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Executive Summary

Climatic stabilization, as mandated by the Paris Agreement, necessitates a transition away from fossil fuel-based economic production and processes. In particular, the call to shift away from coal is crucial, given South Africa's substantial reliance on this energy source. The nation stands out as a larger CO_2 emitter than the global average, with 86% of its primary energy supply and 85% of its CO_2 emissions attributed to coal (Ritchie, Roser & Rosado, 2022). South Africa finds itself at the early stages of transitioning away from coal, but this is a move not devoid of socio-economic costs, as coal has a direct and indirect economic footprint. Coal is a relatively cheap energy source, accounting for USD 3.8 billion and 4% of total merchandise exports, and is a source of employment and livelihood for many South Africans. Despite these socio-economic costs, delaying the transition could also prove costly, especially in light of evolving trade protocols that increasingly demand environmentally friendly alternatives such as electric vehicles or green steel.

In this paper, we provide a robust quantitative estimate of jobs – both direct and indirect – associated with the coal sector in South Africa, and in so doing, explore the labour market profile and characteristics of the individuals and households linked to the coal sector. In particular, we are interested in the size and shape of the coal labour market. Understanding the labour market implications associated with a transition is pivotal in shaping policy decisions linked to the just transition.

The South African coal mining landscape is characterised by the regional concentration. Of the 78 operating coal mines in South Africa, 65 (or 83%) are located in Mpumalanga, which accounts for 80% of national coal production. The spatial distribution of mines within the Mpumalanga province is further concentrated within local municipalities located in western parts of the province. Five municipalities – Emalahleni, Govan Mbeki, Msukaligwa, Steve Tshwete and Victor Khanye – account for 70% of national coal production. The coal industry is further characterised by firm concentration, with 5 mining companies – Seriti, Sasol, Exxaro, Thungela and Glencore – together accounting for 77% of all coal production. Similarly, coal-fired power production is also concentrated within Mpumalanga, with 11 of the national utility's (Eskom) 14 coal-fired power plants located in the province. These coal-fired power plants account for 70% of Eskom's operating capacity.

There is a natural endogenous transition that is already underway by virtue of the lifespan of coal-fired power plants operated by the national utility. This is working in conjunction with the regulated transition to renewables. In a decade and a half, half of South Africa's coal-fired power plants will be retired. This has implications in terms of the need for alternative energy sources, and for employment in the coal mining and electrical utility industries.

The coal industry is a core component of the South African mining sector, accounting for approximately 20% of mining gross value added in 2019; up from 13% in 1993. Despite this, the economic contribution of the coal mining industry is relatively small, contributing only 1%

of national gross value added in 2019. This contribution is small in relation to several manufacturing industries, which present pathways to reindustrialisation.

However, coal mining provides an important source of export revenue in South Africa and has important downstream linkages to other industries, such as transport, petrochemicals, and electricity production. The sector is a critical employer in the Mpumalanga province, where there are few other employment opportunities.

The study uses industry and spatial dimensions to determine the scope of analysis. Existing publicly available data does not allow for the reliable measurement of employment across the entire coal value chain. The study thus focuses on measurable elements of the value chain, with particular focus on direct jobs linked to the coal mining industry. Using the industry dimension, the analysis is restricted to direct employment in the coal mining industry (denoted by Standard Industrial Classification code 210), as well as a component of indirect employment linked to the coal-fired power production (denoted by Standard Industrial Classification code 411). Existing estimates of employment in the coal value chain suggest that these two industries constitute 68% of employment along the value chain, which indicates that the paper is measuring the bulk share of employment along the coal value chain. The spatial dimension shows that coal mining and coal-fired power production is concentrated in the Mpumalanga province. As such, much of the labour market analysis is focused on the regional labour market in Mpumalanga.

The study uses data drawn from a variety of sources. Using multiple sources allows for verification and cross-confirmation of estimates. Individual-level data on workers is drawn from household survey data, including the Post-Apartheid Labour Market Series (PALMS), the Quarterly Labour Force Survey (QLFS), the Labour Market Dynamics (LMD) data, and Census data. Within these sources, we are able to identify employment in the coal mining industry (SIC 210) and coal-fired power generation (SIC 411) for the period 1994 to 2019. When estimating the population of coal workers, aggregated firm-level data is also available. These sources are the Statistics South Africa Mining Census data and the Department of Mineral Resources and Energy (DMRE) employment estimates.

The QLFS data poses a challenge of statistical representativity when disaggregating the data at the 3-digit occupation level, since it is designed to be representative at the national level, not at a provincial or lower spatial level. The disaggregation of the data in this way creates the risk of small sample bias, which can result in statistically noisy results.

We combat this bias in two ways. First, we use LMD survey data, which pools the QLFS data for each year, resulting in a larger sample size. Second, we use the Census data to support and cross-check the results we obtain from the LMD. A disadvantage of the Census data is that it is only available for 1996, 2001 and 2011. Therefore, it is necessary to use the later LMD figures to get more recent estimates. The LMD data is used to create a profile of the individual and job characteristics of the coal mining industry workers, while the Census allows us to profile the household characteristics of the coal mining sector workers.

In 2019, employment in the coal mining industry sat between 76 000 and 108 000 workers. This estimate indicates that the coal mining industry represents approximately 0.5% of total employment in South Africa, and 19% of aggregate mining employment. The upper bound estimate from Statistics South Africa's firm level estimate is larger than the household survey estimate from PALMS, because the firm census measurement picks up outsourced workers and sub-contractors who may not identify as coal industry employees in the household surveys. The PALMS/QLFS estimates are fairly reliable when cross-checked against the Census data.

