 unemployed people over the period. This is especially important, considering the finding by Greenspon & Raimi (2022) that current fossil fuel workers are typically the primary earner in their household. However, Weber's findings also suggest that social assistance programmes, such as unemployment insurance, reduced the negative effects of job losses. This highlights the usefulness of policies, such as grants, to support workers in the transition, especially considering the age profile of current fossil fuel workers in the US; and the fact that the current cohort of workers is, on average, far from retirement age (under 55 years old). The findings, showing that coal workers in the US are less educated and have a lower moving rate, suggest that planning around retraining and the creation of alternative employment within the region are essential.

Studying the labour market effects of energy transitions and the policy approaches taken by these countries can provide important insights for policymakers in countries that are in the early stages of transitioning. Using the Bulmer et al. (2021) classification of coal-producing countries at varying stages of their energy transitions, these countries include *expanding exporters* that have not yet experienced a decline in coal demand, such as South Africa; and *domestic demand accommodators*, such as India (Bulmer et al., 2021).

When looking at the impacts of transitions away from coal, it is clear that labour market effects of coal transitions are primarily regional due to the geographic concentration of coal mining and coal power generation activities around coal deposits. As we show below, South Africa is no different in this regard. Regions within countries that have shifted away from coal production have all faced considerable employment losses in the coal mining sector. These regions often suffer from historical dependence on coal mining, which makes the transition particularly challenging. This dependence on coal has significant implications for transition policies, as coal-related workers are often the primary wage earners of their households, and the non-coal businesses in these regional economies rely heavily on the presence of these coal households.

One reason for the development of a high dependence on coal-related activities in these regional economies is that coal mining jobs typically offer higher wages (often to make up for the health risks) and better benefits compared to alternative regional employment opportunities. In some cases, this has led to a localised 'Dutch disease' effect, where the coal sector has drawn resources and labour away from other industries, limiting the development of alternative, lower-wage employment opportunities in the region. As suggested by earlier studies, this higher job quality must be considered when creating a support package for job leavers, since these coal workers would be accustomed to a higher level of income to support their households. This must also be considered when assessing the alternative employment options available to workers as they may be less likely to take on lower paying alternatives in the region.

In addition, strong unionisation in the mining sector provides an added layer of security for workers. In regions with strong union presence, such as in Poland and the United States, there may be greater resistance to mine closures and a higher demand for substantial compensation packages. The case of Germany's Ruhr region has also illustrated the negative impact that resistance to the transition can have on labour market outcomes. A successful transition will require co-operation and communication between policymakers and unions.

The literature also highlights the importance of considering the age composition of the coal mining workforce during transition planning. In regions with older workforces, early retirement schemes provide a suitable policy response, for example in Germany and Poland. However, in regions with younger workforces, such as in parts of the United States, retraining and finding alternative employment in new or related industries are more pressing concerns. Therefore, the policy decisions must be informed by the age distribution of the workforce.

Effective transition policies must operate on two levels: regional economic diversification and individual social protection. Structural policies aimed at regional economic diversification, such as those implemented in Germany, have shown that attracting new industries to the region is a more sustainable strategy than simply creating new jobs at a national level. This approach not only addresses immediate employment needs but also has the potential to support long-term regional development.

The choice of industries in which to invest during the transition is crucial for ensuring sustainable regional growth. In Germany, the investment in the automotive industry was successful in providing alternative employment but resulted in the Saarland region becoming dependent on a new industry. In Russia, the diversification plan has focused on matured sectors, which may not lead to strong long-term employment and productivity growth. Policymakers should prioritise investment in a diverse number of fast-growing industries, which leverage off existing industrial capabilities in the region, and which have the potential to foster employment growth in the region.

With regards to social protection policies, when a large share of the workforce is close to retirement, retirement packages can provide a suitable policy option. However, policies that focus solely on social protection, such as grants or early retirement packages, may not be sufficient to ensure the economic viability of transitioning regions. Without comprehensive regional development coupled with retraining and reskilling to ensure that younger workers have alternative employment options, these workers are likely to leave the region or become unemployed. Overall, policy should also be aimed at different levels of vulnerability in the workforce and the different treatments that they require. To achieve this, social protection and regional development goals need to be balanced within policy.

Finally, it is important to consider not only the direct effects of coal mine closures but also the broader value chain, including coal-fired power plants and related industries. The literature highlights the fact that most transitioning countries have experienced significant indirect job losses in power generation, steel, manufacturing and other sectors linked to coal mining. Other research has focused on fossil fuel employment as a whole. What is important to draw from this is that coal mining employment and coal production are at the head of a wider value chain and are closely tied to a number of other industries. Where possible, policymakers must therefore adopt an extended policy approach that includes support for all affected sectors.

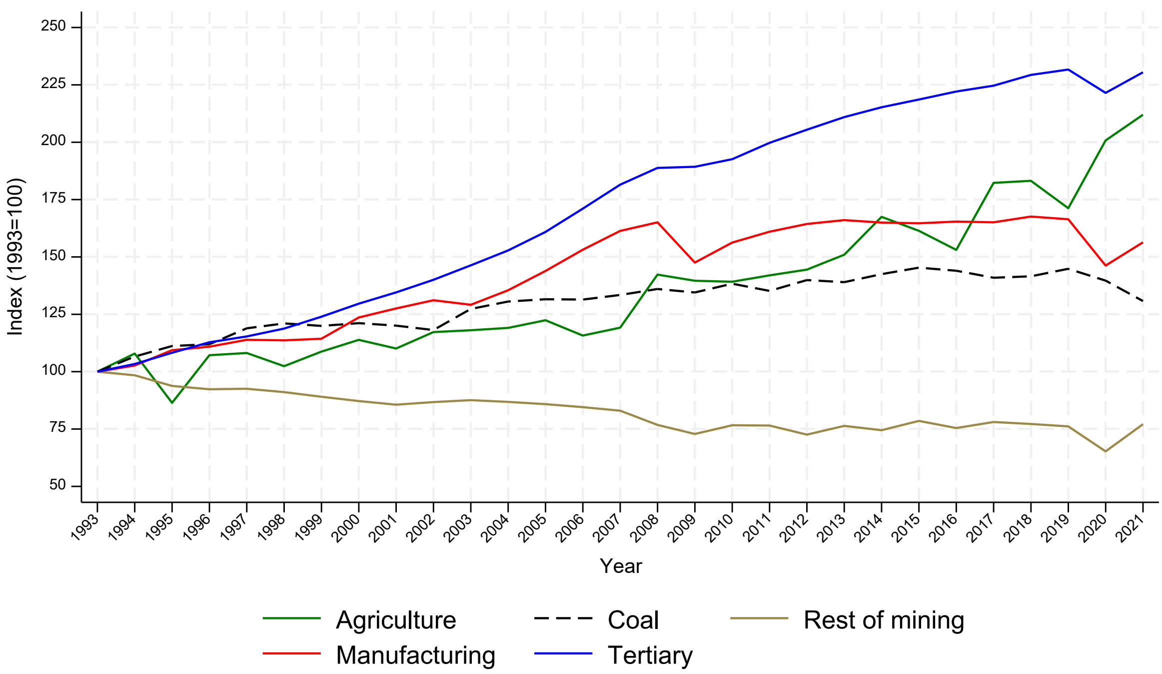
3 The Context of South Africa's Energy Transition

South Africa's energy transition is shaped by both endogenous and exogenous factors. On the one hand, a large contingent of South Africa's coal energy infrastructure is approaching retirement, and this acts as an endogenous force driving a shift away from fossil fuels. At the same time, in line with a global shift towards greener and more sustainable energy production, South Africa's Paris Agreement commitments act as an exogenous force driving a shift away from fossil fuels. As a coal-based economy with a coal value chain spanning petrochemicals, metals, transportation, and electricity generation, the country will face substantial labour market challenges as it shifts away from coal. Understanding the magnitude of this transition is critical to ensuring that workers and communities are supported through appropriate policy measures. In this section, we begin by providing an overview of the economic contribution of coal to the South African economy. This is followed by a discussion on the regional concentration of coal mining and coal-fired power generation, as well as the current timelines for the closure of mines and retirement of coal power plants.

The coal mining industry is a core component of the South African mining sector. In 2021, coal mining accounted for approximately 17.7 percent of the gross value-added (GVA) generated by the mining and quarrying sector (Statistics South Africa, 2024a). This share has grown from 13 percent in 1993 to a peak of 21 percent in 2020. The rising importance of coal in the mining and quarrying sector is evident in the growth trends presented in Figure 1. Here we see that the coal mining industry has outperformed the broader mining sector, with the former growing at an average annualised rate of 0.93 percent over the period, while the latter experienced an average annual decline of 0.89 percent.

However, with respect to the industry's contribution to the national economy, the contribution is relatively small and has been declining over time.[4] In 1993, the coal mining industry accounted for 1.43 percent of gross value-added in the South Africa economy (Statistics South Africa, 2024a). This relative contribution declined to 0.95 percent in 2021 (Statistics South Africa, 2024a). This declining relative contribution to output is further expressed in Figure 1, where the coal mining industry has underperformed relative to the tertiary, manufacturing and agriculture sectors since the 2000s.

Figure 1: Growth of value-added by industry, 1993–2021



Source: Statistics South Africa (2024a)
Note: Industry value added series reported at 2015 constant prices.

While the coal mining industry's contribution to national GVA is relatively small, the industry remains a key source of export revenue. The minerals sector is South Africa's second-largest export sector,

[4] It is worth noting further that the coal mining industry is smaller, in terms of contribution to GVA, than a number of key manufacturing industries, which include: Food and beverages (2.83 percent of GVA); Wood and paper (1.23 percent); Petroleum, chemicals and plastics (2.39 percent); Metals and machinery (2.52 percent); and Transport equipment (1.07 percent) (see Figure A 1 in the Appendix). These industries are key to industrial growth, and require both a stable energy environment, and a shift to cleaner energies to enable access to key export markets that increasingly require cleaner energy inputs into production.

with coal being the second-largest contributor within this sector. Coal accounted for 4.19 percent of South Africa's total exports in 2021, down slightly from 5.15 percent in 1995, indicating a consistent share over time (The Growth Lab at Harvard University, 2024).

South Africa's top three coal export destinations or partners are India, Pakistan, and China. India's coal imports have shown a rapid increase in value since 2006, while Pakistan's coal imports have also been growing steadily over the years. Coal exports to China saw a substantial rise between 2009 to 2014, with demand increasing again from 2020. These trends suggest a growing export demand for South African coal, highlighting the ongoing importance of coal exports to the economy despite ongoing changes in global energy markets.

The coal industry's economic contribution is felt more acutely in its downstream linkages to other industries along the coal value chain. In terms of domestic demand, key components of South Africa's industrial structure fall along the coal value chain. Since coal is an input in various production processes, the coal value chain has linkages to the petrochemicals sector, the metals industry, and electricity production. According to Makgetla et al. (2019), coal mining employed approximately 87 000 employees, Eskom's electricity production workforce was estimated to be 12 000 employees, and Sasol employed approximately 26 000 workers in South Africa in 2018. Additionally, the transport sector is linked to coal through its rail and road transport, both between industries and to export destinations.

We now shift focus toward South Africa's energy generation structure, which is concentrated in coal-fired power production. Table 1 presents the total power generation capacity of South Africa's power stations by type, and the share of each of these power types to total power generation capacity in megawatts (MW). Coal accounts for approximately 77 percent of the country's power generation capacity. Although there are a number of alternative energy sources in use, these sources account for less than one quarter of all energy production.

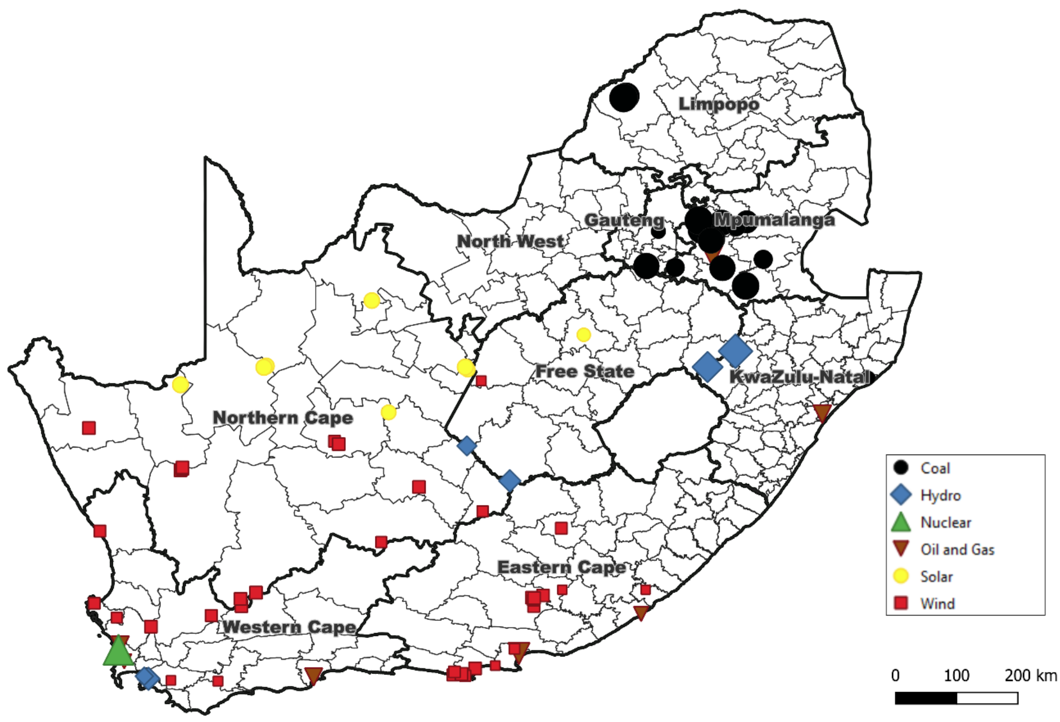
Table 1: Power stations by type and overall share of capacity (MW)

Type	Capacity (MW)	Share (%)
Oil and Gas	1 490	3.08
Coal	37 222	76.99
Solar	554	1.15
Hydro	3 492	7.22
Nuclear	1 940	4.01
Wind	3 648	7.55
Total	**48 346**	**100.00**

Source: Global Energy Monitor (2024a)
Notes: Limited to power plants that are listed as 'operating'.

Not only is South Africa's energy structure concentrated in coal power generation, it is also concentrated spatially in the north-east of the country, specifically in the Mpumalanga and Limpopo provinces. Figure 2 maps South Africa's power plants by type, with the size of each node representing the capacity (MW) of each plant. The figure clearly illustrates the spatial concentration and orientation of South Africa's energy structure toward coal-fired power generation. Figure 2 further details the provincial distribution of coal-fired power generation in South Africa. Coal-fired power production in Mpumalanga province accounts for 70 percent of all coal power generation capacity. This is followed by Limpopo, which accounts for approximately one fifth of coal power generation capacity.

Figure 2: Map of operating power plants/stations by type



Source: Global Energy Monitor (2024a)
Note: Size of nodes represent capacity (MW) of each station. Limited to power plants that are listed as 'operating'.

Over and above the exogenous forces driving the shift towards the greater use of renewable energy sources, there are also endogenous forces driving the current energy transition. A number of South Africa's coal-fired power plants are old and already have planned retirement dates. Table 2 shows that approximately one fifth of South Africa's coal-fired energy capacity is set to be retired by 2030 and, by 2040, half of the country's coal-based energy structure will have retired. Figure 3 illustrates the decline in capacity associated with the planned plant retirements. According to this figure, coal-fired energy production capacity is set to reduce by approximately 75 percent by 2050.

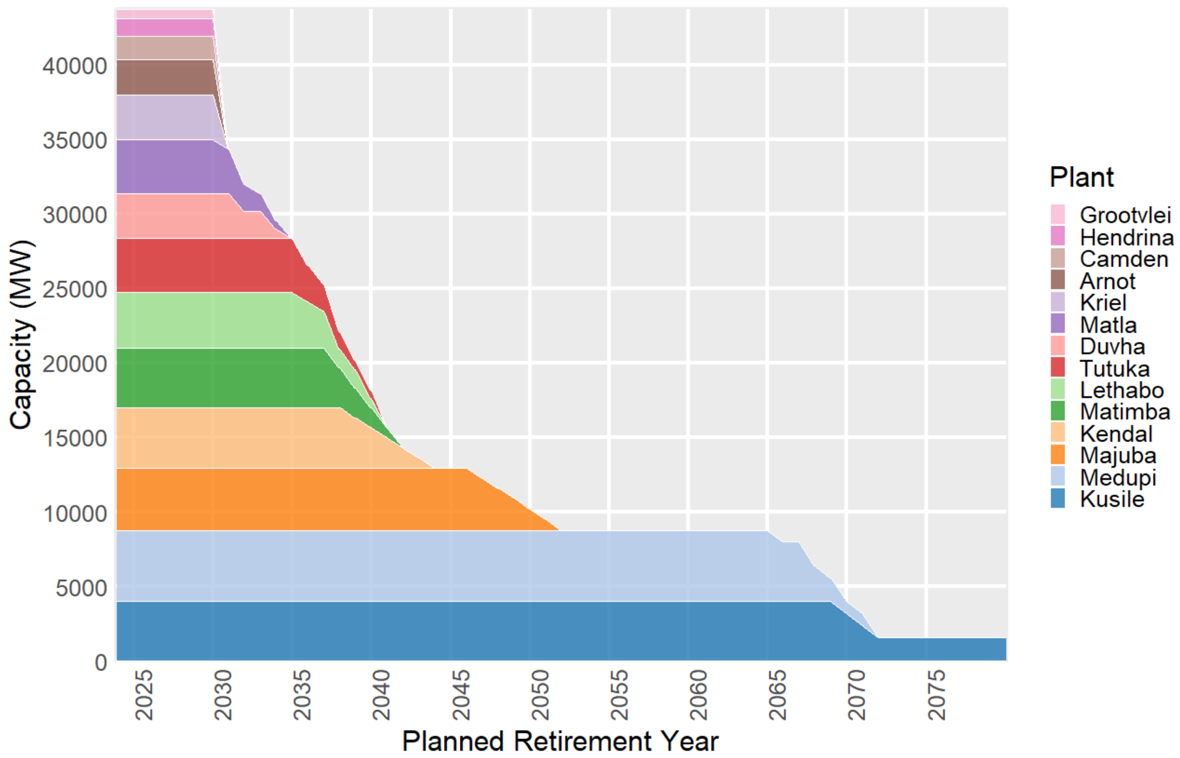
Table 2: Capacity and planned retirement of coal-fired power plants

Power station	Province	Operating capacity (MW)	Share of total operating capacity (%)	Last unit retirement	Combined capacity to be retired (MW)	Share of total operating capacity to be retired
Grootvlei	Mpumalanga	600	1.4	2025	8 952 by 2030	21.5
Hendrina	Mpumalanga	1 400	3.2	2025		
Camden	Mpumalanga	1 600	3.7	2025		
Arnot	Mpumalanga	2 352	5.4	2029		
Kriel	Mpumalanga	3 000	6.9	2030		
Matla	Mpumalanga	3 600	8.3	2034	6 600 by 2035	15.1
Duvha	Mpumalanga	3 000	6.9	2034		
Tutuka	Mpumalanga	3 654	8.4	2040	7 362 by 2040	16.9
Lethabo	Free State	3 708	8.5	2040		
Matimba	Limpopo	3 990	9.1	2041	8 160 by 2045	18.6
Kendal	Mpumalanga	4 116	9.4	2043		
Majuba	Mpumalanga	4 143	9.5	2051	4 143 by 2051	9.5
Medupi	Limpopo	4 769	10.9	2071	7 969 by 2071	18.3
Kusile	Mpumalanga	3 200	7.3	2071		
Eskom Total		**43 132**	**98.9**			
Kelvin	Gauteng	420	1.0	2026		
Richards Bay Mill	KwaZulu-Natal	72	0.2			
Total		**43 624**				

Source: Global Energy Monitor (2023) and adapted from Cole et al. (2023)
Notes: For share of total operating capacity to be retired by 2030, we include share of capacity from Kelvin power station. Also note that the total value for coal-powered operating capacity differs between Tables 1 and 2. The reason for this discrepancy is unclear but may be due to differences in data aggregation or classification methods used within the source material.