The quantification of aggregate employment in the coal mining industry indicates a consistent upward trend in national employment over the period from 1994 to 2019. Employment in coal mining was relatively stable in the 1990s, followed by a strong upward trend from the mid-2000s until 2010. Although the estimated employment falls in 2015 and 2016, the trend proceeds upward from 2017 onwards. The coal employment in Mpumalanga province follows this trend, as the bulk share of coal industry employment is concentrated in the province. According to the LMD data, Mpumalanga's share of coal mining employment has grown over time from 80% in 2011, to 86% in 2019.

The coal mining industry is a core employer within the Mpumalanga province and the local municipalities located in the western parts of the province. The industry accounts for approximately 5% of total employment in the province, while accounting for 19% of employment in Emalahleni, 15% in Msukaligwa, 14% in Steve Tshwete, 3.5% in Govan Mbeki, 9.4% in Mkhondo, 5% in Albert Luthuli, and 7% in Victor Khanye. It should be noted that these figures do not account for indirect employment through coal, such as retail and financial services.

When exploring the characteristics of coal mining workers, the 2011 Census and LMD estimates are reasonably aligned. The average coal mining worker is a Black African male, aged 25-44 years. The coal mining industry workforce is relatively youthful, with 51% of the employed being aged between 15 and 34 years. Furthermore, the average employee exhibits relatively high levels of educational attainment. Between 60 and 71% of coal industry employees have at least a complete secondary education.

In a decade and a half, when only three of South Africa's 14 coal-fired power plants will be in commission, a quarter of the 2019 cohort of coal workers will be at retirement age (assuming retirement at 65 years of age). This is also likely to be an underestimate since the retirement age of mine workers is 50-60 years for underground workers and 53-63 years for surface workers. However, the point is not that workers will not get replaced, but that new entrants will come in at lower wages. Thus, the cost of the just transition may possibly be reduced as high paid retirees are replaced by entrants.

The coal industry is a semi-skilled intensive industry. Approximately 40% of employees are involved in craft and related trade occupations, while 35% are involved in plant and machine operator occupations. The implication is that we need to look to preserve these skills through matching into alternative sectors, which in turn will alleviate the burden of a pure fiscal solution to the just transition.

Coal mining industry jobs are predominantly formal sector jobs. Coal mining industry employees enjoy job quality indicators that are relatively favourable in relation to other formal sector workers (note: we are not able to measure job health and safety indicators). Large shares of employees have permanent employment conditions (81%), Unemployment Insurance Fund (UIF) contributions (96%), pension contributions (80%), receive annual leave (89%) and receive medical aid contributions (68%). Dependent on demand, job matching to alternative industries – such as manufacturing and construction – would result in adverse job quality outcomes for coal mining employees (noting that we cannot measure health and safety outcomes).

There are 46 100 coal households (households with at least one coal mining worker present) in Mpumalanga. For the majority of coal households (60% or 29 500), a single coal worker is the only employed person in the household. A further 2 400 coal households have at least two coal mining industry workers. These households are completely reliant on coal industry employment income, making them vulnerable to the transition away from coal. More than a third (16 500 or 36%) of coal households have at least one other employed individual from another industry and/or the coal mining industry in the household. However, it should be noted that these other industries may be closely linked to the coal economy in the locality.

In terms of dependents in these households, most coal households (70% or 32 500) do not have unemployed individuals in their household. Given the mean coal household size of 3.6, this suggests that the remainder of individuals in these households are not economically active. Approximately 13 500 (29%) of coal households have at least one unemployed individual in the household. Households with unemployed individuals present also appear more likely to be single coal-worker households, rather than households with multiple coal workers.

Child and elderly dependency in coal households is low. More than half of coal households (26 200 or 57%) do not have any child dependents. Further, 19% (8 500) have one child and 25% (11 300) have at least two children. The mean number of child dependents in coal households is 2.0. Finally, most coal industry worker households (43 900 or 95%) do not have any elderly dependents.

We further categorise households according to their reliance on coal mining industry income and the number of dependents in the household. We find that 17 600 (38%) of households can be considered less vulnerable. These are households with zero dependents, and 4 700 of these households have individuals employed elsewhere. However, 62% (28 400) of households fall into the more vulnerable categorisation. These are households that have at least one dependent. A further 16 700 of these households are solely reliant on coal income as they have no individuals employed elsewhere.

The study also focuses on the electrical utility industry in Mpumalanga. In 2019, employment in the electrical utility industry was estimated to be 30 481 employees in Mpumalanga. The average worker in the electrical utility industry is a Black African male aged between 25 and 44 years. Electrical utility industry workers are relatively more educated than the average formal sector worker in Mpumalanga. These workers tend to be employed in professional, technician and plant and machine operator occupations – i.e. high- and semi-skilled occupations.

Electrical utility industry jobs are predominantly formal, and are characterised by high levels of UIF contributions, pension contributions, and various forms of leave. Additionally, the prevalence of unionized employees has increased over time, with 66% of employees belonging to a union in 2011; rising to 88% in 2019. The data suggest that, on average, electrical utility industry jobs have better employment conditions than the average formal sector job in Mpumalanga.

There are 11 200 electrical utility industry households in Mpumalanga. There is no substantial overlap between coal and electrical utility households in Mpumalanga. Although utilities households are not directly exposed in the event of the closure of coal mines or the retrenchment of coal employees, there is an indirect exposure, due to the relationship between coal mines and coal-powered stations. Slightly less than 8% of electrical utility industry households in Mpumalanga have one or more coal mining industry employees present in the household. The vast majority of these households (86%) are single electrical utility industry worker households with no other coal mining industry workers present. However, more than 40% of electrical utility industry households have at least one individual employed elsewhere, making these households less exposed to the closure of coal mines and the decommissioning of coal-fired power stations.

Similar to coal households, more than one-quarter (28%) of electrical utility industry households have at least one unemployed dependent. However, almost all (94%) of these households have zero elderly dependents, and just under half (48%) have one or more child dependents. As is the case with coal households, households with child dependents typically have more than one child dependent, and the mean number of child dependents in electrical utility industry households is also 2.0.

As with coal households, electrical utility households are grouped according to their vulnerability. We find that 4 000 (33%) households can be considered less vulnerable. These are households with zero dependents, and 1 400 of these households also have individuals employed elsewhere (making them less vulnerable to adverse shocks). However, 67% (8 100) of households fall into the more vulnerable categorisation. These are households that have one or more dependents, with 4 500 of these households being solely reliant on electrical utility industry income as they have no individuals employed elsewhere.

In terms of our quantification of coal industry jobs, we find that, in 2019, the industry accounts for 76 406 jobs nationally. Employment correlates with production, and thus the bulk share of these coal industry jobs – 66 252 jobs (87%) – are located in Mpumalanga. The remaining 10 154 coal industry jobs (13%) are located in the rest of South Africa. A further 30 481 electrical utility industry jobs, linked to coal-fired power production, are located in Mpumalanga. Thus, we estimate approximately 106 887 direct and indirect jobs linked to the coal value chain. The average worker across these two industries is Black African, male and young.

Using the occupation-education level space, we put together a first attempt at breaking up the just transition challenge by dividing the coal and coal-related workforce into three analytical groupings. The first grouping, defined as the no just transition challenge grouping, comprises workers with a post-secondary education qualification, who work in high-skilled or semi-skilled occupations, and can thus be considered as relatively high-skilled. Across the two industries, this grouping accounts for 29% of the workforce or 31 187 workers. Given the relatively high skill level of workers in this grouping, it is likely that they will be able to find alternative employment opportunities, and thus the market is set to resolve the transition challenge for this grouping of worker.

The second grouping, defined as an intermediate just transition challenge, comprises those with at most a complete secondary education, and who work in high- or semi-skilled occupations. This grouping of predominantly semi-skilled workers numbers 66 928, or almost two-thirds of the workforce (63%). Given the semi-skilled nature of this large grouping of workers, there is a degree of uncertainty regarding the appropriate policy intervention. The relatively more skilled workers within this grouping may require a skills top-up intervention, which may facilitate a more successful match into alternative employment opportunities. The less skilled workers within this grouping may require a special allocation from government into green jobs.

The third grouping, defined as the just transition challenge, comprises those engaged in low-skill elementary occupations. This low-skilled grouping is comprised of 8 416 workers (7.9% of the workforce). These low-skill workers are unlikely to successfully match into alternative employment opportunities, and thus social protection in the form of income support, offers the best policy response for this grouping.

A fourth grouping of workers, defined as the retirement cohort, are those who are set to exit the workforce through retirement over the coming decade. This group constitutes those who are set to naturally exit as they reach retirement age – those aged 55 and 64 years of age – and those who may warrant early retirement packages – those aged 45 to 54 years of age. Drawing on the former quantifies 10 139 employees (9.5%), and the latter 19 212 employees (18%). The age distribution of the coal industry is skewed toward the younger cohorts, and early retirement interventions are likely to be less prevalent in the coal industry relative to the electrical utility industry.

Driven by both endogenous forces – natural closure of coal-fired power plants – and exogenous forces – regulatory policy shifting energy production toward renewables – the transition is set to continue, and likely accelerate. It is vital that appropriate policy interventions are devised in order to ensure a just transition. This paper contributes to the ongoing policy debate surrounding the just transition in South Africa, by carefully deriving a robust empirical estimate of the coal labour market in South Africa, and the related coal-based electrical utility industry in Mpumalanga. These initial empirical insights into the size and shape of the coal labour market can inform the scale and scope of these policy interventions. Given the heterogenous nature of the labour market, a diverse suite of policy interventions is likely to be required.

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1 Introduction

The climate stabilisation imperative emerging from the Paris Agreement necessitates a transition away from fossil fuel based economic production and processes. In particular, there is a need to shift away from coal as a source of energy. In 2021, coal constituted 36% of global primary energy supply, while accounting for 40.3% of global CO_2 emissions (Ritchie, Roser & Rosado, 2020). Whilst the use of coal as a primary energy source varies across countries, South Africa does present itself as an economy highly dependent on coal. Given the abundance of this mineral in the South African context, coal's footprint on the South African economy is disproportionately larger than the global average: For example, in 2021 coal accounted for 86% of South Africa's energy supply and 85% of its CO_2 emissions (Ritchie, Roser & Rosado, 2022). As such, and in line with its Paris Agreement commitments, and the climate imperative of reducing carbon emissions, the South African economy finds itself at the initial stages of a transition away from coal (Presidential Climate Commission, 2022; Department of Mineral Resources and Energy, 2019).[1]

Such transition is not without costs as the coal economy has a relatively substantial direct and indirect economic footprint, with much of this footprint being regionally concentrated in the Mpumalanga province. Coal provides a critical and relatively inexpensive input for electricity generation, and in coal mining localities, households make use of coal directly for heating and cooking (Burton et al., 2018). The industry is a source of export revenue, bringing 6.1 billion US dollars into South Africa, and accounting for approximately 4.19% of total merchandise exports in 2021.[2] Most importantly, in the context of high unemployment, the sector is a source of employment and livelihood, and thus a transition away from coal is set to adversely impact on the labour market that orbits the sector.[3]

Herein then lies the focus of this paper: We provide a robust quantitative estimate of jobs – both direct and indirect – associated with the coal sector in South Africa, and in so doing, explore the labour market profile and characteristics of the individuals and households linked to the coal sector.