However, there is a level of uncertainty regarding the planned retirement of these coal-fired power plants, similar to the uncertainty around the extensions of coal mine lifespans. While the 2019 Integrated Resource Plan (IRP) suggests a decommissioning timeline in line with what is shown in Table 2, the latest version of the 2023 IRP notes additional coal-fired power capacity of 1 440 MW currently under construction in 2024 and 2025, as well as noting scenarios which delay the shutdown of coal-fired power stations (DMRE, 2024). However, it should be noted that the 2023 IRP is yet to be finalised and may undergo further changes as South Africa's energy environment continues to evolve. The Global Energy Monitor data also list one coal plant project currently under construction for 2025, and another announced for 2027 (Global Energy Monitor, 2024b).

Figure 3: Planned retirement of coal-powered plants

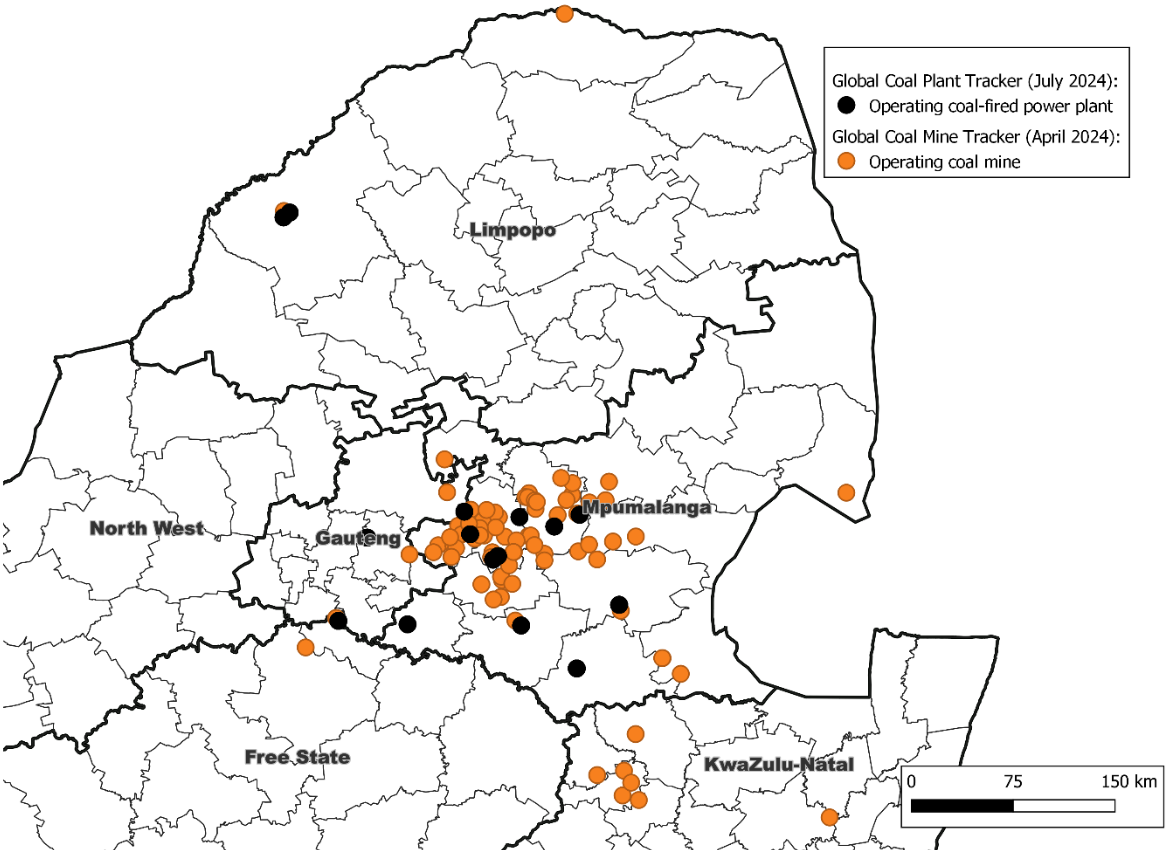


Source: Global Energy Monitor (2024b)
Note: Capacity over time of coal-fired power plants that are listed as 'operating'. Excludes plants with <1% of capacity (MW) in South Africa.

The spatial concentration of coal-fired power generation is expected as South Africa's coal resources, and hence coal mining, are also concentrated in Mpumalanga. The efficiency of the coal-based energy structure is ensured by locating coal power plants nearby the coal mines. As is shown in Table 3, the majority of operating coal mines in South Africa are located in Mpumalanga (approximately 77 percent), accounting for 69.3 percent of coal production. This is again followed by Limpopo, accounting for 21.5 percent of coal production. The coal mining industry is also concentrated within four mining companies – Seriti, Sasol, Exxaro, and Glencore – which together account for over 70 percent of all coal production (Global Energy Monitor, 2024c).

Figure 4 illustrates the spatial connectedness between coal mines and coal power plants in South Africa. The figure also suggests that both coal mines and coal-powered plants are further concentrated in the western municipal localities of the Mpumalanga province. This spatial concentration indicates that any transition away from coal will disproportionately affect the communities within these municipalities.

Figure 4: Spatial location of coal mines and coal-fired power plants in Mpumalanga



Source: Global Energy Monitor (2024b, 2024c)
Note: Limited to coal-fired power plants and coal mines that are listed as 'operating'.

As is the case for the age of coal power plants creating an endogenous shift, the remaining life of coal mines adds to this natural shift. The average life of mine for coal mines in South Africa is approximately 15 years, while the median life of mine is 13 years. This difference is due to a small number of mines with relatively high expected life of mine values driving up the average. We observe a high maximum life of mine in Limpopo and Mpumalanga (50 years). Using the mean and median life of mine values in Table 3, we should expect the majority or a large number of coal mines to close within the next 15 to 20 years. However, similar to the uncertainty around the decommissioning of coal-fired power plants, Cole et al. (2023) suggest that mine lifespans are likely to be extended. Data from the Global Energy Monitor list 37 proposed coal mine projects, with six already under construction. These proposed projects can be either extensions of existing mines or new mines.

Table 3: Spatial distribution of operating coal mines in South Africa

Province	No. of mines	No. of companies	Total annual production (Mt)	Share of production (%)	Life of mine (Years)		
					Mean	Median	Max
Free State	2	2	18.2	6.9%	19	19	19
Gauteng	2	1	2.5	1.0%	10	10	14
KwaZulu-Natal	8	7	3.3	1.3%	15	14	25
Limpopo	2	2	56.6	21.5%	35	35	50
Mpumalanga	65	43	182.2	69.3%	15	12	50
South Africa	79	50	262.9	100.0%	15	14	50

Source: Global Energy Monitor (2024c)
Note: Limited to coal mines that are listed as 'operating'.

The transition away from coal is expected to have significant labour market implications, especially for the regions and industries most dependent on the coal value chain. As coal mines and coal-fired power plants close, job losses and economic disruptions will disproportionately impact areas like Mpumalanga, where coal-related activity is spatially concentrated. A just energy transition will require careful planning and targeted policies to mitigate the negative labour market effects, including reskilling programmes, economic diversification, and social support for affected communities.

4 DATA AND METHOD

The analysis in this study primarily employs administrative tax data. The administrative tax data are made available to researchers at the National Treasury Secure Data Facility (NT-SDF) in Pretoria through a collaboration between the National Treasury (NT), the South African Revenue Service (SARS), and UNU-WIDER. These data include information garnered from filed tax forms linked to personal income tax (IRP5), company income tax (ITR14), value-added tax, and customs.

4.1 Motivations for using administrative tax data

This study quantifies and profiles workers in the coal mining industry who are at risk of losing their jobs as a result of South Africa's energy transition. The quantification of the size and shape of the coal labour market provides valuable input into policy considerations, such as social protection policy, which is designed to ensure a planned transition that counters the adverse socio-economic impacts likely to emerge from the transition. The quantification of the coal mining industry labour market can be achieved using a variety of data sources, including household surveys such as the Census and Quarterly Labour Force Survey; firm-level aggregations such as the Mining Census and Department of Mineral Resources and Energy data; and, as applied in this analysis, the administrative tax data. While each dataset brings a different lens to the same problem, each dataset also brings its own challenges. Some of the challenges include issues of coverage or representativity, irregular periods, under-sampling, limited disaggregation, and limited demographic characteristics. Bhorat et al. (2024) draw upon a variety of publicly available data sources to quantify and profile workers in both the coal mining industry and workers linked to coal-fired power generation. They primarily use household survey data that are harmonised in the Post-Apartheid Labour Market Series (PALMS) dataset. A key challenge that they noted when using these data, is the difficulty with statistical representativity when one disaggregates along the spatial and industrial dimensions.[5] Given that the administrative tax data capture information from all taxpayers, statistical representativity is not a concern.

A key motivation for using the administrative tax data is the quality of the earnings data. Bhorat et al. (2024) did not analyse the wages of coal mining industry workers. This is due to the well-documented concerns with the wage imputation method applied to generate the wage data variable in the Quarterly Labour Force Survey (QLFS) (Wittenberg, 2017a; Kerr & Wittenberg, 2019; Kerr & Wittenberg, 2021; Kohler et al., 2023).[6] Therefore, this study benefits from using the administrative tax data, which provide good quality earnings data. There is increased use of the administrative tax data to study key South Africa labour markets issues, particularly those pertaining to inequality (Jacobs et al., 2024; Kerr, 2021; Hundenborn et al., 2019). A key benefit of the administrative tax data is that it provides the actual income received by workers as reported by their employers. Furthermore, it provides better coverage of top income earners, as household surveys typically struggle to capture data on top income earners.

Nevertheless, there are certain limitations associated with the administrative tax data. First, the administrative tax data, by definition, are data capturing the formal sector of the economy. However, while it is important to take note of this, the analysis in this paper is unlikely to be materially impacted by only measuring formal sector coal mining employment. Bhorat et al. (2024) show that between 95 and 100 percent of coal mining industry workers are formal sector workers. Second, when compared to household survey data, the administrative tax data are limited in terms of measures capturing the individual characteristics of workers, such as the occupation, race, education, and the like. However, in the analysis below, we use what data are available, and control for gender and age.

4.2 Scope of analysis

The analysis in this paper focuses on workers in the coal mining industry. As discussed in Bhorat et al. (2024), these are workers along the coal value chain – as defined by Makgetla and Patel (2021) – that are directly affected by the energy transition. There are also workers in industries positioned along the coal value chain that are indirectly affected by the energy transition – including transportation of coal, coal-fired power production, manufacture of petro-chemicals and downstream chemicals, and manufacture of metals. Bhorat et al. (2024) detail how, apart from power production, it is impossible

[5] For example, the industry code measuring the coal mining industry (SIC210) is representative at the national level, but not at the provincial or municipal levels.

[6] See Wittenberg (2017a) for a detailed explanation of the challenges with the imputed QLFS wage data.

to quantify employment linked to coal production in these industries. As such, we do not attempt to include these industries in our analysis. Bhorat et al. (2024) do provide a means for measuring the size and shape of the labour market linked to coal-fired power production. They do this by exploiting the spatial distribution of various types of power production in South Africa. Unfortunately, given current data access controls at the NT-SDF, such analysis is not possible.

Relatedly, the analysis of employment in the coal mining industry is restricted to the national level. The NT-SDF data team is tasked with protecting the anonymity of firms and workers in the data, and it was contended that analysing coal mining industry employment at levels of spatial disaggregation below the national level would present a risk. Unfortunately, this nullifies our ability to, firstly, address the head office issue associated with these data and, secondly, reliably identify workers linked to coal power production.

4.3 Constructing an employee-level dataset

The IRP5 certificate, or Employee Tax Certificate, is submitted annually to SARS. We use version e5_v1 of the cleaned IRP5 datasets from the 2010/11 tax year to the 2021/22 tax year. The IRP5 data are at the individual worker level, with the tax year running from 1 March until end of February the following calendar year. In this study, for example, we refer to the 2010/11tax year as the 2011 period.[7]

To estimate employment numbers using the administrative tax data, we follow the data cleaning approach outlined in Kerr (2021). This involves the following: employees in the dataset are restricted to individuals who have ID numbers, which means that the dataset only includes individuals who are either South African citizens or permanent residents; the sample is restricted only to natural persons; individuals with no income data are removed; certificates with labour income less than R2 000 per year and more than R500 million per year are dropped; duplicate certificates are dropped; invalid job spells are dropped. Finally, we restrict our sample to the working age population, 15–64 years old.

The construction of the age categories in the analysis below is informed by the legislated retirement age for mining industry workers. The retirement age for mine workers is 55–60 years for underground workers and 55–63 years for surface workers (Mineworkers Provident Fund, 2024). Using this information to construct age categories is important because we are better able to quantify the number of coal mining industry workers nearing retirement.

To construct the wage variable used in our analysis, we follow Kerr (2020). We use the Kerr income variable, which is derived from the main income source codes. The Kerr income variable captures annual nominal labour income in each tax year for formal sector workers. We convert the annual

[7] One implication of this is that 2011 tax year mainly captures the 2010 period, the estimates will reflect a lag in relation to estimates from other datasets.

labour income to monthly labour income. We do this by calculating the number of days worked and then adjust the daily wages to reflect a full month of work in a given tax year. Furthermore, we winsorize the wage data by recoding the top and bottom one percent of the earning data. Winsorizing the data addresses the problem of outliers in a distribution of data, by recoding or substituting the extreme values with the minimum value of the upper bound and the maximum of the lower bound (Sharma & Chatterjee, 2021; Wu & Zuo, 2008). To account for inflation and generate real wage estimates, the earnings data are adjusted to December 2023 prices.

To allocate an industry to a worker identified in the IRP5, we use the industry data contained within the SARS-NT panel dataset, follow the recommendations detailed in Budlender & Ebrahim (2020), and map the recorded industry of the firm to the employee of the firm. Budlender & Ebrahim (2020) created the best practice industry variable using the Company Income Tax (CIT) profit code.

To identify workers in the coal mining industry, two variables are important: industry and province. However, these variables present some challenges: First, the industry variable is sparsely populated in 2011, 2012, 2013, and 2022. Secondly, the ITR14 is captured by the firm head office and assigned by the person responsible for the tax filing. The implication is that in the case of a firm that operates across multiple industries, the individual responsible for filing the ITR14 form makes a judgement call on the industry within which the firm operates. For example, a mining firm that mainly operates in platinum mining, but also has coal operations, will identify as a platinum firm and, as a result, all employees within the firm will be allocated to the platinum mining industry (or vice versa). Such scenarios may result in an over- or under-estimation of employment in the coal mining industry. Furthermore, we noticed that the Main Industry Code was missing in some tax years for certain firms but populated in others. To resolve this, we appended CIT datasets from 2011 to 2022 and took the mode of the Main Industry Code for each firm to select the most-frequent reported firm industry classification across all years. This allowed us to successfully impute the industry code for firms with missing data. As a result, we achieved over 80 percent coverage of the main industry code across the period. This study uses the 1- and 3-digit SIC5 industry classification.

5 THE SIZE AND SHAPE OF EMPLOYMENT IN THE SOUTH AFRICAN COAL MINING INDUSTRY

In this section we detail the number of workers employed in South Africa's coal mining industry.[8] In so doing, we get a sense of the quantum of workers at risk of job loss as South Africa's energy transition unfolds. We start by providing a discussion that unpacks the coal mining industry employment estimates

[8] The administrative tax data at the NT-SDF, while possible, do not afford us the opportunity to unpack employment estimates at a more disaggregated regional level. Nevertheless, we know from previous analysis by Bhorat et al. (2024) that South Africa's coal mining industry is concentrated in Mpumalanga, with near on 80 percent of employment in the industry being located within the province. Employment is further concentrated within the local municipal areas to the west of the province, accounting for approximately 70 percent of total employment in the industry.

derived from different data sources, and the implications of these estimates. This builds off initial work conducted by Bhorat et al. (2024). We then discuss employment trends in the coal mining industry in relation to the broader South African economy.

5.1 National level coal mining industry employment estimates

We contribute to the analysis of Bhorat et al. (2024), which sets out to measure the quantum of coal mining industry jobs, by adding our series of administrative tax data estimates to the series of estimates they generated from several reliable statistical sources.[9] We present these estimates in Figure 5 where we plot employment estimates for the coal mining industry for the period 1994 to 2022, using the following data sources: first, we use annual estimates from the constituent household survey instruments – October Household Survey, Labour Force Survey, and Quarterly Labour Force Survey – that comprise the PALMS dataset (blue line).[10] Second, we include point estimates from the three household Census – 1996, 2001, and 2011 – carried out since 1994 (orange circles).[11] Third, we employ updated estimates from the Mineral Statistics Tables compiled by the Department of Mineral Resources and Energy (DMRE) (red line); fourth, we provide seven sets of point estimates – 1996, 2004, 2009, 2012, 2019, and 2022 – from Statistics South Africa's Mining Census.[12] We provide two sets of these estimates: the first, comprising employment numbers for mining employees, capital employees, employees of labour brokers, and employees of sub-contractors (yellow triangles); and the second, comprising employment numbers for mining employees and capital employees only (purple triangles). Finally, we provide a series of employment estimates using the administrative tax data – as detailed above – for the period 2011 to 2022 (green line).