[1] It is worth noting that there are several additional factors driving the decline of South Africa's coal sector. These include – but are not limited to – declining firm profitability linked to declining coal export revenues as global demand for coal declines as countries shift toward low-emissions policy; the replacement of old retiring coal-powered power plants by alternative cost-effective energy sources, such as renewables; policy-driven shifts of global value chains toward greener processes (e.g. green steel) and greener final products (e.g. electric vehicles).

[2] Export estimates taken from The Growth Lab at Harvard University (2023).

[3] South Africa's official unemployment rate stood at 35% in quarter four of 2021. The corresponding figure for Mpumalanga, the province within which the majority share of coal mining takes place, stood at 39.7%. (Statistics South Africa, 2022).

We address the following research questions:

- How many individuals are employed in the coal sector?
- What is the spatial allocation of these jobs?
- How many households are dependent on incomes derived from jobs in the coal sector?
- What are the socio-economic characteristics of individuals and households linked to coal sector jobs?

A key motivation driving this study is the need to bring rigorous and robust micro-data-based empirical estimates of the size and shape of the coal labour market to discussions regarding the just transition. Such information would seem critical to begin the practical process of crafting a quantifiable just transition plan. In terms of the coal industry specifically, several challenges exist in quantifying the size and shape of the labour market associated with this industry: Firstly, existing estimates of aggregate employment in the coal mining industry differ by data source, and there is little explanation as to why these estimates differ. Secondly, while employment numbers of the coal mining industry are available, measures of employment for the broader coal value chain are sparse, and where present, little detail is provided. Thirdly, existing labour market information is primarily focused on measurement of aggregate employment in the coal industry, and little emphasis is placed on generating a detailed picture of the coal labour market and the socioeconomic profile of the individuals and households linked to the industry through the labour market.

The study is further motivated by the importance of understanding the labour market implications associated with the transition, as this is arguably one of the key factors shaping policy choices by the South African government in respect of the transition away from fossil-based energy. However, current research in this area – whilst rich in terms of the climate consequences of coal product and usage – is fairly thin and arguably empirically poor at providing a robust empirical analysis of the number and types of jobs, labour income to households and communities, that are likely to be deleteriously affected by this shift to clean energy or lost as a result of the shift to green jobs.

To provide a robust quantitative estimate of jobs associated with the coal industry – particularly those related to coal mining and energy production in coal-fired power plants – and to explore the socio-economic profile of the individuals and households linked to these coal industry jobs, we consult several data sources, including household survey data, such as the Quarterly Labour Force Survey (QLFS) and the Census, and additional data emerging from Statistics South Africa and the Department of Mineral Resources and Energy (DMRE). To reach a set of robust, and considered, estimates of the quantum of coal sector jobs, we refer to a variety of data sources, which allows us to cross-check our estimates. We explicitly make note of both the advantages and limitations of each dataset, such that the analysis that is presented is one that provides an empirically verifiable view of the sector. Along the industry and spatial dimensions, we restrict our analysis to individuals located in Mpumalanga, who are engaged in coal mining activity – SIC210 – and energy production – SIC411 – and thus do not measure indirect employment outside of energy production.

It is worth noting up front that the just transition involves a process of creative destruction – as coined by Schumpeter (1942: 83). This process of changes to the economic structure, typically driven by innovation, results in a set of declining industries and associated job destruction, and a set of emerging industries associated with job creation. In the case of the transition from a fossil fuel-based economy – such as coal dependent South Africa – to a low-carbon economy, job destruction is expected in industries linked to the coal value chain, and job creation in industries linked to alternative low-carbon energy sources, such renewables. This study focuses on the job destruction side of the transition. The quantification of the size and shape of the coal labour market provides valuable input into policy considerations designed to ensure that the transition is not only a transition, but a just one.

The paper is structured as follows: Section 2 provides an overview of the emerging literature focused on examining the labour market impacts associated with transitions away from coal-based economies. Section 3 details the South African coal mining landscape in terms of the spatial distribution and economic footprint of the industry. We detail the methodology and empirical approach applied in the analysis in Section 4, and we describe the data employed in the analysis in Section 5. Section 6 presents a descriptive analysis of the quantum of jobs linked to the coal sector, and the socio-economic profile of the individuals and households linked to these jobs. Section 7 concludes by summarising and discussing the key findings and estimates to emerge from the analysis.

2 Literature Review: Transitions away from Coal and Regional Labour Market Impacts

Before considering the literature that explores the labour market impacts associated with what is known as the just transition, we begin by providing a definitional understanding of what the just transition is. We then examine a subset of the just transition literature focused on the labour market impacts associated with the transition, which we delineate between the international literature and studies focused on the South African context.

2.1 The just transition

The just transition is about balancing the climatic imperative of driving the energy transition away from fossil fuels, with the socioeconomic challenges that emerge from the receding economic footprint of fossil fuel industries. A transition that is just, is a fair change from one state to another. The forces of *creative destruction* drive the transition and shape the socio-economic outcomes that emerge. Schumpeter (1942: 83) coined the term '*creative destruction*', which refers to the process of '*industrial mutation that incessantly revolutionises the economic structure from within, incessantly destroying the old one, incessantly creating a* *new one'*. Creative destruction describes the innovation mechanism. This process implies that there are economic winners in a new industry where jobs are created, and economic losers where jobs are destroyed.

Heffron and McCauley (2018:74) suggest that justice scholarship literature is divided into three realms of justice, namely: Energy justice – application of human rights across the energy life cycle; Environmental justice – aims to treat all citizens equally and to involve them in the development, implementation and enforcement of environmental laws, regulations and policies; and Climate justice – sharing the benefits and burdens of climate change from a human rights perspective. These ideas encompass the Just Energy Transition Partnership (JETP), which aims to support South Africa in its efforts to decarbonise its economy – to move away from coal and towards a low emission, climate resilient economy based on clean, green energy and technology (G7, 2022). However, along with energy, environmental and climate justices, we are also interested in social justice, which is fairness in terms of the distribution of wealth, opportunities, and privileges within a society (Lexico, 2022).

The International Labour Organisation (2015) provides a guideline for a just transition, which García-García, Carpintero and Biendía (2020) condense into a framework of opportunities and challenges. First, opportunities are the creation of net employment, the improvement of labour quality and social inclusion. Second, the potential challenges brought about by a just transition are socioeconomic restructuring, adaption to climate change and compensation of regressive political effects.

2.2 Labour market impacts of the just transition

2.2.1 International studies exploring job destruction

The literature exploring the labour market effects associated with a transition away from coal contains evidence of these effects across countries at various stages of their evolution (Bulmer et al., 2021). 'Advanced transitioners' represent those economies that are at an advanced stage of coal phase-out, and includes countries such as Germany (Oei et al., 2020), Poland (Frankowski et al., 2022; Sokołowski et al., 2021; 2022), the Czech Republic (Bruha et al., 2005) and the United Kingdom (Beatty & Fothergill, 1996; Beatty et al., 2007; Aragón et al., 2018). 'Partial transitioners' are countries where the transition has either stalled or experienced a very recent transition in response to declining local demand for coal. These include economies such as Russia (Haney & Shkaratan (2003), Greece (Christiaensen & Ferre, 2021), Romania (Bruha et al. (2005) and United States (Hearer & Pratson, 2015; and Bulmer et al., 2021). Early stage transitioners are countries that are still experiencing rising export and/or rising local demand for coal – these include countries such as Indonesia (Bulmer et al., 2021) and South Africa (Bulmer et al., 2021). One can thus glean important information around the labour market effects associated with the transition from countries that have already undergone or are undergoing the transition, as well as gain insight into how policymakers attempted to ameliorate the adverse impacts associated with the transition.

When considering the impacts of these transitions away from coal, it is clear that the unit of analysis becomes the regional economy and the regional labour market. Frankowski et al. (2022) examine the labour market effects associated with coal phase-out in the Upper Silesia region of Poland, where Poland's coal mining operations are concentrated. Similarly, Christiaensen and Ferre (2021) examine these effects in the Western Macedonian region of Greece. Studies emerging from the United Kingdom focus on the English and Welsh coal fields (Beatty & Fothergill, 1996; Beatty et al., 2007; Fothergill, 2017). Therefore, analyses exploring the labour market effects of a transition away from coal require an in depth understanding of the nature and composition of the regional labour market. The need to place analytical focus on regional labour markets suggests that labour market effects are likely to be concentrated and acute within these regional economies.

Regions within countries that have shifted away from coal production have faced considerable employment losses in the coal mining sector. This is especially evident among the advanced transitioners (Bulmer et al., 2021). In the 1980s, there were approximately 416 000 miners employed in the coal mining sector in Poland, 365 000 in Germany, and 172 000 in the UK. Governments in these nations implemented aggressive phase-out policies to close mines, which resulted in substantial portions of the workforce being laid-off. As a result, in 2021 there were fewer than 1 000 coal mining workers who were working in the UK, and fewer than 15 000 in Germany, while 93 000 were employed in Poland, which still has an active coal mining operation. The United States – a partial transitioner – has experienced more recent jobs losses of around 49 000 jobs over the period 2008 to 2012 (Hearer & Pratson,2015).

Evidence from the UK experience suggests that the adverse labour market effects were felt more acutely by women. Aragón et al. (2018) examined the impact of resource shocks on non-primary employment by gender in the UK. They employed a novel dataset including coal mine location and closure date information, and geographically linked it to the UK Census for the years 1981 to 2011 to investigate the impact of mine closures. The data allowed them to examine both the immediate and long-term consequences by using a difference-in-difference approach that compares the evolution of employment in areas near coal mines versus those further away, using the number of mines closed as a treatment. The study demonstrated that the impact of coal mine closures in the UK differed for men and women. When a mine closes, men see a rise in alternative employment avenues in the manufacturing and services industries, while women experienced a decline. These effects were also shown to persist more than twenty years after mine closure. These findings support the notion that men and women are imperfect substitutes in the labour market and emphasize the significance of taking gender equality into account when evaluating the economic impact of natural resources.

The transition pathways and their respective policy interventions varied across the different country case studies. The age composition of the workforce played a role in determining the nature of the transition intervention. In the case of Germany, Oei et al. (2020) reported that early retirement schemes were offered to the retrenched workers since two-thirds of these workers were already over 46 years of age. In the case of the Silesia region in Poland, Christiaensen et al. (2022) show that more than 40% of the current mining workforce are expected to retire by 2030, making retirement the main channel through which employment in the sector will be reduced. In the case of younger employee cohorts, Oei et al. (2020) show that in the German case, these individuals were set to change their profession. Studies speak of several other policy interventions that were implemented to ease the transition and limit the adverse impacts. In the case of Poland these interventions included: the establishment of a mine restructuring company which provided a safety net for workers transitioning from coal to new jobs; pre-retirement and welfare allowance benefits; and mining social welfare packages (Sniegocki et al., 2022).