These different data series measuring coal mining employment are capturing different types of employment in the industry. The employment estimates generated by Statistics South Africa emerge from their Mining Census (yellow triangles) and explicitly divide employment in a mining establishment into four categories: mine employees; capital employees[13]; employees employed through labour

[9] Where applicable, we also provide updated estimates for data series used by Bhorat et al. (2024), including: updated Statistical Tables from the DMRE; estimates from the more recent 2022 iteration of Statistics South Africa's Mining Census; revisions to the 2019 estimates for Statistics South Africa's Mining Census.

[10] The PALMS dataset, developed by Kerr, Lam & Wittenberg (2019), is a harmonised series of South African household survey data for the years 1994 through 2019. To generate estimates post-2019, we augment these data with estimates taken from more recent QLFS datasets.

[11] The labour module of the most recent 2022 Census will not be released to the public as these estimates were characterised by reporting and coverage biases (Statistics South Africa, 2024). As such, we cannot provide a 2022 employment estimate using the most recent Census.

[12] We omit estimates from the 2015 version of Statistics South Africa's Mining Census as the employment estimates for the coal mining industry are likely inflated. The 2015 estimates are of concern for two reasons: First, they are at levels well in excess of those recorded in the 2012, 2019 and 2022 versions of the report, and thus sit outside the long-term trend. Second, these high estimates run counter to the trend of declining employment levels in the industry over the 2014–2015 period.

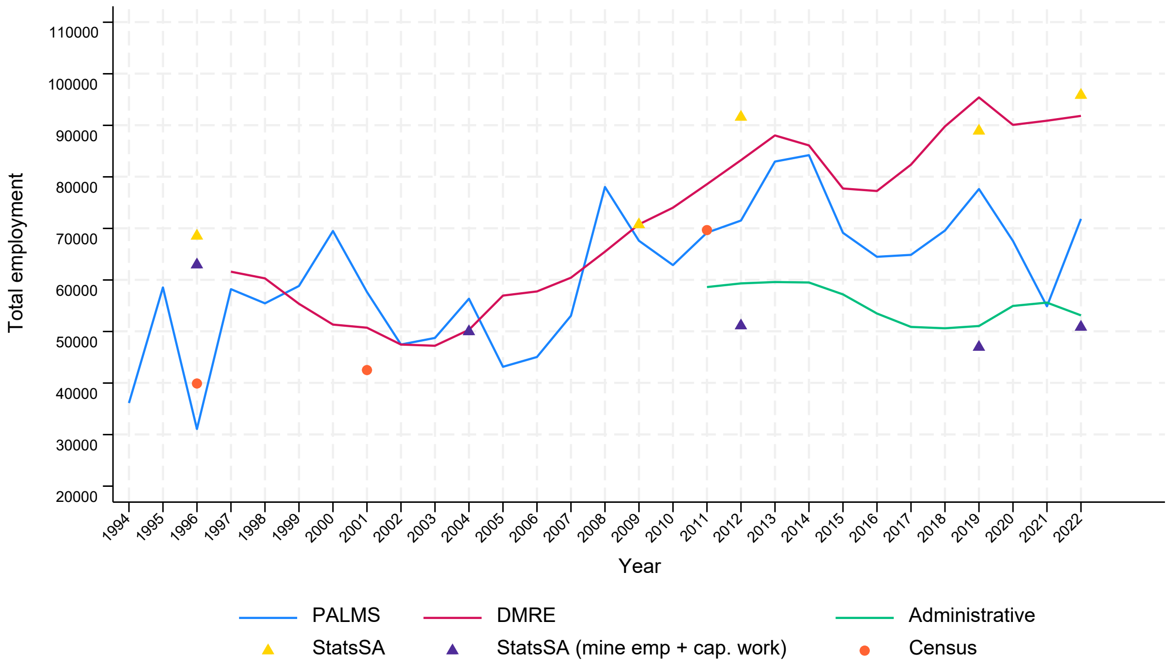
[13] Employees working on projects outside the daily scope of business operations.

brokers; employees of subcontractors[14]. These estimates capture all forms of employment at coal mines. As is evident in Figure 5, the DMRE estimates (red line) align quite closely with Statistics South Africa's Mining Census estimates and are most likely capturing all forms of employment on coal mines. The DMRE Statistical Bulletin does not provide metadata, but we do know that the data are captured directly from mining establishments by the department, and given how closely the levels align with those obtained from the Mining Census, it is likely, while not explicitly stated, that they are measuring employment in a similar manner. Together, these two series of data provide the upper bound estimate of coal mining industry employment, as they are capturing all forms of employment at coal mines.

The notion that the different series presented in Figure 5 are capturing different types of employment is bolstered when we compare the employment estimates generated using the administrative tax data (green line) to that evident in Statistics South Africa's employment estimates that only count mining employees and capital employees (purple triangle). We observe that the estimates from these two data sources align quite closely. This is unsurprising since the administrative tax data are counting workers employed in the industry as those who have an IRP5 form from a firm that declares itself to be operating in the coal mining industry – i.e. they are direct employees of the firm. The second set of Statistics South Africa estimates include mine employees and capital employees, both of which would receive an IRP5 form from the coal mining firm. Conversely, employees of labour brokers and sub-contractors, while providing services to a coal mining firm, are employed in firms that are positioned in a different industry. For example, a sub-contractor employee engaged in construction activities for the mine would work for a firm located within the construction industry. These two series, capturing employees directly employed by coal mining companies, provide a lower bound estimate for employment in the coal mining industry.

[14] Employees of sub-contractors are employees of outside contractors involved in mining production on a fee or contract basis.

Figure 5: Coal mining industry employment levels, 1994–2022



Source: Authors' calculations using PALMS (Kerr, Lam & Wittenberg, 2019); South Africa Census (Statistics South Africa, 1998; 2003; 2015); Mining Census (Statistics South Africa, 1999; 2005; 2011; 2014; 2021; 2024); Department of Mineral Resources and Energy (2020; 2023); National Treasury & UNU-WIDER (2024)
Notes: Statistics South Africa Mining Census estimates comprise mining employees, employees of labour brokers, employees of sub-contractors, and capital employees. Statistics South Africa (mine emp. + cap. work) estimates comprise only mining employees and capital employees.

The employment estimates that emerge from the household survey datasets – the Census and PALMS series – tend to fall between these two bounds. The household surveys determine an employed individual's industry based on his/her response to the following question: *What are the main goods and/or services produced at your place of work?* In the case of a mine employee, the answer is obvious – coal is the main good produced (mined) at his/her place of work, and thus the household survey estimates are likely to capture this type of employment comprehensively. This is corroborated by the household survey estimates lying above the series that are capturing mine employees (i.e. the administrative tax data and Mining Census estimates for only mine employees and capital employees).[15] That the household survey data, for the most part, lie above the series capturing the employment of mine employees, is perhaps explained by the nature of work performed by the sub-contractor or labour

[15] This is certainly the case since 2011 where the various series are well populated. Two points are worth noting: first, there is only one instance, in 1996, where the household survey data provide estimates below the Statistics South Africa Mining Census estimates for mine employees. Second, as discussed in Bhorat et al. (2024), the household survey data, particularly those derived from the Labour Force Surveys, are noisy, and as depicted, the PALMS estimates, while holding a common trend, exhibit a great deal of variation. This is a small sample size issue.

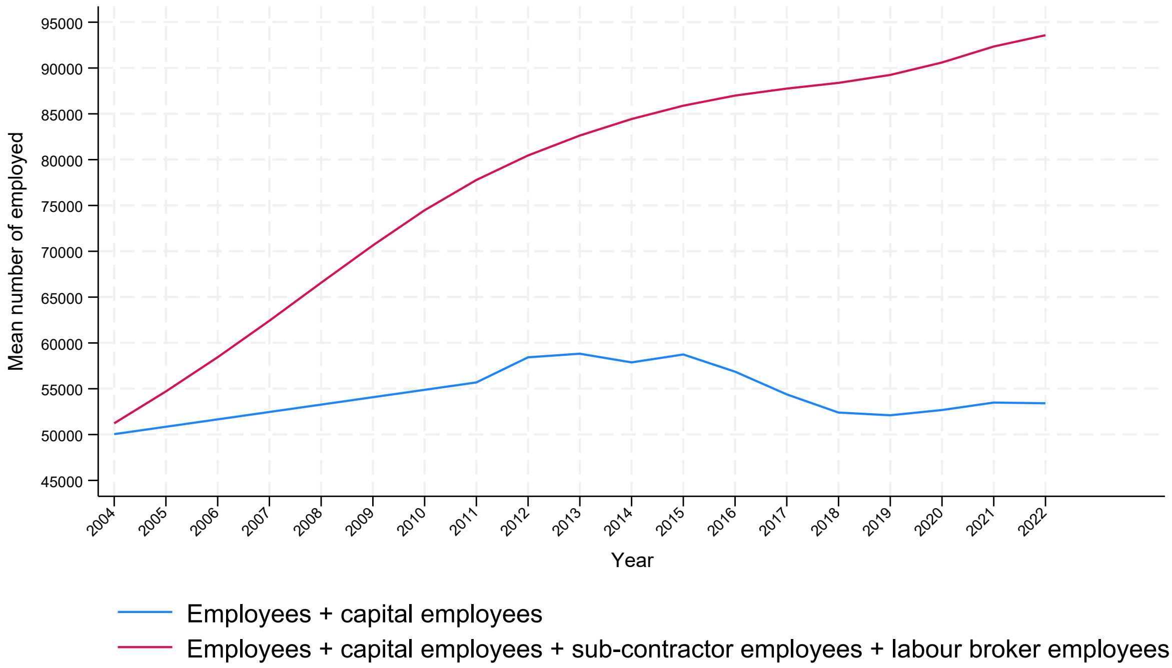
broker employee, and how such individual would answer the aforementioned survey question. For example, an employee providing security at a coal mine would be correct in stating that the main good produced at his/her place of work is coal, as opposed to security services, and the survey data would thus allocate such a worker to the coal mining industry. Using similar reasoning, the household survey estimates tend to lie below the Mining Census estimates that capture all types of employment on the mines (yellow triangles), because in the case of a sub-contractor employee that engages with coal mining firms, his/her response may not necessarily align with the industry that they provide services to – in this case the coal mining industry. For example, a sub-contractor employee may be a research consultant and thus would more likely provide a response to the household survey question that aligns with their core service.

Therefore, at the upper bound we are getting estimates for all types of employment linked to the coal mining firms, and at the lower bound we are getting estimates specifically related to employees of the mining firm. From these data, we can discern two key employment trends in the coal mining industry:

First, we can plot post-1994 employment growth trends using these data series. In the 1990s, going into the early 2000s, coal mining employment appears to be relatively stagnant, possibly declining. Thereafter, corresponding with the commodities super cycle, there is a period of relatively strong employment growth in the mid-2000s going into the early 2010s. There is a distinct drop in employment over the period 2014 to 2016, followed by a period of relatively stagnant employment levels thereafter.

Second, the period of strong growth in coal mining employment is driven by the increased employment of sub-contractor employees (and to a lesser extent labour broker employees), while the employment of direct mine employees has remained relatively constant. We present this trend in Figure 6 where we take the mean employment level for direct coal mining employment (blue lowess curve) – comprising employment estimates from the administrative tax data and the sum of mine employees and capital employees from the Mining Census data – and the mean employment level for all types of employment at coal mines – comprising employment estimates from the DMRE data and the sum of mine employees, capital employees, employees of sub-contractors and employees of labour brokers from the Mining Census data (red lowess curve). We focus on the period 2004 onward as this corresponds with the period of employment growth detailed above, and the respective data series are well populated. It is clear that employment growth is not being driven by an increased number of direct mining employees as the number of these workers hovers between 50 000 and 60 000 employees over this period.

Figure 6: Mean coal mining industry employment for direct employment and all employment types



Source: Authors' calculations using Mining Census (Statistics South Africa, 1999; 2005; 2011; 2014; 2021; 2024); Department of Mineral Resources and Energy (2020; 2023); National Treasury & UNU-WIDER (2024)

Further, we observe that employment in the coal mining industry has become increasingly oriented toward outsourced and sub-contractor work. This is reflected in the growing gap – representing outsourced and contract work – between the two series in Figure 6. Using Statistics South Africa's Mining Census data from 1996, we note that approximately 8.16 percent of coal mining employment was outsourced and sub-contractor work (we show these data in Table A 1 the Appendix). This share has grown over time with the corresponding estimates for 2022 standing at 46.93 percent. Notably, the majority of which is accounted for by employees of sub-contractors (92 percent) (see Table A 1 the Appendix). ILO (2002) shows that this is not a recent trend with five percent of employment in the South African coal mining industry being characterised as contract work in 1988. They note that this share grew to approximately 16 percent by 1998. This is in line with global trends, where mining firms have increasingly shifted to the outsourcing and sub-contracting of labour (Mining Qualifications Authority, 2014; Stacey et al., 1999). The Mining Qualifications Authority (2014) notes that these contracted activities include: non-core functions such as catering, cleaning, security, and building construction and maintenance; core specialised functions such as shaft sinking, as well as general mining activities where contractors either mine certain shafts or parts of shafts, or work in integrated teams alongside permanent employees.

To summarise, using available data sources, we are able to distinguish between employees employed directly by coal mining firms, and employees employed through third parties, such as labour brokers and sub-contractors. Employment levels in the coal mining industry appear to be relatively stagnant in the 1990s going into the early 2000s. A period of relatively strong employment growth proceeds with the commodities super cycle in mid-2000s going into the early 2010s. There is a distinct drop in employment over the period 2014 to 2016, followed by a period of relatively stagnant employment levels thereafter. Notably, the level of employment for mine employees has stagnated, certainly over the past decade, while the level of employment associated with sub-contractors, in particular, has grown over time. In fact, nearly half of all employment at coal mines is linked to a combination of sub-contracting, and to a lesser extent outsourcing, employment relationships. For the remainder of the analysis, given that we are using the administrative tax data that are reflecting mine employees only, we focus our analysis on this grouping.

5.2 Employment in the coal mining industry: Composition and trends

In this section, we examine employment trends in the coal mining industry in relation to other industries in the South African economy. This provides a sense of the industry's size in relation to the rest of the South African economy. In this analysis we use the employment series from the administrative tax data as these data are employed for the remainder of the analysis where we profile coal mining industry workers. Given the use of these data, there are data considerations worth noting: first, on the basis of our findings above, these data are measuring the employment of mining employees and are excluding coal mining employees that are associated with outsourcing and sub-contractor employment relationships. The estimates, and associated employment shares are, thus, a lower bound; second, given that these data are administrative tax data, they are providing estimates for formal sector employment in the coal mining industry.[16]

The coal mining industry is a relatively important source of employment in the overall mining and quarrying sector. Just over a tenth of all employment in the mining and quarrying sector is accounted for by coal mining industry employees. This share has remained constant over the past decade, at 11.1 percent in 2011 and 11.9 percent in 2022.[17] Referring back to Section 3, we note that the industry's relative contribution to the mining and quarrying sector is higher in the case of its contribution to gross value added (17.7 percent in 2021).

As is the case with the industry's contribution to GVA, the coal mining industry is a relatively small employer in the overall South African economy, and this relative contribution has declined over the

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[16] Bhorat et al. (2024) show that close to all workers in the coal mining industry are formal sector workers. Thus, the formal sector estimates are sufficient for capturing total employment in the industry.

[17] For 2011: 59/(59+468) = 0.112; For 2022: 53/(53+391) = 0.119

last decade. We observe in Table 4 that the coal mining industry accounts for 0.6 percent of total formal employment in 2011, and this declined to 0.4 percent in 2022.[18] In level terms, the number of coal mining employees declined from 58 624 workers in 2011 to 53 133 workers in 2022. This decline is in line with the broader mining sector, which has experienced a more acute decline in employment over the period. Other industries account for much larger shares of employment, including agriculture (13.2 percent), manufacturing (15.1 percent), and the broader services sector and its various sub-sectoral components.

Table 4: Formal sector employment by industry, 2011–2022

	Employment levels		Growth (2011–2022)		Employment shares (%)		Share of change ($\Delta Emp_i/\Delta Emp$)
	2011 (000s)	2022 (000s)	Absolute (000s)	Average annual growth (%)	2011	2022	2011–2022
Primary	**1 256**	**1 558**	**302**	**2.0**	**12.3**	**13.2**	**18.4**
Agriculture	729	1 114	385	3.9	7.2	9.4	23.4
Coal mining	59	53	-5,4	-0.9	0.6	0.4	-0.3
Rest of mining	468	391	-77	-1.6	4.6	3.3	-4.7
Secondary	**2 325**	**2 323**	**-2,6**	**0.0**	**22.8**	**19.6**	**-0.2**
Manufacturing	1 717	1 783	66	0.3	16.8	15.1	4.0
Utilities	89	94	4,7	0.5	0.9	0.8	0.3
Construction	519	446	-73	-1.4	5.1	3.8	-4.4
Tertiary	**6 600**	**7 730**	**1 130**	**1.4**	**64.8**	**65.3**	**68.7**
Trade	1 398	1 748	350	2.1	13.7	14.8	21.3
Transport	380	390	10	0.2	3.7	3.3	0.6
Finance	1 587	1 578	-8,8	-0.1	15.6	13.3	-0.5
CSP services	3 234	4 013	779	2.0	31.7	33.9	47.4
Total	**10 193**	**11 837**	**1 645**	**1.4**	**100.0**	**100.0**	**100.0**

Source: Authors' calculations using IRP5 Worker-Level Data from National Treasury & UNU-WIDER (2024)
Note: Sum of employment across industries does not add to total due to a relatively small share of workers having missing industry classifications. Agriculture = Agriculture, hunting, forestry and fishing. Utilities = Electricity, gas and water supply. Trade = Wholesale and retail trade and Catering and accommodation. Transport = Transport, storage and communication. Finance = Financial intermediation, insurance, real estate and business services. CSP = Community, social and personal services.