Organised labour has an impact on the manner in which the transition proceeds. Bruha et al. (2005) looked at how organised labour impacted on the reorganization of two coal mining regions in the 1990s – Ostrava in the Czech Republic and Jiu Valley in Romania. The Jiu Valley reorganisation was delayed until 1997, and was then followed by a significant number of layoffs over a two-year period. In contrast, the Ostrava region underwent progressive restructuring from the beginning – in the early 1990s – under similar external conditions. The study carried out a quantitative analysis that takes into consideration the productivity of the mine, the state of the labour market, and limitations on paying the dismissed miners. Bruha et al. (2005) demonstrated the ineffectiveness of the Jiu Valley restructuring delay by demonstrating how a progressive reorganisation with compensation would have benefited both the government and the miners. Consistent with their history of militancy, the Jiu Valley miners' protest restructuring was the main cause of the delay. Carley et al. (2018) discuss how, in the United States case, coal jobs were highly unionised and high paying, and thus given the nature of these jobs, there was little incentive for these mono-industry regional economies to diversify and foster entrepreneurship. This, in turn, made it difficult for the communities in these regions to adapt to shocks, given the lack of alternative employment opportunities.

Initial labour market impacts of the transition are adverse and strong, and while regional economies do recover, the recovery process is lengthy, and these economies do not return to their pre-transition condition. Studying the Polish transition in the 1990s, Sokołowski et al. (2022) show that the labour market transition pathways available to miners are subject to the state and structure of the broader economy at a point in time. They show that job opportunities for miners were scarce between the 1990s and 2000s. Coal phase-out decreased miners' labour market prospects as the industries that offered similar jobs (manufacturing and construction) were also struggling. However, this reversed in the 2010s when prospects improved. Industries such as manufacturing and construction expanded during that period, thereby increasing the set of alternative employment opportunities for those previously engaged in mining. In the UK case, Beatty et al. (2007) provide evidence that after substantial jobs losses between 1981 and 2004 in the English and Welsh coal fields, these regional economies experienced economic regeneration with the number of male jobs increasing by 180 000. However, while Beatty et al. (2007) note that some former coal fields have more than made up for the loss of mining jobs, they further note that many of these new jobs were less well paid and often less secure compared to jobs in the mining industry.

However, there are also cases where the economic recovery is, at best weak, and the adverse employment effects appear to remain for some time. Haney and Shkaratan (2003) evaluated the effects of mine closure on Romanian, Russian and Ukrainian towns that had undergone significant labour reductions in the mining industry at least five years prior in 1997. They show that even five or more years after the local mining workforce has been reduced, the issue of employment remains one of the gravest and most enduring effects of mine closure. The mining towns in all three country case studies share both the difficulty in providing sufficient quantity of jobs, as well as jobs of suitable quality. Jobs paying what is deemed a living wage proved to be scarce in all three local labour markets. The fundamental state of these local labour markets resulted thus in significant welfare erosion for affected workers and their households. Further, the nature of work changed significantly, with a rise in informal, precarious forms of employment.

Fothergill (2017) contends that the UK case study serves as an example of how a sizeable, developed economy can transition away from coal. The UK case demonstrates that power markets can be designed to facilitate a transition away from coal. Moreover, the UK case provides an example on how layoffs in a declining coal sector can be handled in a rational and orderly manner. However, he further argued that the employment losses generated by the UK sector still caused a great deal of misery, and could have been handled better – for example, by issuing a longer notice period for the shutdown and adopting a more proactive planning approach. We also learn from the UK case that it takes time for past mining regions to experience economic recovery. The consequences persist even after former mine employees find new employment opportunities, relocate, or retire. The decline of the coal sector had a significant negative impact on the regional economy. Fothergill (2017) also stated that the UK, though arguably investing more time than any other country in coalfield regeneration, this broader project is still incomplete.

The sectoral composition of post transition employment varies across construction, manufacturing, and renewable energy. In Germany, Oei et al. (2020) observe short- and medium-term job creation in the energy-focused building refurbishment sector. Suwala (2010) shows that between 54 and 65% of the workers who lost their jobs in Poland’s coal phase-out had found new jobs outside of mining, and one-third of those interviewed had changed their profession. Sokołowski et al. (2022) find that sectoral composition of job creation after Poland’s coal phase-out was concentrated in manufacturing and construction.

The renewable energy industry emerges as a key job creation point for these transition economies. In the German case, Pegels and Lütkenhorst (2014: 529) find that 380 000 jobs were created in the renewables sector in 2012, with most of these jobs in maintenance and operation services for solar and wind installations. In terms of the creation of employment opportunities, wind outperformed solar. However, it is unclear whether the jobs that were created in the renewable energy sector were occupied by the workers who lost their jobs during the coal phase-out period. Hearer and Pratson (2015) show that while the coal industry lost 49 000 jobs between 2008 and 2012, the renewable energy sector – comprising wind, solar and gas – witnessed increased employment levels of 175 000 jobs. In quantifying the effects of the just transition, Markandya et al. (2016) find that the European Union's (EU) energy transition between 1995 and 2009 created 530 000 jobs in the region. Moreover, a third of the jobs came from spill-over effects, and 78% of countries in the sample experienced an aggregate positive effect. Furthermore, Fragkos and Paroussos (2018: 935) find that the EU's renewables expansion would lead to the net creation of 200 000 direct jobs in energy sectors by 2050. The newly created jobs are located in the construction of solar photovoltaics, the supply and production of advanced biofuels, and the manufacturing and installation of wind turbines; whereas destroyed jobs are in conventional energy supply sectors: especially in coal mining, refineries, and refuelling stations. In the Netherlands, the transition to renewable energy may create 50 000 new full-time jobs by 2030 (Bulavskaya & Reynès, 2018: 528).

The transition process is faced with a matching problem, where those who lose their jobs in the coal sector face a number of barriers to being absorbed into other sectors and/or new employment opportunities in the renewables sector. Lewandowski et al. (2020) detail that coal mining employees in Poland are considered relatively low-skilled with lower-than-average education attainment, compared to many other sectors, which suggests a potential skills shortages as former coal miners transition to other sectors. In the UK case, Beatty and Fothergill (1996) found proof of "hidden unemployment", where despite the job loss, the official unemployment rate remained stable in the English and Welsh coalfield regions. Assuming the standard definition of the unemployed – willing, able and searching – is applied, then this suggests that coal mine workers may have simply left the labour market as there were no realistic employment opportunities available to them – hence, not being picked up in the unemployment statistic. These workers may have been presented with no realistic employment opportunities because their skill set did not match those required by jobs in other sectors of these regional economies. Both Behrens et al. (2014) and Rodríguez-Huerta et al. (2017) suggest that the energy transition will create jobs that require higher levels of education and different skill sets.

Therefore, a key challenge in the just transition debate is the matching problem, where the *match rate* – the rate at which those who lose their jobs in the coal industry are matched to other employment opportunities – is low. Ultimately, policy emerging from the just transition should aim to push up the *match rate* for coal sector workers.

2.2.2 Studies focused on the South African labour market

South Africa's national dialogue on just transitions is one of the most advanced in the world (WRI, 2021). However, it is complicated by two factors: the country's high level of coal dependence, and the high unemployment rate. Coal provides a critical and inexpensive input for electricity generation, a source of export revenue, as well as jobs in mining, at power stations, and in transportation. It accounts for around 90% of South Africa's electricity generation (Cahill, 2020; Strambo et al., 2019; WRI, 2021), and 30% of all fuel production in South Africa (Stacey, 2022). In fact, South Africa is the most carbon-intensive electricity producer. Furthermore, in coal mining areas, households make use of coal directly for heating and cooking (Burton et al., 2018). The just transition will therefore have far-reaching macroeconomic consequences, affecting even transport costs and inflation.

Currently, South Africa has implemented three instruments in order to achieve its climate policy targets: A carbon tax, a carbon budgets system, and the Integrated Resource Plan (IRP) for the electricity sector. Although these instruments provide incentives for decarbonisation, they have not impacted on coal extraction directly, or addressed the socio-economic risks of emissions reductions (Burton et al., 2019). Following the National Development Plan (NDP) chapter that provided proposals for a framework to ensure environmental sustainability and an equitable transition to a low carbon, climate resilient economy and society, the National Planning Commission launched the Social Partner Dialogues on Pathways for a Just Transition. The aim of this was to build a consensus on a vision for a just transition by 2050[4], through a series of discussions between civil society, businesses, government, labour unions, communities, and experts (NPC, 2019). Furthermore, a Sector Jobs Resilience Plan (SJRP) is being developed to analyse the impact of decarbonisation on employment and the coal value chain.

Understanding the labour market implications associated with the transition is thus undoubtedly important – and arguably one of the key factors shaping short-term policy choices by the South African government in respect of the transition away from fossil-based energy. However, current research in this area – whilst rich in terms of the climate consequences of coal product and usage – is fairly thin and arguably empirically poor in providing a robust empirical analysis of the number and types of jobs, households and communities, that would be deleteriously affected by this shift to clean energy.

In terms of the coal industry, specifically, a number of challenges exist in quantifying the size and shape of the labour market associated with this industry: Firstly, there are various estimates of aggregate employment in the coal mining industry but in a number of instances these estimates differ across data sources, often with minimal information regarding how authors arrive at these numbers. For example, Statistics South Africa's Mining Industry Report provides an estimate of 108 717 employees in the coal mining industry in 2019 (Statistics South Africa, 2021a), which is 14 420 more than the corresponding estimate provided by the Minerals Council of South Africa in their 2019 Facts and Figures Report (Minerals Council of South Africa, 2020).

Secondly, while employment numbers of the coal mining industry are available, measures of employment for the broader coal value chain are sparse, and where present, little detail is provided. The World Resource Institute (WRI) states that in 2019, the coal value chain

[4] PWC: It is to be noted that South Africa's strategy is not to eliminate coal entirely, but to see no new power plants built after 2030 and four-fifths of capacity closed by 2050.

employed up to 200 000 workers in South Africa's coal mines, coal power plants and coal transport – but without the primary data source being referenced. Further investigation indicates that these estimates are most likely taken from research conducted by the Trade and Industrial Policy Strategies (TIPS) research institution (Makgetla et al., 2019; Patel et al., 2020; Makgetla et al., 2021). These papers provide a quantification of jobs in the coal value chain. They do, however differ. For instance, Patel et al. (2020) quantify employment in the coal value chain in 2018, stating that coal mining accounts for 80 000 jobs, coal-fired power generation (Eskom) accounts 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.[5]

Thirdly, existing labour market information is primarily focused on the measurement of aggregate employment in the coal industry, and little emphasis is placed on generating a detailed picture of the coal labour market and the socioeconomic and spatial profile of the individuals and households linked to the industry through the labour market. However, recent research has begun to profile workers in the industry. Hermanus and Montmasson-Claire (2021) provide the following details of coal industry workers: With a median age of 38 years, they are relatively young; they typically support three dependents; the majority have jobs characterised by features that constitute formal employment relationships – including retirement fund contributions, Unemployment Insurance Fund (UIF) contributions, written contracts, and permanent positions; union membership is relatively high; and education levels are slightly lower relative to other formal sector workers. Cole et al. (2023) describe the socio-economic characteristics of coal mining communities. Using Census data from 2011, they find that these communities are characterised by low levels of income, low levels of employment, and low levels of education.

Nevertheless, relatively little is known about the age, race, gender, education and income levels of the individuals linked directly or indirectly with the South African coal mining industry. The latter would seem critical – beyond pure aggregate estimates of the industry – to begin the process of crafting a just transition plan in practice.