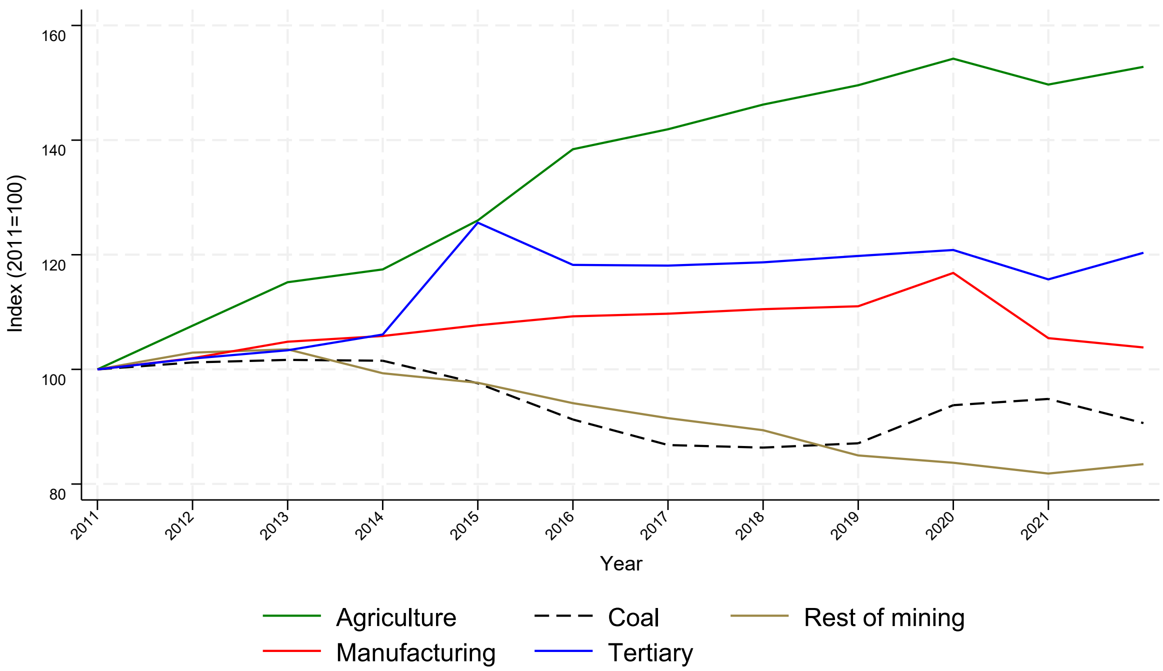
While the coal mining industry's direct contribution to aggregate employment is relatively small, it is worth noting that the coal mining industry is a component of the coal value chain, which has a relatively larger economic footprint. Bulmer et al. (2021) note that the coal value chain is long, with linkages to the transport sector (rail and road), the downstream petrochemicals sector, the metal products and machinery industry, and electricity production. Hence, the coal value chain contains key components of South Africa's overall industrial structure. Researchers at the Trade and Industrial Policy Strategies

[18] The cross-industry formal sector estimates using the administrative data broadly align with those generated using the QLFS data – see Appendix Table A 2 – thus suggesting that the construction of our industry variable using the administrative data is producing results robust with other datasets.

(TIPS) have attempted to quantify employment along the coal value chain, with Patel et al. (2020) showing that, in 2018, coal mining accounted for 80 000 jobs, coal-fired power generation (Eskom) accounted for 12 000 jobs, petrochemical production (Sasol) for 26 000 jobs, and coal transportation by small coal truckers at 2 000 jobs – a total of approximately 120 000 coal value chain jobs. More recent work by Makgetla et al (2021) put this number closer to 200 000 coal value chain jobs.[19]

Consistent with its declining employment share, the coal mining sector has experienced negative growth over the past decade. Employment in the coal mining industry declined at an average annualised rate of 0.9 percent over the period 2011 to 2022. This decline in the coal mining industry was not as large in magnitude as that experienced by the rest of the mining and quarrying sector (-1.6 percent p.a.). This growth performance trend is depicted in Figure 7, where we see how both the coal mining industry and the broader mining and quarrying sector have experienced a declining employment trend over the past decade. In contrast, the manufacturing sector stagnated, while the tertiary (services) and agricultural sectors expanded.

Figure 7: Growth of employment by industry, 2011–2022



Source: Authors' calculations using IRP5 Worker-Level Data from National Treasury & UNU-WIDER (2024)

[19] Our reading of the Patel et al. (2020) report suggests that their estimates emerged from an earlier TIPS report by Makgetla et al. (2019). Their coal mining employment estimate comes from the Minerals Council of South Africa, their power generation estimate comes from Eskom's 2018 Integrated Annual Report, their Sasol estimate comes from a Sasol annual report, and the coal trucker estimate emerges from interviews with industry representatives.

In summary, while the coal mining industry is an important source of employment in the mining and quarrying sector, the industry constitutes a relatively small share of national formal sector employment. As with the broader mining sector, the industry has experienced a decline in employment over the past decade. It is worth noting that these estimates are at the lower bounds as we are measuring employees of coal mining firms and exclude employees operating at coal mines under outsourcing and sub-contractor employment relationships. However, it is worth reiterating that the economic footprint in terms of contribution to employment in the South African economy is more apparent when one considers the coal value chain.

6 PROFILING EMPLOYMENT IN THE SOUTH AFRICAN COAL MINING INDUSTRY

Building on Section 5, where we quantified employment in the South African coal mining industry, we now profile the characteristics of these workers. Specifically, we profile mine employees, since the discussion above details how these workers are identified in the administrative tax data. Our profile is restricted to three characteristics of these workers, namely, their age profile, their gender profile, and their earnings profile.

6.1 Age profile of workers in the coal mining industry

Understanding the age profile of the coal mining workforce helps inform two broad policy approaches for managing the transition away from coal. The first involves policies aimed at facilitating early retirement for those nearing the end of their careers, while the second focuses on reskilling and retraining workers who are likely to remain in the labour force, but that requires matching to alternative job opportunities. Targeted policies that address the specific needs of different age groups within the workforce can help ensure the effective allocation of resources. This would mean supporting older workers who may prefer early retirement, while providing pathways for youth and adult workers to shift into new industries.

In Table 5 we present estimates describing the age distribution of the coal mine employees by dividing the workforce into age group categories.[20] We include the two youth age group categories: 15–24, and 25–34. Workers falling within these age groups would need to remain in the labour force for a minimum of two decades (i.e. those aged 35 would be up for retirement in 20 years' time) and would thus require policy interventions that enable sustained participation in the labour market. The older age group categories are defined to align with the prescribed retirement ages for mine workers:

[20] We also include employment estimates by age category that are derived using the Quarterly Labour Force Survey data. Bhorat et al. (2024) used these data, but did not apply the industry specific age categorisation used to identify workers up for retirement. These estimates are included in Table A 3 for 2022 and Table A 4 for 2011 in the Appendix. The estimated employment shares, while differing slightly, exhibit similar distributions across age categories, and are thus qualitatively consistent across the various sets of estimates over time.

between 55 and 60 for underground workers, and between 55 and 63 for surface workers. Workers within, and near, these age groups are set for retirement or early retirement, and such information can help inform policy aimed at advancing early retirement options for coal mine workers.

The estimates in Table 5 show that a relatively sizeable share of coal mine employees are within, or nearing, the retirement age bracket. The estimates in Table 5 show that approximately 10.6 percent of the current coal mining workforce is within the retirement age bracket (aged 55 and older), and thus up for retirement. A further 8.3 percent of the workforce is within five years of retirement, while a further 10.5 percent are up for retirement within the next decade. As such, a tenth of the workforce is within retirement age, and a further 18.8 percent of the workforce is potentially up for early retirement. Implementing policies that provide incentives for early retirement, such as pension packages, as successfully carried out in Germany and Poland, can help ease the transition by gradually reducing the number of workers dependent on the coal sector.

Table 5: Coal mining employment by age group, 2011–2022

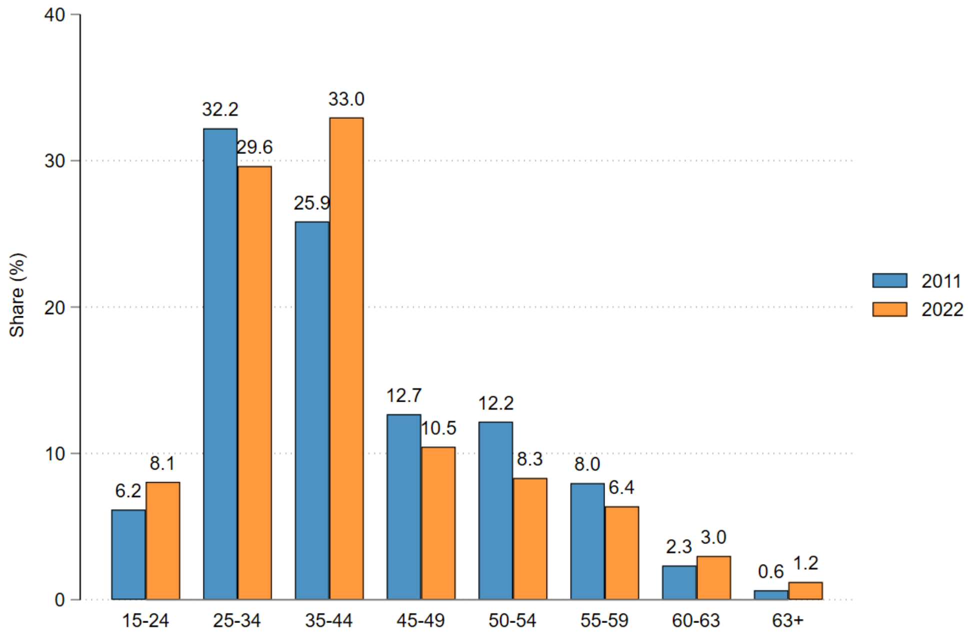
	2011		2022		Change		Growth
	Level	Share (%)	Level	Share (%)	Level	Share (%)	AAGR
Total coal mining	**58 624**	**100.0**	**53 133**	**100.0**	**-5 491**		**-0,8**
15–24	3 610	6.2	4 280	8.1	670	1.9	1.4
25–34	18 881	32.2	15 744	29.6	-3 137	-2.6	-1.5
35–44	15 155	25.9	17 512	33.0	2 357	7.1	1.2
45–49	7 430	12.7	5 555	10.5	-1 875	-2.2	-2.4
50–54	7 134	12.2	4 419	8.3	-2 715	-3.9	-3.9
55–59	4 668	8.0	3 390	6.4	-1 278	-1.6	-2.6
60–63	1 368	2.3	1 590	3.0	222	0.7	1.3
63+	378	0.6	643	1.2	265	0.6	4.5
Mean age	40		39				

Source: Authors' calculations using IRP5 Worker-Level Data from National Treasury & UNU-WIDER (2024)
Notes: Coal employment refers to coal mining employment within the formal sector for the working age population (15–64 years old). The 63+ year cohort refers to the 63–65-year-olds. AAGR = average annualised growth rate.

Over a third of mine employees can be classified as youth, while the rump of the workforce falls within the middle age categories, particularly the younger middle age category. We observe in Table 5 that the two youth age categories, 15–24 and 25–34, account for 8.1 and 29.6 percent of employment, respectively. Just over half of the workers can be categorised as middle age, with a third of all workers falling within the 35–44-year age group. For these cohorts of workers, an early retirement package is not an option. As such, the policy focus should shift towards finding ways to match these workers to alternative employment opportunities, through for example, reskilling programmes designed to re-align workers to jobs in other industries.

In terms of changes to the distribution of mining employees across the age group categories, although there are changes within these categories, there is no systematic shift in the age distribution over the period 2011 to 2022. In Table 5 we see that the mean age of the workforce does not change substantially, while Figure 8 shows that the shape of the age distribution has not altered to any significant degree. Nevertheless, given that coal mining employment experienced an overall decline over the period, we observe declines in employment across several of the age categories, which contribute to this net decline in employment. The older youth age category (25–34) declined at an average annualised rate of 1.5 percent, coinciding with a declining employment share from 32.2 percent in 2011 to 29.6 percent in 2022. Similar such declines were evident in two of the middle age categories, 45–49 and 50–54. There was also a decline in the youngest retirement age category, 55–59, possibly due to workers retiring and exiting the workforce.[21] Expansion was experienced in the youngest of the youth age groups, 15–24, as well as two of the retirement age groups, 60–63 and 63+. In level terms, the 35–44 age group experienced the largest gain, growing by 2 357 workers, corresponding with a 7.1 percentage point increase in the age group's share of employment – depicted in Figure 8. This may be due to more hires within this group, as well as younger cohorts moving into this age group over time.

Figure 8: Coal mining employment share by age group, 2011–2022



Source: Authors' calculations using IRP5 Worker-Level Data from National Treasury & UNU-WIDER (2024)
Note: The 63+ year cohort refers to the 63–65-year-olds.

[21] This analysis is not able to track whether these workers exited the workforce, shifted to the older age group, or a combination of both.

To summarise, with an average age of 39, the coal mining workforce is relatively youthful, and thus a transition policy package will need to be tailored to the fact that a substantial number of workers will need to continue working. That being said, a fairly sizeable portion of workers are of retirement age or nearing retirement, and thus, a transition policy package can include early retirement packages to ease the transition for these workers.

6.2 Gender profile of workers in the coal mining industry

Historically, the South African coal mining industry workforce has been male-dominated, and despite growing female participation in the industry, it remains as such. This is not only true for South Africa but is also the general trend globally. Looking at Table 6, we observe that, in 2022, 72.8 percent of the coal employees were male, with the corresponding share for females being 26.1 percent.[22]

However, the gender composition of the workforce has experienced a degree of change over the past decade. Despite a decline in overall employment levels, with the number of male employees declining from 49 345 in 2011 to 38 679 in 2022, the number of female employees has increased from 7 853 in 2011 to 13 892 in 2022. Figure 9 illustrates this steady increase in female representation since 2011. The share of women working in the coal mining industry has nearly doubled over the past decade, from 13.4 percent in 2011 to 26.1 percent in 2022.

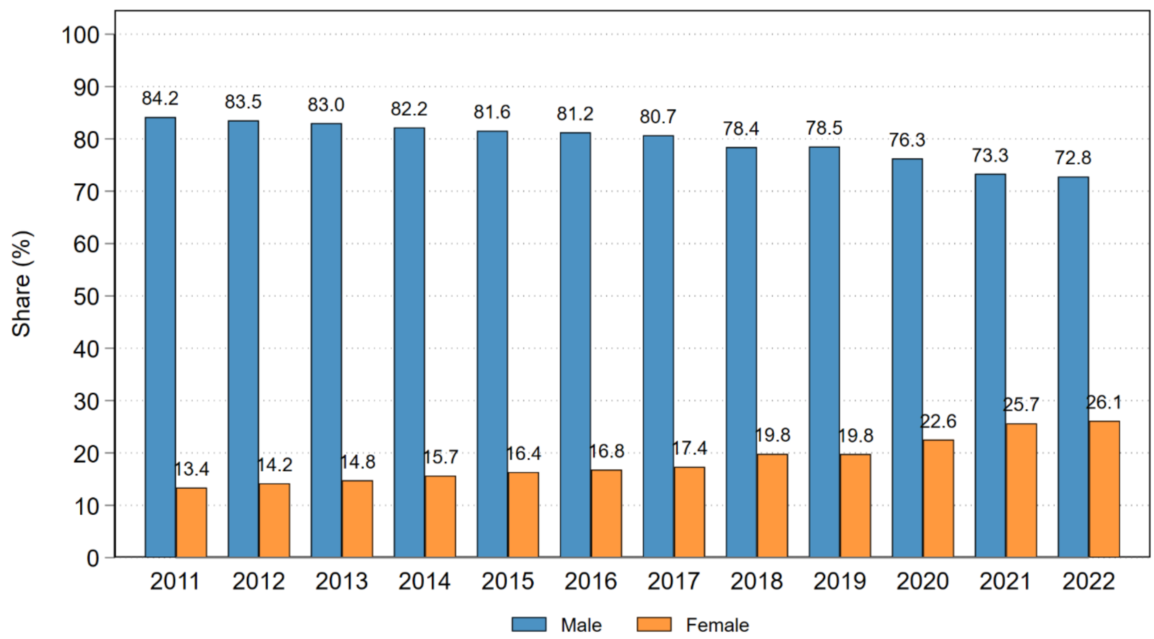
Table 6: Coal mining employment by gender, 2022

	2011		2022		Change		Growth
Coal employment	**Level**	**Share (%)**	**Level**	**Share (%)**	**Level**	**Share (%)**	**AAGR**
Total coal mining	**58 624**	**100.0**	**53 133**	**100.0**			**-0.8**
Male	49 345	84.2	38 679	72.8	-10 666	-11.4	-2.0
Female	7 853	13.4	13 892	26.1	6 039	12.8	4.9

Source: Authors' calculations using QLFS Q1–Q4 (Statistics South Africa 2022; 2023); IRP5 Worker-Level Data from National Treasury & UNU-WIDER (2024)
Notes: Coal employment refers to coal mining employment within the formal sector for the working age population (15–64 years old). Male and female shares do not sum to 100 because of missing observations in the data. AAGR = average annualised growth rate.

[22] These estimates are qualitatively in line with estimates derived from alternative data sources, including the QLFS and Census – see Appendix Table A 5 and Table A 6 – thus pointing to the robustness of our estimates.

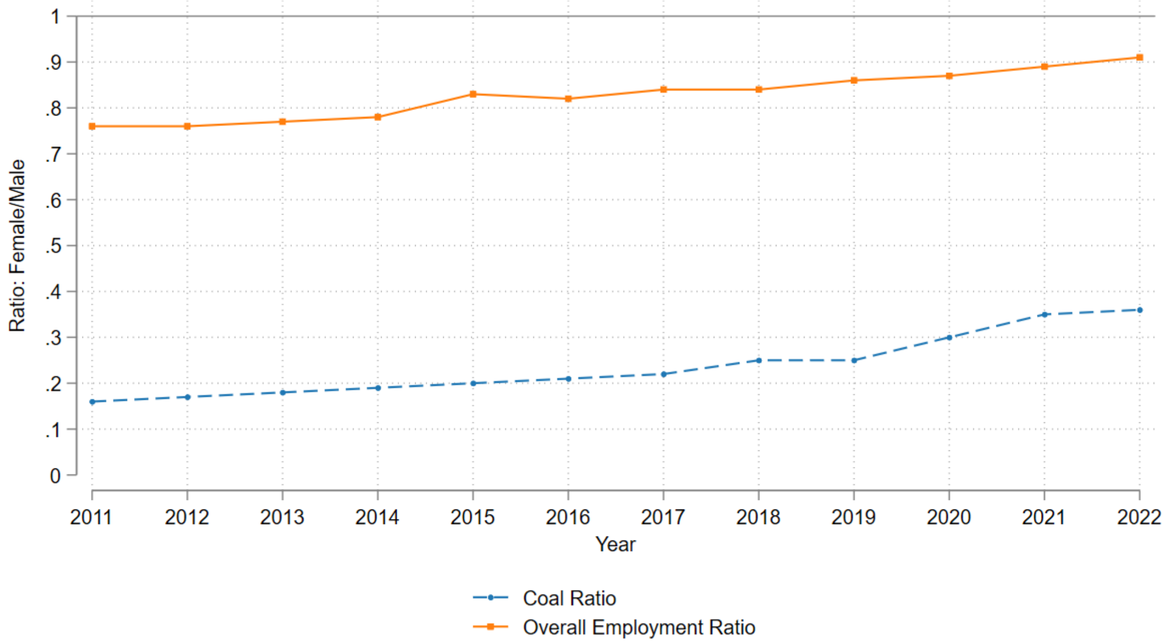
Figure 9: Coal mining employment share by gender, 2011–2022



Source: Authors' calculations using IRP5 Worker-Level Data from National Treasury & UNU-WIDER (2024)
Notes: Male and female shares do not sum to 100 because of missing observations in the data.

While we observe increased female participation in the coal mining industry workforce, the level of female participation remains well below that of the broader labour market, where gender ratios have shifted to being more balanced over time. This is illustrated in Figure 10, where we show the ratio of females to males in employment in the coal mining industry (dotted blue lines) and the corresponding ratio for total employment in the formal sector. A ratio of unity would imply an equal share of female and male workers in the industry, while a ratio below unity would imply a lower share of females relative to males, and hence an underrepresentation of women in the industry. Despite doubling since 2011, the ratio for the coal mining industry remains well below the national average for the formal sector employment aggregate, which is nearing unity (unity would imply a 50:50 ratio). In 2022, the gender employment ratio for overall employment stood at 0.9, while it was approximately 0.36 for the coal mining industry.

Figure 10: Gender employment ratio in the coal sector and overall employment, 2011–2022



Source: Authors' calculations using IRP5 Worker-Level Data from National Treasury & UNU-WIDER (2024)

To summarise, despite the increased participation of women in the coal mining industry, the industry remains male-dominated, and as such, the adverse effects of the transition are likely to be orientated, at least in level terms, largely toward male employees. It is worth noting further, as we observe in the next section, that women in the industry get paid, on average, less than men, which could suggest that women are over-represented in lower paying and more precarious jobs in the industry.

6.3 Wage profile of workers in the coal mining industry

We now profile the earnings of coal mining industry workers by examining average wage levels in the industry over time, and in relation to average wage levels in other industries. We also examine how average wage levels among coal mining industry workers vary by gender and age.

Understanding the earnings profile of coal mining industry workers is important in the context of a just transition as it provides insights into the financial and economic implications of moving away from coal for those directly affected. As the South African economy shifts toward a low-carbon energy structure, acknowledging the wage dynamics in the coal industry is important for developing targeted policies that ensure fair compensation and support for displaced workers. By examining the wage profile of coal mining industry workers, we can identify the potential financial impact of the transition on the livelihoods of workers engaged in the coal mining industry.

Coal mine employees earn wages well above those earned by the average worker in the formal sector. To get a sense of how coal mining industry wages compare to wages received in the rest of the economy, we report real monthly mean and median wages across industries in Table 7.[23] Looking at the real mean monthly wage in 2022, we observe that the mean coal mining industry wage is almost double of that received by the average formal sector worker (R46 804 versus R25 842). Median wages offer a more accurate reflection of what a typical worker earns, and when considering median real monthly wages, the disparity is more pronounced. The median monthly wage in the coal mining industry (R35 871) is more than triple that is earned in the formal sector (R11 032). This disparity at the median wage level has grown since 2011, as the median wage in the coal industry grew at an average annual rate of 3.2 percent, while the median wage in the formal sector barely grew at 0.2 percent per annum.

Table 7: Mean and median real monthly wage by industry, 2011–2022

	2011			**2022**			**Avg. annual growth (2011–2022) (%)**	
	Mean	**Median**	**Std. dev.**	**Mean**	**Median**	**Std. dev.**	**Mean**	**Median**
Formal sector	**19 339**	**10 827**	**23 393**	**25 842**	**11 032**	**40 107**	**2.7**	**0.2**
By industry								
Agriculture	8 578	3 386	15 791	11 212	4 979	24 252	2.5	3.6
Coal	36 902	25 309	32 426	46 804	35 871	46 793	2.2	3.2
Rest of mining	24 803	14 601	26 951	59 733	27 508	72 044	8.3	5.9
Manufacturing	20 267	10 881	24 599	24 413	11 157	37 350	1.7	0.2
Utilities	41 329	33 125	33 916	51 690	43 481	44 768	2.1	2.5
Construction	15 603	7 825	22 657	20 430	9 103	35 484	2.5	1.4
Trade	12 222	6 400	17 537	14 663	6 624	27 343	1.7	0.3
Transport	28 247	19 311	26 795	31 801	19 875	39 020	1.1	0.3
Financial	20 125	8 853	26 927	31 372	12 941	46 993	4.1	3.5
CSP services	21 820	16 257	21 087	29 372	18 868	39 187	2.7	1.4
Other	13 257	7 857	16 995	20 481	7 581	37 946	4.0	-0.3

Source: Authors' calculations using IRP5 Worker-Level Data from National Treasury & UNU-WIDER (2024)
Note: Wages are adjusted to December 2023 prices. Mean, median and standard deviation reported in Rands per month. Wages have been winsorized at the top and bottom one percent. The working-age population includes individuals aged 15 to 64 years inclusive. Agriculture = Agriculture, hunting, forestry and fishing. Utilities = Electricity, gas and water supply. Trade = Wholesale and retail trade and Catering and accommodation. Transport = Transport, storage and communication. Finance = Financial intermediation, insurance, real estate and business services. CSP = Community, social and personal services.

The high relative wages of coal mining industry workers are further evident when comparing the industry's wages with that earned in other industries. It is evident in Table 7 that the mean wage of the coal mining industry (R46 804) is only surpassed by the mean wage earned in the utilities industry (R51 690), and that earned in the industries that comprise the rest of mining (R59 733). The next

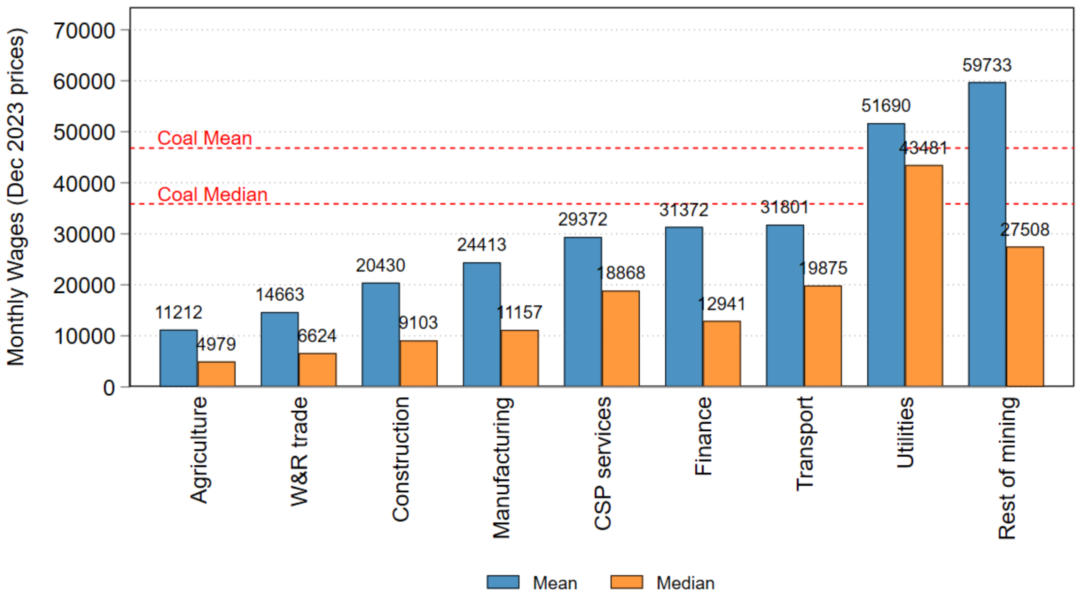
[23] It is important to note that these cross-industry wage comparisons focus on measures of average wages (mean and median), and we are thus comparing wages for the average worker in each industry.

highest mean wage levels are found in the transport and communications (R31 801), financial services (R31 372), and the community, social and personal services (R29 372) industries – all sitting at approximately two-thirds of the average wage earned in the coal mining industry. Looking at the median wage, only the utilities industry (R43 481) offered a higher median wage than the coal mining industry (R35 871). The next highest being that earned in the transport and communications industry (R19 875) – around only half that earned in the coal mining industry.

In sharp contrast, average wages in the agriculture and wholesale and retail trade industries are considerably low compared to the coal mining industry. The real mean monthly wage in the coal mining industry is more than four times that earned in agriculture, and more than three times that earned in wholesale and retail trade. Similarly, in the case of median wages, coal mining industry wages are more than seven times that of agriculture and four times that of wholesale and retail trade. These stark differences underscore the wage inequalities across industries, with coal mining positioned far above many other industries in terms of both mean and median wages.

Using the combination of Table 7 and Figure 11, we can compare the mean and median wage levels for the coal mining industry to the corresponding wage levels for industries that typically provide alternative avenues of employment for coal miners. Coal mining industry workers are more likely to be absorbed by the manufacturing and construction industries, as these industries have similar skills requirements (Aragón et al., 2018; Sokolowski et al., 2022). Using the same logic, coal mining industry workers may more easily transition to similar jobs in other mining industries. Figure 11 illustrates the real mean and median monthly wages by industry in 2022. The coal mining industry acts as a baseline comparison where the mean and median monthly wage levels for the industry are depicted by horizontal dashed lines. The mean and median monthly wage levels for the other industries are represented by the blue and orange bars, respectively.

Figure 11: Mean and median real monthly wage by industry (December 2023 prices), 2022



Source: Authors' calculations using IRP5 Worker-Level Data from National Treasury & UNU-WIDER (2024)
Note: Wages are adjusted to December 2023 prices. Wages have been winsorized at the top and bottom one percent. The working age population includes individuals aged 15 to 64 years inclusive.

The coal mining industry's high average wage levels are well in excess of those present in the construction and manufacturing industries. The real mean monthly wage in manufacturing and construction is approximately half of what a typical coal mining industry worker earns. In 2022, real mean wages in construction and manufacturing were R20 430 and R24 413, respectively, while the corresponding wage level for coal mining was R46 804. In the case of median wage levels, the typical worker in the manufacturing or construction industries earns roughly a third of what a typical coal mining industry worker earns. As such, should the average coal mining industry workers shift to either of these industries, it is likely that they would have to incur a significant wage cut.[24] Furthermore, Bhorat et al. (2024) show that the average worker in the coal mining industry enjoys relatively favourable job quality indicators – i.e. more likely to have Unemployment Insurance Fund (UIF) contributions, pay into a pension fund, receive annual leave, and have access to a medical aid – in relation to these two industries.

[24] A key caveat is that we are referring to the average worker across these industries. It is entirely possible that a worker in a given occupation in the coal mining industry could shift to a similar such occupation in the manufacturing industry and earn a comparable wage. Below we look at the wage distributions of these industries and show that portions of the wage distributions across these industries overlap, thus suggesting that certain workers could receive similar wages across the industries.

Should workers in the coal mining industry transition into other mining industries, it is unlikely that they would suffer a significant change to their wages. The real mean monthly wage in the rest of mining (R59 733) is in fact higher than that received in the coal mining industry (R46 804), while the median wage in the coal mining industry (R35 871) is higher than that in the rest of mining (R27 508). Again, looking at job quality indicators, Bhorat et al. (2024) show that coal mining industry workers experience relatively similar job conditions to workers in other mining industries.

We examine how wages in the coal mining industry vary by gender and age. In Table 8 we report the mean real monthly wage for coal mining industry workers by gender and age category for the years 2011 and 2022. We also report the average annual growth rates of the mean wage within each of these categories. In addition, we include the ratio of the mean wage in the coal mining industry in relation to the mean wage in the formal sector aggregate for each gender and age category. A ratio above unity indicates that the coal mining wage is higher than overall formal sector wage, while a ratio below unity indicates that coal mining wages are lower than formal sector wages. A ratio of unity suggests that wages in coal mining are equal to those in the formal sector.

On average male coal mining industry workers earn more than their female counterparts, and the wage gap has widened over time.[25] In 2011, the mean wage for men was R37 680, whereas for women it was R33 587. Put differently, the mean wage for the average female worker in the coal mining industry was 89 percent of what the average male worker in the industry earned. The gap has widened over time, with the mean wage for the average female worker in the coal mining industry being 78 percent of what the average male worker in the industry earned in 2022. The growing differential has been driven by the mean wage for men (2.6 percent p.a.) growing at an average annual rate that is double that experienced by the average female worker in the industry (1.3 percent p.a.). A similar pattern is observed when examining median wages (see Appendix Table A 7).

However, despite women earning less than men in the coal mining industry, women in the coal mining industry are, on average, better paid than their female counterparts in the formal sector. This is evident by considering the ratio of the mean wage in the coal mining industry in relation to the mean wage in the formal sector for female workers. The ratio of 1.6 for female workers in 2022 indicates that female coal mining industry workers earn more than the average female worker in the formal sector.

As one would expect, average wages increase as workers get older.[26] In Table 8, we observe that the youth age groups are characterised by the lowest mean wage levels – R10 347 and R33 951 for the

[25] It is important to note that the wage gap is purely a difference in mean wage levels between the two groups and does not control for differences in individual characteristics, such as differences in occupation, experience and education. Providing robust gender gap estimates is beyond the scope of this analysis.

[26] This is expected as age is used to proxy for experience in standard Mincerian wage equations (Lemieux, 2006). Further, the relationship between age (experience) and wages is non-linear – i.e. as workers get older (gain experience) their wages increase up to a maximum point and then start to decline. We observe this quadratic pattern in Table 9.

15–24 and 25–34 age groups, respectively. Mean monthly wages rise substantially for older age groups – R52 492 for the 35–44-year age group – and continue to rise, with those nearing retirement having the highest mean monthly wage level in 2022 (R68 145). Consistent with the aggregate finding – detailed above – the mean wage for the average coal mining industry worker is higher than the corresponding wage for the average formal sector worker. This is evidenced by all the ratios in Table 8 being in excess of unity.

Table 8: Mean real monthly wage by demographic characteristics (2023 prices), 2011–2022

	2011		2022		Avg. annual growth (2011–2022)
	Mean	Ratio mean Coal: Formal	Mean	Ratio mean Coal: Formal	
National coal	**36 902**	**1.9**	**46 804**	**1.8**	**2.2**
By gender					
Male	37 680	1.8	49 915	1.7	2.6
Female	33 587	1.9	38 687	1.6	1.3
By age group					
15–24	17 392	2.3	10 347	1.2	-4.6
25–34	30 003	2.0	33 951	2.0	1.1
35–44	42 172	1.9	52 492	1.9	2.0
45–49	43 575	1.7	59 806	1.8	2.9
50–54	42 630	1.6	65 144	1.7	3.9
55–59	41 912	1.7	65 751	1.7	4.2
60–63	40 141	1.8	64 147	1.5	4.4
63+	43 765	2.3	68 145	1.6	4.1

Source: Authors' calculations using IRP5 Worker-Level Data from National Treasury & UNU-WIDER (2024)
Note: Wages are adjusted to December 2023 prices. Mean wages reported in monthly Rands. Wages have been winsorized at the top and bottom one percent. The working age population includes individuals aged 15 to 64 years inclusive.

In addition to lower average wage levels, the youth also experienced the lowest levels of wage growth, with the youngest youth age category experiencing declining average wage levels. The average real wage for the youth aged 15 to 24 declined at an average annual rate of 4.6 percent – consistent with a real mean wage decline from R17 392 in 2011 to R10 347 in 2022. While all other age categories experienced rising real mean monthly wages, the older youth age category experienced the slowest average annual growth rate (1.1 percent p.a.). The older age cohorts experienced rising mean wage growth rates, while those within the retirement age categories – i.e. older than 55 years of age – experienced the highest average annual growth rates – in excess of 4 percent.

In summary, coal mining industry jobs are relatively well paid. The average worker in the coal mining industry earns more than the average worker in the formal sector, as a whole, and more than the average worker in every industry apart from the utilities industry. Furthermore, the average wage received in industries that typically provide alternative employment opportunities for coal mining industry workers, namely the manufacturing and construction industries, is much lower than that currently received by the average coal mining industry worker. As such, should the average coal mining industry workers shift to either of these industries, it is likely that they would have to incur a significant wage cut. In the case of other mining industries, should coal miners shift into these industries, they are likely to receive comparable wages, thus pointing to a possibly easier transition into these industries. The average male coal mining industry workers earns more than his female counterpart, and this average wage differential has grown over time. Female coal mining industry workers receive higher wages that their formal sector counterparts. As coal mining industry workers get older, their mean wage increases.

6.4 The distribution of wages in the coal mining industry: Wage inequality

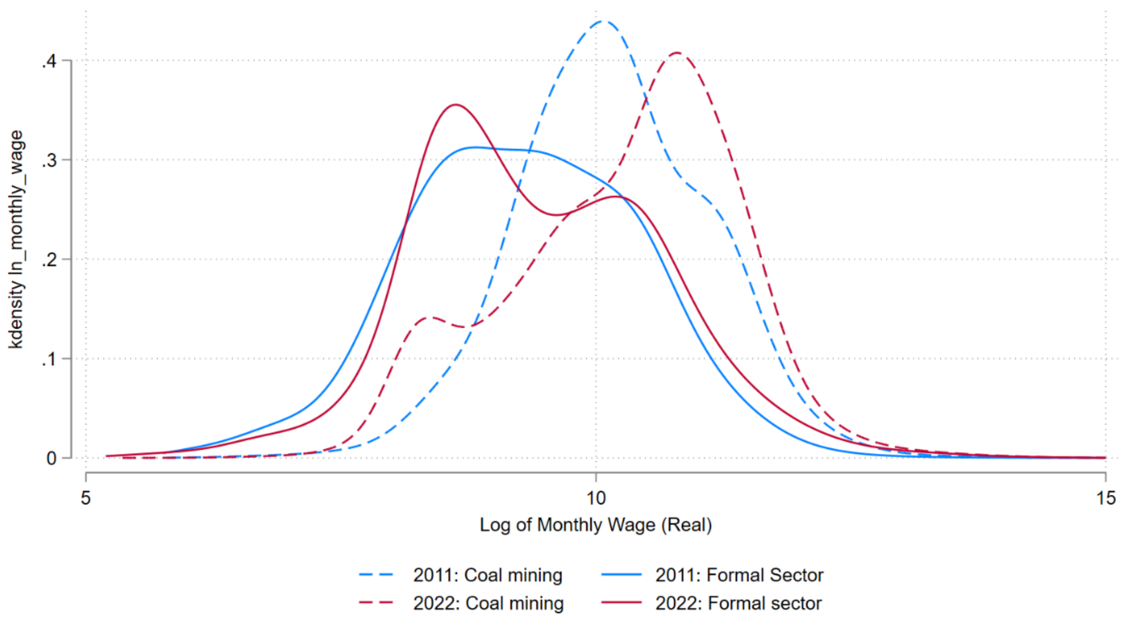
The previous section profiled the wages of coal mining industry workers by looking at point estimates of average wage levels within the industry. We now apply an additional lens to this discussion by examining the distribution of wages in the industry. In doing so, we gain insight into the nature and extent of wage inequality within the industry.

It is well established that South Africa is one of the most unequal countries in the world, and there is broad consensus that differences in labour income is the main driver of household income inequality (Jacobs et al., 2024; Shifa et al., 2023; Kerr, 2021; Bhorat et al., 2020; Hundenborn et al., 2018; Finn & Leibbrandt, 2018; Wittenberg, 2017). This implies that changes in wages are likely to drive changes in overall inequality. Most studies have used survey data in analysing the distribution of income and wage inequality (Kerr & Wittenberg, 2019; Hundenborn et al., 2018; Leibbrandt et al., 2010; Bhorat et al., 2009). Wittenberg (2017b) compares wage data from the QLFS and the administrative tax data, and finds that the wages of employees in the QLFS are underreported by approximately 40 percent, with larger gaps appearing near the top of the wage distribution. The main challenge with survey data is missing wage data, under-sampling, and a high non-response rate for richer individuals (Wittenberg, 2017b). In turn, these inaccuracies affect poverty and inequality estimates. This study uses the administrative tax data from 2011 to 2022, which provide good quality wage data. The use of administrative tax data to study inequality in South Africa is gaining momentum (Jacobs et al., 2024; Kerr, 2021; Hundenborn et al., 2019). One of the benefits of the administrative tax data is that it provides the actual income received by workers as reported by their employers and it provides better coverage of top income earners. However, the administrative tax data also bring its own challenges, such as excluding informal sector workers and workers earning less than R2 000 per year. As such, workers at the bottom of the wage distribution are underrepresented, if not omitted using these data. With respect to the coal mining industry this is not a major limitation as the industry is almost completely formal and, as we have seen, wages in the industry are relatively high.

We begin our analysis by looking at the wage distribution within the coal mining industry by presenting kernel density functions for the industry. Figure 12 compares the density of the wage distribution for workers in the coal mining industry to workers in the formal sector, for 2011 and 2022. The x-axis plots the log of real monthly wages, while the y-axis plots the density (or proportion) of workers at any given wage level. The solid kernel density plots represent the wage distribution for formal sector workers, with the blue line showing the wage distribution in 2011, and the red line showing the distribution in 2022. The dashed kernel density plots represent the wage distribution for coal mining industry workers, with the blue dashed line showing the wage distribution in 2011, and the red dashed line showing the distribution in 2022.

Consistent with our analysis in Section 6.3, workers in the coal mining industry typically earn higher wages than workers in the broader formal sector. It is evident in Figure 12 that, while there is a degree of overlap, the kernel density plots for the coal mining industry sit to the right of the kernel density plots for the formal sector. This pattern is evident in both our initial period – 2011 – and our end period – 2022. Again, consistent with our findings in Section 6.3, we also observe that workers in the coal mining industry experienced real wage growth over the period. This is depicted by the 2022 kernel density plot for the coal mining industry sitting to the right of the corresponding 2011 plot. Put differently, the wage distribution for the coal mining industry shifted to the right. As detailed in Table 7, mean and median monthly wages in the coal mining industry grew by 2.2 and 3.2 percent per annum, respectively. As such, coal mining industry workers not only enjoy relatively high wages, but have been experiencing rising real wages over time.

Figure 12: Real monthly wage distribution, 2011 and 2022

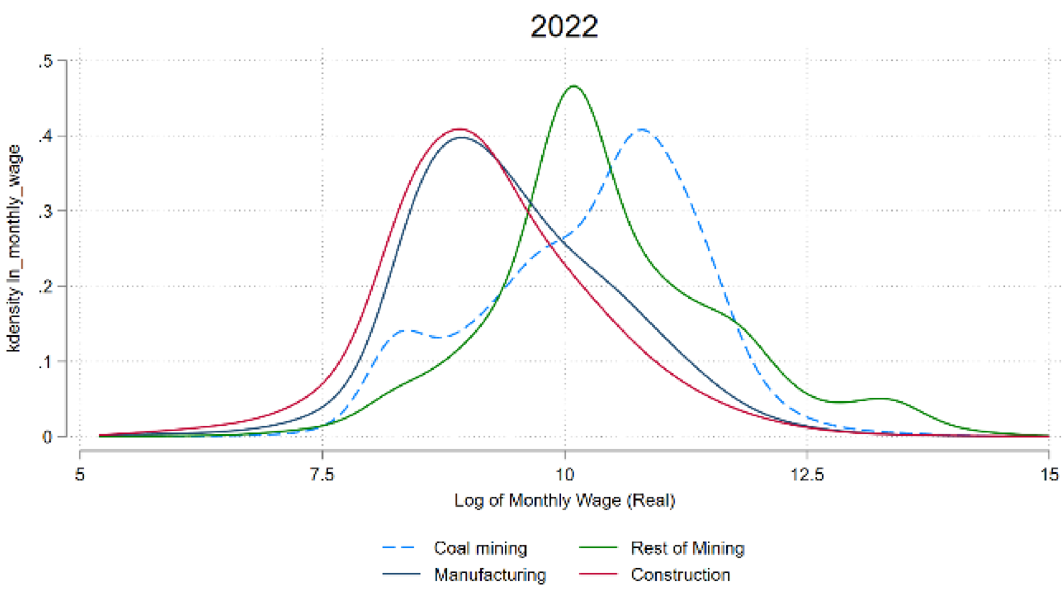


Source: Authors' calculations using IRP5 Worker-Level Data from National Treasury & UNU-WIDER (2024)
Note: Wages are adjusted to December 2023 prices. Wages have been winsorized at the top and bottom one percent. The working-age population includes individuals aged 15 to 64 years inclusive.

Closer inspection of the evolving wage distribution for the coal mining industry points to rising wage inequality within the industry. Despite higher overall wages in the coal mining industry, lower wage earners have experienced declining wages over the period (further detail is provided below). In particular, comparing 2011 to 2022, there is a leftward shift at the bottom end of the distribution, while the upper end shows a rightward shift. This indicates that, over time, high wage earners experienced wage growth, whereas low wage earners experienced a decline in wages, resulting in a growing disparity between these two ends of the wage distribution. As we discuss below, this pattern is consistent with rising wage inequality within the sector.

Previous energy transition experiences show that coal mine industry workers typically transitioned more easily to the manufacturing or construction industries (Aragón et al., 2018; Sokolowski et al., 2022). We now examine the wage distribution for these two industries, as well as the wage distribution for other mining industries, and compare these to the coal mining industry wage distribution. This provides a sense to which wages across these industries overlap. In Figure 13, we observe that the kernel density plot for coal mining industry workers is positioned more to the right, indicating higher wage levels, while the plots for construction and manufacturing are more to the left, indicating lower wage levels. Notably, the wage distributions for manufacturing and construction are similar, whereas those for coal mining and other mining industries are more compressed and positioned more to the right.

Figure 13: Real monthly wage distribution for selected industries, 2022



Source: Authors' calculations using IRP5 Worker-Level Data from National Treasury & UNU-WIDER (2024)
Note: Wages are adjusted to December 2023 prices. Wages have been winsorized at the top and bottom one percent. The working age population includes individuals aged 15 to 64 years inclusive.

It is possible that coal mining industry workers at the lower end of the wage distribution may be better able to shift to alternative job opportunities in the relatively lower-paying manufacturing and construction industries. In Figure 13, we see that the lower end of the coal mining wage distribution overlaps with substantial parts of the manufacturing and construction wage distributions. This suggests that lower wage earners in coal mining may find similar wages in these industries should they be able to make the shift to these industries. However, the upper end of the coal mining wage distribution exceeds the wages found in these industries, indicating that transitions to these industries would involve substantial wage cuts, thus making the transitions less likely. The wage distribution for other mining industries aligns more closely to that of the coal mining industry, thus suggesting that shifts to these industries may offer more realistic job transition pathways for the higher wage earners in the coal mining industry.

We now examine wage inequality both between the coal mining industry and the formal sector, and wage inequality within the coal mining industry. We draw on standard inequality measures, including the Gini coefficient, the Atkinson index, and several percentile ratios. We start by briefly detailing wage inequality within the formal sector aggregate.

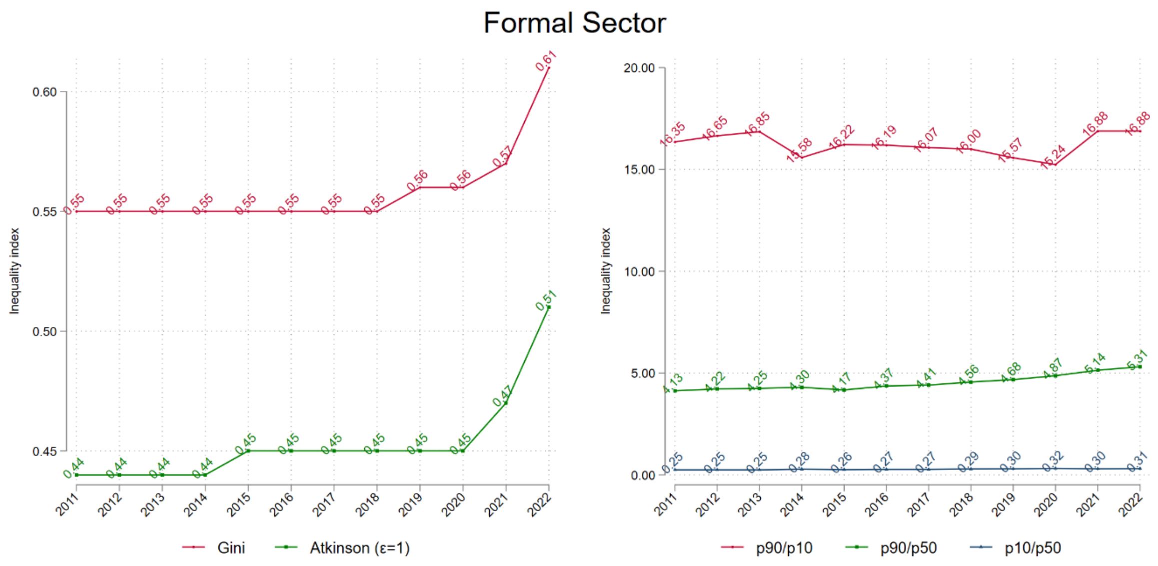
Irrespective of the inequality measure used, wage inequality in the formal sector has remained consistently high and has started to rise in more recent periods. In Figure 14, for the period 2011 to 2022, we present the Gini coefficient and the Atkinson index in the left panel, and the p90/p10, p90/p50 and p10/p50 ratios in the right panel. The Gini index remained stable at 0.55 between 2011 and 2018, thereafter gradually increasing from 0.56 in 2018 to 0.61 in 2022. The rising Gini coefficient indicates that wage inequality in the formal sector has been worsening. Similarly, the Atkinson index increased from 0.44 in 2011 to 0.51 in 2022.[27]

Looking at the percentile ratios, the largest wage gap is for the p90/p10 differentials, as it represents workers at the top and bottom ends of the wage distribution. Wages at the 90th percentile were 16.35 times higher than wages at the 10th percentile in 2011, increasing to 16.88 times in 2022. This suggests that the wage gap between the top and bottom end of wage earners has increased slightly in the formal sector. Similarly, wages at the 90th percentile were 4.13 times higher than wages at the 50th percentile in 2011, rising to 5.31 times in 2022. This suggests that the wage gap between the top earners and median wage earners has also marginally increased in the formal sector over the period. Conversely, the wage gap between the median and the bottom 10 percent of wage earners remained narrow, with wages at the 10th percentile being 0.25 times those at the 50th percentile in 2011, rising slightly to

[27] The Atkinson index can be used to calculate the proportion of total income that would be required to achieve an equal level of social welfare if incomes were perfectly distributed (Costa et al., 2019; De Maio, 2007). The theoretical range of Atkinson values is 0 to 1, with 0 being a state of equal distribution (De Maio, 2007). Thus, an increasing index points to rising inequality.

0.31 in 2022. In short, formal sector wage inequality increased between the top and bottom wage earners, as well as between the top and median wage earners over time.

Figure 14: Inequality measures in the formal sector, 2011–2022



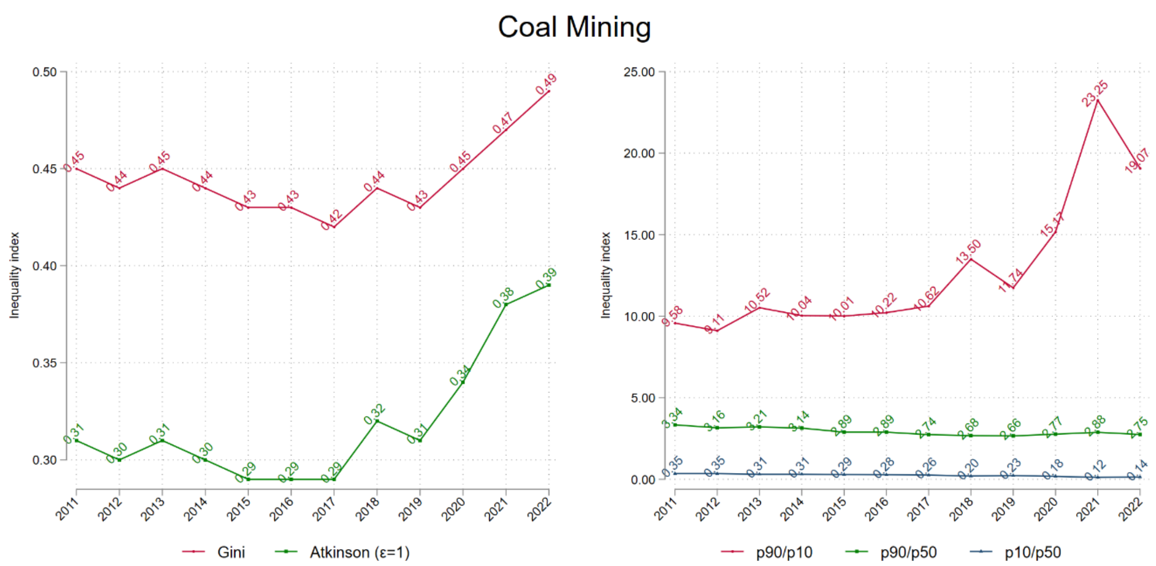
Source: Authors' calculations using IRP5 Worker-Level Data from National Treasury & UNU-WIDER (2024)
Note: Wages have been winsorized at the top and bottom one percent. The working-age population includes individuals aged 15 to 64 years inclusive.

Wage inequality within the coal mining industry is lower than wage inequality within the broader formal sector economy. For instance, when we compare the Gini coefficient estimates for the formal sector in Figure 14 with the corresponding estimates for the coal mining industry in Figure 15, we observe higher estimates in the former. In 2022, the Gini coefficient for the formal sector was 0.61, while the Gini coefficient for the coal mining industry was 0.49. This is consistent with the more compressed wage distribution for the coal mining industry in relation to the formal sector wage distribution depicted in Figure 12. As such, should coal mining industry workers shift to formal sector jobs, then they would be moving from a (relatively) low inequality industry to a high inequality sector.

While inequality within the coal mining industry is comparatively low, inequality within the industry has been rising over time. The Gini index in the coal mining industry gradually decreased from 0.45 in 2011 to 0.42 in 2018; this was the lowest level reached in the last decade. Thereafter, it gradually rose from 0.42 in 2018 to 0.49 in 2022. Thus, although the Gini in the coal mining industry has consistently been lower than the broader formal sector, we observe a rising inequality post-2018. The Atkinson index follows a similar pattern. The Atkinson index remained relatively stable around 0.30 until 2019, after which it gradually increased to 0.39 in 2022. Looking at the percentile ratios for the coal mining industry, we note a significant increase in the p90/p10 ratio, rising from 9.58 in 2011 to 19.07 in 2022.

This indicates a large and widening gap between the top 10 percent and the bottom 10 percent of earners in the coal mining industry. The p90/p50 ratio remained fairly steady throughout the period, while exhibiting a small decline from 3.34 in 2011 to 2.75 in 2022. Interestingly, the p10/p50 ratio decreased from 0.35 in 2011 to 0.14 in 2022 – almost half the ratio a decade ago. This indicates that the wage gap between the bottom 10 percent and median wage earners has widened over time. In short, this shows that top wage earners are driving up the overall wage inequality within the industry.

Figure 15: Inequality measures in coal mining, 2011–2022

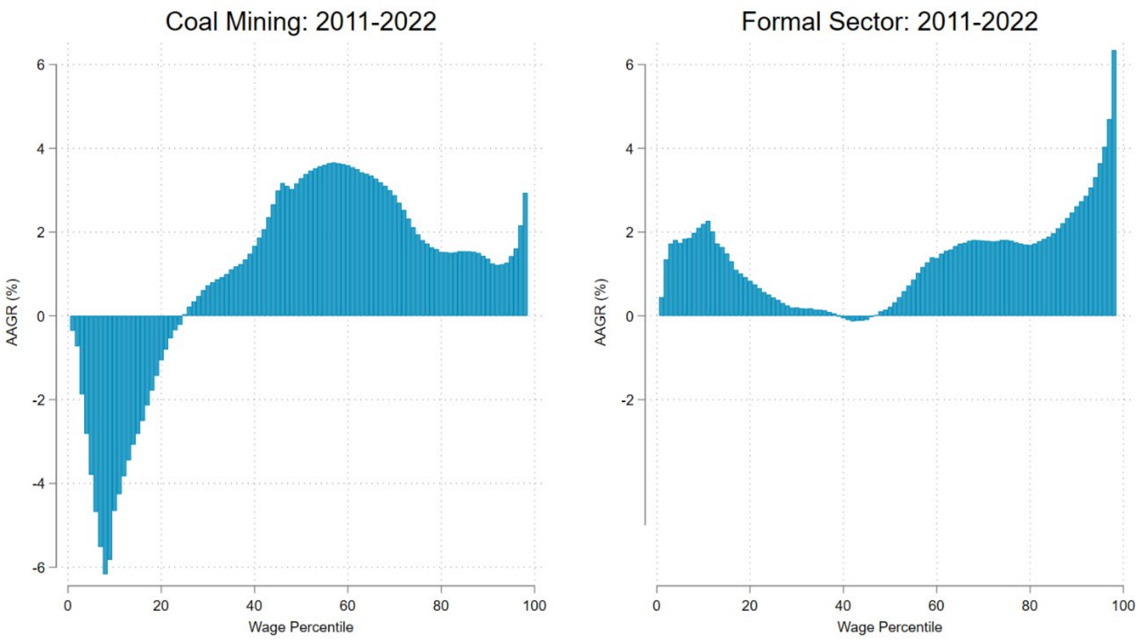


Source: Authors' calculations using IRP5 Worker-Level Data from National Treasury & UNU-WIDER (2024)
Note: Wages have been winsorized at the top and bottom one percent. The working-age population includes individuals aged 15 to 64 years inclusive.

To further explore inequality within the coal mining industry, we examine changes along different parts of the wage distribution and assess how these changes influence inequality. We do this by using the Growth Incidence Curve (GIC). The GIC illustrates the average annual growth rate of real wages between two points in time for every percentile along the wage distribution. This allows us to understand where growth has been concentrated along the wage distribution. We present the GIC for the formal sector and the coal mining industry in Figure 16.

Real wage growth in the coal mining industry has been concentrated in the middle and top of the wage distribution. The left panel of Figure 16 shows that real wages increased relatively rapidly above the 25th percentile, with particularly strong growth around the 60th percentile – average annual growth in excess of three percent. Conversely, low wage earners in the coal mining industry have experienced declining real wages. Real wages below the 25th percentile in the coal mining industry decreased, with some experiencing a decline of more than six percent per annum. Referring back to Table 8, it is likely that these workers at the bottom of the wage distribution are youth, since this grouping of workers have the lowest average wage level and experienced declining real wage growth.

Figure 16: Growth Incidence Curves – annual average growth of real wages, 2011–2022



Source: Authors' calculations using IRP5 Worker-Level Data from National Treasury & UNU-WIDER (2024)
Note: Wages are adjusted to December 2023 prices. Wages have been winsorized at the top and bottom one percent. The working-age population includes individuals aged 15 to 64 years inclusive.

A different picture emerges when we look at the broader formal sector. The right panel of Figure 16 shows that wage growth in the formal sector was more rapid at the top end of the wage distribution, with the top percentiles experiencing average annual real wage growth in excess of four percent. Furthermore, real wage growth was largely confined to the bottom 25th and the top 50th of the wage distribution, while real wages around the 40th percentile – the middle of the distribution – were either stagnant or slightly declining. This phenomenon is referred to as the wage polarisation and is consistent with similar such findings made by Bhorat et al. (2020).

In summary, we observe wage inequality within the coal mining industry is lower than wage inequality within the broader formal sector economy. A key implication being that, should coal miners transition from jobs in the relatively low inequality coal mining industry to jobs in high inequality industries, then it is possible that overall inequality will rise.[28]

[28] Baymul & Sen (2020) examine how structural transformation shapes inequality patterns. They contend, and show empirically, that the movement of workers from a low wage inequality industry to a high wage inequality industry induces higher levels of aggregate inequality.

7 CONCLUSION

In this paper, we use, for the first time, administrative tax data to measure the quantum of employment in the South African coal mining industry. Furthermore, we provide an employment, wage, and inequality profile of workers in the coal mining industry. Profiling the level and distribution of wages among workers in the coal mining industry is a key contribution to the energy transition discussion in South Africa, as there is a relative dearth of analyses detailing the wage profile of these workers. The administrative tax data provide high quality micro-level wage data that allow for such analysis.

Using the administrative tax data, as well as other available data sources, we are able to distinguish between employees employed directly by coal mining firms, and employees employed indirectly through outsourcing and sub-contracting employment relationships. We observe that employment levels in the coal mining industry appear to be relatively stagnant in the 1990s going into the early 2000s. A period of relatively strong employment growth proceeds with the commodities super cycle in the mid-2000s going into the early 2010s. There is a distinct drop in employment over the period 2014 to 2016, followed by a period of relatively stagnant employment levels. Notably, the level of employment for mine employees has stagnated, certainly over the past decade, while the level of employment associated with sub-contractors, in particular, has grown over time. In fact, nearly half of all employment at coal mines is linked to a combination of sub-contracting, and to a lesser extent outsourcing, employment relationships. A broader implication of this finding is that we do not know that much about employees at coal mines that fall under these outsourcing and sub-contracting employment relationships. As such, it is not possible to develop informed and tailored policy interventions for such workers. This grouping of employees is large and we would need data from mining firms to fill this gap.

Consistent with other energy transitions, the phasing out of the coal mining industrial structure is a regional economic event. Near on 80 percent of employment in the industry is concentrated within the Mpumalanga province. In close correlation with the location of mines and coal-fired power plants, employment is further concentrated within the local municipal areas to the west of the province. Advantageously, from a policy perspective, this pattern of concentration allows for spatially targeted interventions. However, this very same pattern of concentration can potentially become a disadvantage because, should the policymaker err, then the negative outcomes materialise in a highly concentrated area.

We observe that the coal mining industry is an important source of employment in the mining and quarrying sector. However, with respect to its national footprint, the industry constitutes a relatively small share of aggregate formal sector employment. As with the broader mining sector, the industry has experienced a decline in employment over the past decade. However, it is worth reiterating that the economic footprint in terms of contribution to employment in the South African economy is more apparent when one considers the broader coal value chain.

The coal mining industry workforce is relatively youthful, and thus a transition policy package will need to be tailored to the fact that a substantial number of workers will need to continue working. As such, skills development and job matching policy interventions are going to be key to ensuring a just transition for a relatively large number of workers. Nevertheless, a restively sizable share of workers are of retirement age or nearing retirement age, and thus, a transition policy package can include early retirement packages to ease the transition for this cohort of workers.

Men comprise the bulk share of employees in the coal mining industry, and as such, the adverse effects of the transition are likely to be orientated, at least in level terms, largely toward male employees. Nevertheless, the industry has seen increased participation of women, and thus, as South Africa plans its energy transition, policymakers should ensure that policies account for the increased female representation in the workforce, actively supporting women's participation in the shift into both existing sectors and the emerging green economy. This could include targeted training programmes that facilitate shifts to alternative employment opportunities. It is worth noting further that women in the industry get paid, on average, less than men, which could suggest that women are over-represented in lower paying and more precarious jobs in the industry and thus may require more targeted interventions to combat the adverse impacts of the transition.

Coal mining industry jobs are relatively well paid. The average worker in the coal mining industry earns more than the average worker in the formal sector and more than the average worker in every industry apart from the utilities industry. As such, a just transition policy tool aiming to provide grants to workers who are set to lose their jobs would be exceedingly higher than any grant that currently forms part of South Africa's social protection policy environment. Consequently, such an intervention is likely to carry with it a substantial fiscal burden. This in fact motivates for a nuanced policy approach where different cohorts of workers receive different policy interventions based on their underlying characteristics. In turn, a much smaller subset of workers, those being the most vulnerable, and located at the lower end of the wage distribution, would be eligible for a grant.

The average wage received in industries that typically provide alternative employment opportunities for coal mining industry workers, namely the manufacturing and construction industries, is much lower than that currently received by the average coal mining industry worker. As such, should the average coal mining industry workers shift to either of these industries, it is likely that they would have to incur a significant wage cut. Conversely, a coal mining industry workers shift to a job in another mining industry may be easier since the wage levels are comparable.

The average male coal mining industry worker earns more than his female counterpart, and this average wage differential has grown over time. Female coal mining industry workers receive higher wages than their formal sector counterparts. Further, we note that, as coal mining industry workers get older, their mean wage increases. A key implication being that providing a replacement wage for older workers is likely going to be a costly exercise, and thus, early retirement packages funded by pension and provident funds provide viable policy intervention.

Examining wage inequality, we observe wage inequality within the coal mining industry is lower than wage inequality within the broader formal sector economy. A key implication being that, should coal miners transition from jobs in the relatively low inequality coal mining industry to jobs in high inequality industries, then it is possible that overall inequality will rise.

To conclude, understanding the size and shape of the coal mining industry workforce provides key insights that can inform policy interventions designed to overcome any adverse impacts arising from South Africa's energy transition. It is clear that a suite of policy interventions, tailored to the characteristics of groups of workers within the coal mining industry, is required. This study provides value insights that inform such a suite of policy interventions.

REFERENCES

Aragón, F.M., Rud, J.P. & Toews, G. 2018. Resource shocks, employment, and gender: evidence from the collapse of the UK coal industry. *Labour Economics*. 52: 54–67.

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

Baymul, C. & Sen, K. 2020. Was Kuznets right? New evidence on the relationship between structural transformation and inequality. *The Journal of Development Studies*. 56(9): 1643–1662.

Beatty, C. & Fothergill, S. 1996. Labour market adjustment in areas of chronic industrial decline: the case of the UK coalfields. *Regional Studies*. 30(7): 627–640.

Beatty, C., Fothergill, S. & Powell, R. 2007. Twenty years on: has the economy of the UK coalfields recovered? *Environment and Planning A*. 39(7): 1654–1675.

Bhorat, H., van der Westhuizen, C. & Jacobs, T. 2009. Income and non-income inequality in post-apartheid South Africa: what are the drivers and possible policy interventions? *DPRU Working Paper No. 09/138*. Cape Town: Development Policy Research Unit, University of Cape Town.

Bhorat, H., Lilenstein, K., Oosthuizen, M. & Thornton, A. 2020. Wage polarization in a high-inequality emerging economy: the case of South Africa. *WIDER Working Paper 2020/55*. Helsinki, Finland: UNU-WIDER.

Bhorat, H., Kupeta, T., Martin, L. & Steenkamp, F. 2024. Just transition and the labour market in South Africa: measuring individual and household coal economy dependence. *DPRU Working Paper 202402*. Cape Town: Development Policy Research Unit, University of Cape Town.

Bruha, J., Ionascu, D. & Jeong, B. 2010. Organized labour and restructuring: coal mines in the Czech Republic and Romania. *Physica-Verlag HD*.

Budlender, J. & Ebrahim, A. 2020. Industry classification in the South African tax microdata. *WIDER Working Paper 2020/99*. Helsinki: UNU-WIDER.

Bulmer, E.R., Pela, K., Eberhard-Ruiz, A. & Montoya, J. 2021. Global perspective on coal jobs and managing labour transition out of coal: key issues and policy responses. Washington, DC: World Bank.

Carley, S., Evans, T.P. & Konisky, D.M. 2018. Adaptation, culture, and the energy transition in American coal country. *Energy Research & Social Science*. 37: 133–139.

Christiaensen, L. & Ferré, C., 2020. Just coal transition in Western Macedonia, Greece: insights from the labor market. Washington, DC: World Bank.

Christiaensen, L., Ferré, C., Honorati, M., Gajderowicz, T.J. & Wrona, S.M. 2022. Towards a just coal transition: Labor market challenges and people's perspectives from Silesia. *Jobs Working Paper, No. 70*. Washington, DC: World Bank.

Cole, M.J., Mthenjane, M. & van Zyl, A.T. 2023. Assessing coal mining closures and mining community profiles for the 'just transition' in South Africa. *Journal of the Southern African Institute of Mining and Metallurgy*. 123(6): 329–342.

Costa, R.N. & Pérez-Duarte, S. 2019. Not all inequality measures were created equal: the measurement of wealth inequality, its decompositions, and an application to European household wealth. *European Central Bank Statistics Paper No 31*. Frankfurt am Main: European Central Bank.

De Maio, F.G. 2007. Income inequality measures. *Journal of Epidemiology & Community Health*. 61(10): 849–852.

Department of Mineral Resources and Energy (DMRE). 2024. Publication for comments: Integrated Resource Plan, 2023. Pretoria: Department of Mineral Resources and Energy.

Finn, A. & Leibbrandt, M. 2018. The evolution and determination of earnings inequality in post-apartheid South Africa. *WIDER Working Paper 2018/83*. Helsinki, Finland: UNU-WIDER.

Fothergill, S. 2017. Coal transition in the United Kingdom. An historical case study for the project 'Coal Transitions: Research and Dialogue on the Future of Coal'. Paris, France : Institut du developpement durable et des relations internationales (IDDRI).

Frankowski, J., Mazurkiewicz, J. & Sokolowski, J. 2022. Mapping the indirect employment of hard coal mining: A case study of Upper Silesia, Poland. *IBS Working Paper 07/2022*. Warsaw, Poland: Institute for Structural Research.

Greenspon, J. & Raimi, D. 2024. Matching geographies and job skills in the energy transition. *The Extractive Industries and Society*. 17: 101397.

Haney, M. & Shkaratan, M. 2003. Mine closure and its impact on the community: five years after mine closure in Romania, Russia, and Ukraine. *Policy Research Working Paper Series No. WPS 3083*. Washington, D.C.: World Bank Group.

Hanson, G.H. 2023. Local labour market impacts of the energy transition: prospects and policies. *NBER Working Paper No. w30871*. Massachusetts, USA: National Bureau of Economic Research.

Hearer, D. & Pratson, L. 2015. Employment trends in the US electricity sector, 2008–2012. *Energy Policy*. 82: 85–98.

Hundenborn, J., Leibbrandt, M. & Woolard, I. 2018. Drivers of inequality in South Africa. *WIDER Working Paper No. 2018/162*. Helsinki, Finland: UNU-WIDER.

Hundenborn, J., Woolard, I. & Jellema, J. 2019. The effect of top incomes on inequality in South Africa. *International Tax and Public Finance*. 26: 1018–1047.

International Labour Organisation (ILO). 2002. The evolution of employment, working time and training in the mining industry. *TMMI/2002*. Geneva: International Labour Organisation.

Kerr, A. 2020. Earnings in the South African Revenue Service IRP5 data. *WIDER Working Paper 2020/62*. Helsinki, Finland: UNU-WIDER.

Kerr, A. 2021. Measuring earnings inequality in South Africa using household survey and administrative tax microdata. *WIDER Working Paper No. 2021/82*. Helsinki, Finland: UNU-WIDER.

Kerr, A. & Wittenberg, M. 2019. Earnings and employment microdata in South Africa. *WIDER Working Paper No. 2019/47*. Helsinki, Finland: UNU-WIDER.

Kerr, A. & Wittenberg, M. 2021. Union wage premia and wage inequality in South Africa. *Economic Modelling*. *97*: 255–271.

Kerr, A. 2021. Measuring earnings inequality in South Africa using household survey and administrative tax microdata. *WIDER Working Paper No. 2021/82*. Helsinki, Finland: UNU-WIDER.

Köhler, T. & Bhorat, H. 2023. Wages and wage inequality during the COVID-19 pandemic in South Africa. *DPRU Working Paper 202308.* Cape Town: Development Policy Research Unit University of Cape Town.

Korppoo, A. 2021. The Russian coal sector in a low-carbon world: Prospects for a coal transition? Insights Report, Climate Strategies.

Jacobs, C., Ebrahim, A., Leibbrandt, M., Pirttilä, J. & Piek, M. 2024. Income inequality in South Africa: evidence from individual-level administrative tax data. *WIDER Working Paper No. 2024/55*. Helsinki, Finland: UNU-WIDER.

Lehotský, L. & Černík, M. 2019. Brown coal mining in the Czech Republic – lessons on the coal phase-out. *International Issues & Slovak Foreign Policy Affairs*. 28(3/4): 45–63.

Leibbrandt, M., Woolard, I., McEwen, H. & Koep, C. 2010. Employment and inequality outcomes in South Africa. Cape Town: Southern Africa Labour and Development Research Unit, University of Cape Town, pp. 45–46.

Lemieux, T. 2006. The "Mincer equation" thirty years after schooling, experience, and earnings. In *Jacob Mincer a pioneer of modern labor economics*. S. Grossbard, Ed. Boston, MA: Springer US, pp. 127–145.

Makgetla, N., Maseko, N., Montmasson-Claire, G. & Patel, M. 2019. National employment vulnerability assessment: Analysis of potential climate-change related impacts and vulnerable groups. *Trade and Industrial Policy Strategy Report*. Pretoria, South Africa: TIPS.

Mineworkers Provident Fund. 2024. Retirement benefit. Available at: https://www.mwpf.co.za/retirement.html [Accessed 30 October 2024]

Oei, P., Brauers, H. & Herpich, P. 2019. Lessons from Germany's hard coal mining phase-out: policies and transition from 1950 to 2018. *Climate Policy*. 20(8): 963–979.

Oei, P., Hermann, H., Herpich, P., Holtemoller, O., Lunenburger, B. & Schult, C. 2020. Coal phase-out in Germany – implications and policies for affected regions. *Energy*. 196: 117004. https://doi.org/10.1016/j.energy.2020.117004.

Overland, I. & Loginova, J. 2023. The Russian coal industry in an uncertain world: finally pivoting to Asia? *Energy Research & Social Science*. 102: 103150.

Patel, M., Makgetla, N., Maseko, N. & Montmasson-Claire, G. 2020. Sector jobs resilience plan: coal value chain. *TIPS Report*. Pretoria, South Africa. TIPS.

Pavloudakis, F., Roumpos, C., Karlopoulos, E. & Koukouzas, N. 2020. Sustainable rehabilitation of surface coal mining areas: the case of Greek lignite mines. *Energies*. 13(15): 3995.

Presidential Climate Commission. (PCC). 2022. A framework for a just transition in South Africa. Pretoria: PCC. Available online at: https://www.climatecommission.org.za/just-transition-framework [Accessed February 3, 2024].

Safonov, G. 2021. Economic diversification in Russia's Kuzbass coal region. Climate Strategies.

Savitsky, O. 2015. Towards the end of the coal age in Ukraine. A review of the Ukrainian coal sector in the context of Donbass crisis. R. Sperfeld & B. Freund, Eds. Kyiv, Ukraine: Heinrich Böll Foundation, pp. 9–58.

Sharma, S. & Chatterjee, S. 2021. Winsorization for robust bayesian neural networks. *Entropy*. 23(11): 1546.

Shifa, M., Mabhena, R., Ranchod, V. & Leibbrandt, M. 2023. An assessment of inequality estimates in South Africa. *WIDER Working Paper No. 90/2023*. Helsinki, Finland: UNU-WIDER.

Sokolowski, J., Frankowski, J., Mazurkiewicz, J. & Lewandowski, P. 2022. Hard coal phase-out and the labour market transition pathways: The case of Poland. *Environmental Innovation and Societal Transitions*. 43: 80–98.

Stacey, T.R., Steffen, O.K.H. & Barret, A.J. 1999. Outsourcing of professional services. *The Journal of The South African Institute of Mining and Metallurgy*.

Statistics South Africa. 2024. *Update on phase 2 of release of Census 2022 data*. Available at: https://www.statssa.gov.za/?p=17568. [Accessed: 21 October 2024].

Wittenberg, M. 2017a. Wages and wage inequality in South Africa 1994–2011: part 2 – inequality measurement and trends. *South African Journal of Economics*. 85(2): 298–318.

Wittenberg, M. 2017b. Measurement of earnings: comparing South African tax and survey data. *REDI3x3 Working Paper 41*. Cape Town: Research Project on Employment, Income Distribution and Inclusive Growth, University of Cape Town.

Weber, Jeremy G. 2020. How should we think about environmental policy and jobs? An analogy with trade policy and an illustration from US coal mining. *Review of Environmental Economics and Policy*. 14 (1): 44–66.

Wong, J., Roser, F. & Maxwell, V. 2022. Coal phase-out and just transitions – lessons learned from Europe. Germany: NewClimate Institute for Climate Policy and Global Sustainability.

Wu, M. & Zuo, Y. 2009. Trimmed and winsorized means based on a scaled deviation. *Journal of Statistical Planning and Inference*. 139(2): 350–365.

Zinecker, A., Gass, P., Gerasimchuk, I., Jain, P., Moerenhout, T., Oharenko, Y. & Suharsono, A.R. 2018. Real people, real change: strategies for just energy transitions. Canada: International Institute for Sustainable Development.

DATA REFERENCES

Department of Mineral Resources and Energy. 2020. BulletinB1/2020. Minerals Statistical Tables 1994–2019. DMRE: Pretoria.

Department of Mineral Resources and Energy. 2023. BulletinB1/2023. Minerals Statistical Tables 2001–2022. DMRE: Pretoria.

Global Energy Monitor. 2023. Global Coal Plant Tracker, July 2023 release. Global Energy Monitor.

Global Energy Monitor. 2024a. Africa Energy Tracker, August 2024 release. Global Energy Monitor.

Global Energy Monitor. 2024b. Global Coal Plant Tracker, July 2024 release. Global Energy Monitor.

Global Energy Monitor. 2024c. Global Coal Mine Tracker, April 2024 release. Global Energy Monitor.

Kerr, A. Lam, D. & Wittenberg, M. 2019. Post-Apartheid Labour Market Series 1993-2019 [dataset]. Version 3.3.1. Cape Town: DataFirst [producer and distributor], 2019.

National Treasury and UNU-WIDER (2024). 'IRP5 Worker-Level Data 2011–2022 [dataset]. Version. e5_v1 Pretoria: South African Revenue Service [producer of the original data], 2024. Pretoria: National Treasury and UNU-WIDER [producer and distributor of the harmonized dataset], 2024.

Nell, A. & Visagie, J. 2024. Spatial Tax Panel 2014-2023 [dataset]. Version 4. National Treasury – Cities Support Programme and Human Sciences Research Council [producer and distributor], 2024.

Statistics South Africa. 1998. South African Census 1996 [dataset]. Version 1.3. Pretoria: Statistics South Africa [producer], 1998. Cape Town: DataFirst [distributor], 2020. DOI: https://doi.org/10.25828/7yrd-n169.

Statistics South Africa. 1999. Statistical Release P2001 Mining Census, 1996. Statistics South Africa: Pretoria.

Statistics South Africa. 2003. South African Census, 2001 [dataset]. Version 1.1. Pretoria: Statistics South Africa [producer], 2003. Cape Town: DataFirst [distributor], 2011. DOI: https://doi.org/10.25828/bp70-m263.

Statistics South Africa. 2005. Statistical Release P2001, Mining industry, 2004. Statistics South Africa: Pretoria.

Statistics South Africa. 2015. South African Census 2011, 10% sample [dataset]. Version 2. Pretoria: Statistics South Africa [producer], 2015. Cape Town: DataFirst [distributor], 2015. DOI: https://doi.org/10.25828/vjy1-tz66.

Statistics South Africa. 2011. Report 20-01-02 (2009) – Mining industry, 2009. Statistics South Africa: Pretoria.

Statistics South Africa. 2014. Report 20-01-02 (2012) – Mining industry, 2012. Statistics South Africa: Pretoria.

Statistics South Africa. 2017. Report 20-01-02 (2015) – Mining industry, 2015. Statistics South Africa: Pretoria.

Statistics South Africa. 2021. Report 20-01-02 (2019) – Mining industry, 2019. Statistics South Africa: Pretoria.

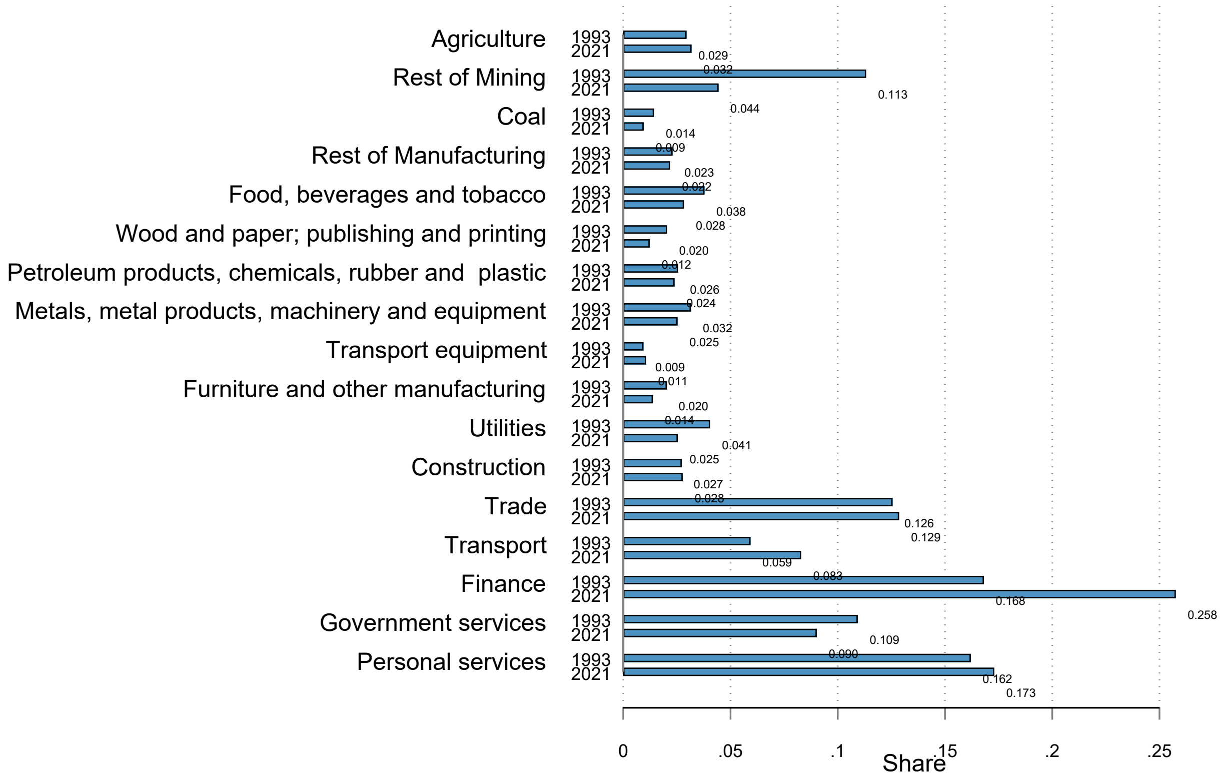
Statistics South Africa. 2024a. P0441 – Gross Domestic Product (GDP), 1st Quarter 2024. GDP P0441 – Generation of income account. Statistics South Africa: Pretoria.

Statistics South Africa. 2024b. Report No. 20-01-02 (2022) – Mining industry, 2022. Statistics South Africa: Pretoria.

The Growth Lab at Harvard University. 2024. International Trade Data (HS, 12), V3 [Data set]. https://doi.org/10.7910/DVN/YAVJDF, Harvard Dataverse.

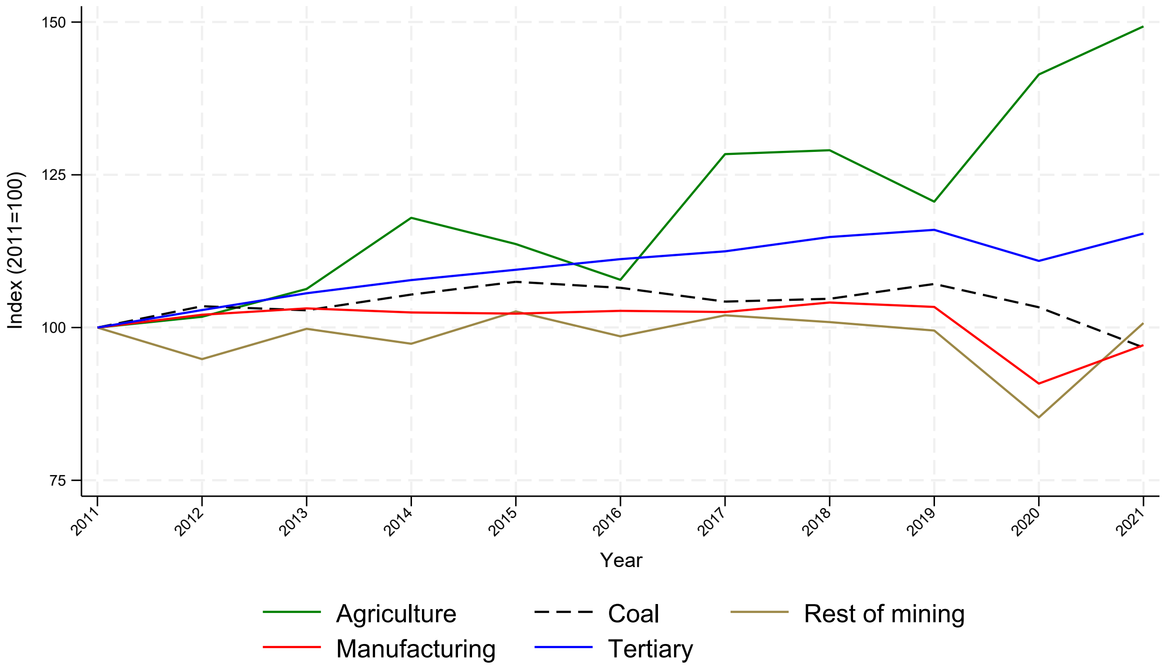
APPENDIX I: SUPPLEMENTARY ANALYSIS

Figure A 1: Contribution to gross value-added, 1993–2021



Source: Statistics South Africa, 2024a
Note: Industry value-added series reported at 2015 constant prices.

Figure A 2: Growth of value-added by industry, 2011–2021



Source: Statistics South Africa, 2024a
Note: Industry value-added series reported at 2015 constant prices.

Table A 1: Breakdown of coal mining employment using Mining Census data

	Type of Employment	1996	2012	2019	2022
A	Mining employees	62 956	49 032	41 133	48 796
B	Capital employees		2 100	5 836	2 074
C	A + B	62 956	51 132	46 969	50 870
D	Employees from labour brokers		9 885	582	3 672
E	Employees from sub-contractors		30 588	41 365	41 321
F	D + E	5 593	40 473	41 947	44 993
G	**Total (C + F)**	**68 549**	**91 605**	**88 916**	**95 863**
	Direct employees as a share of total (C/G)	91.84%	55.82%	52.82%	53.07%
	Employees of labour brokers or sub-contractors as a share of total (F/G)	8.16%	44.18%	47.18%	46.93%
	Sub-contractor employees as a share of employees in non-standard employment relationships (E/F)	..	75.58%	98.61%	91.84%

Source: Authors' calculations using Mining Census (Statistics South Africa, 1999; 2014; 2021; 2024)

Table A 2: Formal sector employment by industry using QLFS data, 2011–2022

	Employment levels		Growth (2011–2022)		Employment shares (%)		Share of change (ΔEmpi/ΔEmp)
	2011 (000s)	2022 (000s)	Absolute (000s)	Average annual growth (%)	2011	2022	2011–2022
Primary	**887**	**1 121**	**234**	**2.2**	**8.4**	**9.9**	**27.0**
Agriculture	555	723	168	2.4	5.3	6.4	19.4
Coal mining	*65*	*63*	*-2*	*-0.3*	*0.6*	*0.6*	*-0.2*
Rest of mining	266	334	68	2.1	2.5	2.9	7.8
Secondary	**2 521**	**2 207**	**-314**	**-1.2**	**24.0**	**19.4**	**-36.3**
Manufacturing	1 645	1 387	-258	-1.5	15.7	12.2	-29.7
Utilities	89	102	13	1.2	0.8	0.9	1.5
Construction	788	718	-70	-0.8	7.5	6.3	-8.0
Tertiary	**7 085**	**8 032**	**947**	**1.1**	**67.5**	**70.7**	**109.2**
Trade	2 085	2 028	-57	-0.3	19.9	17.9	-6.6
Transport	607	629	22	0.3	5.8	5.5	2.5
Finance	1 668	2 120	452	2.2	15.9	18.7	52.1
CSP services	2 725	3 256	531	1.6	26.0	28.7	61.2
Total	**10 493**	**11 360**	**867**	**0.7**	**100.0**	**100.0**	**100.0**

Source: Authors' calculations using LMD (Statistics South Africa, 2012); QLFS Q1–Q2 (2021; 2022)
Note: The working-age population includes individuals aged 15 to 64 years inclusive. Estimates represent formal sector employment.

Table A 3: Coal mining employment by age group using QLFS data, 2022

Coal employment	Level		Share (%)	
	QLFS	Tax admin	QLFS	Tax admin
Total coal mining	**63 167**	**53 133**	**100.0**	**100.0**
15–24	1 564	4 280	2.5	8.1
25–34	20 820	15 744	33.0	29.6
35–44	21 733	17 512	34.4	33.0
45–49	8 870	5 555	14.0	10.5
50–54	5 773	4 419	9.1	8.3
55–59	3 141	3 390	5.0	6.4
60–63	1 267	1 590	2.0	3.0
63+		643		1.2
Mean age	38	39		

Source: Authors' calculations using QLFS Q1–Q4 (Statistics South Africa, 2022; 2023)
Notes: Coal employment refers to coal mining employment within the formal sector for the working-age population (15–64 years old). The 63+ year cohort refers to the 63–65-year-olds.

Table A 4: Coal mining employment by age group, 2011

	Level			Share (%)		
Coal employment	**Census**	**QLFS**	**Tax admin**	**Census**	**QLFS**	**Tax admin**
Age group	**54 221**	**65 128**	**58 624**	**100.0**	**100.0**	**100.0**
15–24	6 678	5 007	3 610	12.3	7.7	6.2
25–34	18 823	26 101	18 881	34.7	40.1	32.2
35–44	13 368	15 710	15 155	24.7	24.1	25.9
45–49	5 769	5 903	7 430	10.6	9.1	12.7
50–54	5 094	6 990	7 134	9.4	10.7	12.2
55–59	3 403	2 811	4 668	6.3	4.3	8.0
60–63	825	2 047	1 368	1.5	3.1	2.3
63+	260	559	378	0.5	0.9	0.6
Mean age	37	39	40			

Source: Authors' calculations using LMD (Statistics South Africa, 2012); IRP5 Worker-Level Data (2022)
Notes: Coal employment refers to coal mining employment within the formal sector for the working-age population (15–64 years old).

Table A 5: Coal mining employment by gender, 2022

	QLFS	
Coal employment	**Level**	**Share (%)**
Total coal mining	**63 167**	**100.0**
Male	48 896	77.4
Female	14 271	22.6

Source: Authors' calculations using QLFS Q1–Q4 (Statistics South Africa, 2022; 2023)
Notes: Coal employment refers to coal mining employment within the formal sector for the working-age population (15–64 years old).

Table A 6: Coal mining employment by gender, 2011

Coal employment	Level			Share (%)		
	Census	QLFS	Tax admin	Census	QLFS	Tax admin
Total coal employment	**54 221**	**65 128**	**58 624**	**100.0**	**100.0**	**100.0**
Male	43 929	55 237	49 345	81.0	84.8	84.2
Female	10 293	9 890	7 853	19.0	15.2	13.4

Source: Authors' calculations using South Africa Census (Statistics South Africa, 2015); LMD (Statistics South Africa, 2012); IRP5 Worker-Level Data (2011; 2022)
Notes: Coal employment refers to coal mining employment within the formal sector for the working-age population (15–64 years old).

Table A 7: Median real monthly wage by demographic characteristics, 2011–2022

	2011		2022		Avg. annual growth (2011–2022)
	Median	Ratio median Coal:Formal	Median	Ratio median Coal:Formal	
National coal	**25 309**	**2.3**	**35 871**	**3.3**	**3.2**
By gender					
Male	25 517	2.2	39 323	3.2	4.0
Female	24 883	2.5	30 956	3.1	2.0
By age group					
15–24	12 589	2.5	3 812	0.8	-10.3
25–34	19 126	2.2	21 937	2.9	1.3
35–44	28 119	2.1	42 959	3.1	3.9
45–49	30 703	2.0	46 777	2.6	3.9
50–54	30 605	1.9	51 347	2.4	4.8
55–59	29 651	2.0	51 344	2.1	5.1
60–63	28 177	2.2	50 654	2.0	5.5
63+	27 968	2.6	50 384	2.0	5.5

Source: Authors' calculations using IRP5 Worker-Level Data from National Treasury & UNU-WIDER (2024)
Note: Wages are adjusted to December 2023 prices. Median wages reported in monthly Rands. Wages have been winsorized at the top and bottom one percent. The working-age population includes individuals aged 15 to 64 years inclusive.