Ultimately then, the imperative to obtain a robust empirical quantification and description of the coal industry labour market presents a key research gap within the just transition debate – one which we attempt to address in Section 6.

[5] 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.

3 The South African Coal Mining Landscape

In this section we provide an overview of the South African coal mining industry landscape. We detail the spatial distribution of both coal mining activity and coal-fired electricity production across South Africa. We then provide a description of the economic contribution of the coal mining industry to the South African economy in terms of gross value-added and exports. The discussion in turn informs our empirical approach, discussed in Section 4.

3.1 Spatial distribution of coal mining and coal-fired electricity production

The South African coal mining industry is concentrated within the Mpumalanga regional economy. Table 1 details the provincial distribution of coal mining activity in South Africa. It is evident that of the 78 operating mines in South Africa, 65 (or 83%) of all these mines are located within the Mpumalanga province. This can also be observed by the black circular markers denoting the location of these mines in Figure 1. In turn, these 65 mines also account for approximately 80% of total coal production. The next highest contributor is a single coal mine in Limpopo, which accounts for 9.9% of total production. The coal mining industry is also concentrated within five mining companies – Seriti, Sasol, Exxaro, Thungela and Glencore – which together account for 77% of all coal production (Cole et al., 2023).[6]

Table 1: Spatial Distribution of Operating Coal Mines in South Africa

Province or Municipality	No. of mines	No. of companies	Total annual production (Mt)	Share of total SA production (%)	Life of mine (Years)		
					Mean	Median	Max
Free State	2	2	19.7	7.3	19	19	19*
Gauteng	2	1	2.8*	1.0	10	10	14
KwaZulu-Natal	8	7	4.1	1.5	17	16	25
Limpopo	1	1	26.9	9.9	20	20	20
Mpumalanga	65	33*	217.4	80.3	11	14	50
Emalahleni	18	13	84.8	31.3	13	11	30
Govan Mbeki	6	3	31.9	11.8	20	25	30
Msukaligwa	3	3	2.4*	1.1	..	..	..
Steve Tshwete	13	10	41.7	15.4	9	7	23
Victor Khanye	11	8	32.0	11.8	15	8	50

[6] Although there are five dominant mining companies, there are approximately 39 other mining companies. Cole et al. (2023) note that these are junior or emerging mining companies operating relatively short-life mines.

Other	14	16	24.7	9.1	17	20	25
Total	78	44*	270.9	100.0	15	13	50

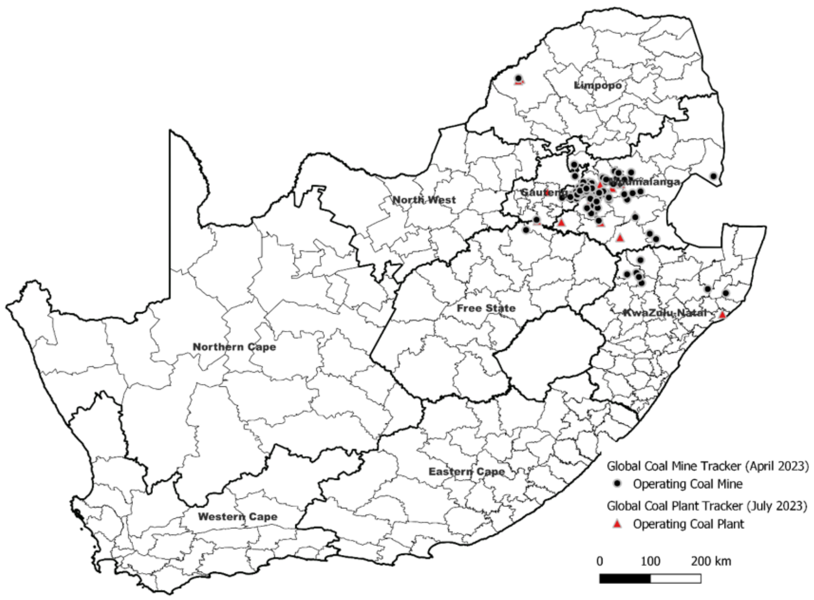
Source: Global Energy Monitor (2023a)

Notes: Other refers to mines located in the other local municipalities within the Mpumalanga province. Number of companies in Mpumalanga local municipalities exceeds that of province due to mining companies operating multiple mines. Asterisks indicate missing data when compiling the aggregate or an approximation based on existing data.

The spatial distribution of mines within the Mpumalanga province is further concentrated within several local municipalities that are located in the western parts of the province. Within the Emalahleni, Govan Mbeki, Msukaligwa, Steve Tshwete and Victor Khanye local municipalities, reside 18, 6, 3, 13 and 14 coal mines, respectively. Together, mines within these five local municipalities account for approximately 70% of coal mine production in South Africa.

While exhibiting cross-region heterogeneity, the average life of mine for coal mines in South Africa is approximately 15 years. The median life of mine of 13 years suggests that there are a small number of mines with relatively high expected life of mine values driving up the average. The maximum life of mine for a given mine within each of the locations listed in Table 1 provides a range of 14 years for a mine in Gauteng, to 50 years for a mine in Mpumalanga. Taking the mean and media life of mine value together, we can expect that a large number of coal mines are set to close within the coming decade and a half. However, as suggested by Cole et al. (2023), it can be expected that mines will extend their lives. Further, the Global Energy Monitor data lists 36 proposed coal mine projects, in the form of mine extensions or entirely new mines, which can be expected to generate a combined annual output of 117 million tons.

Figure 1: Spatial location of coal mines and coal-fired power plants in South Africa

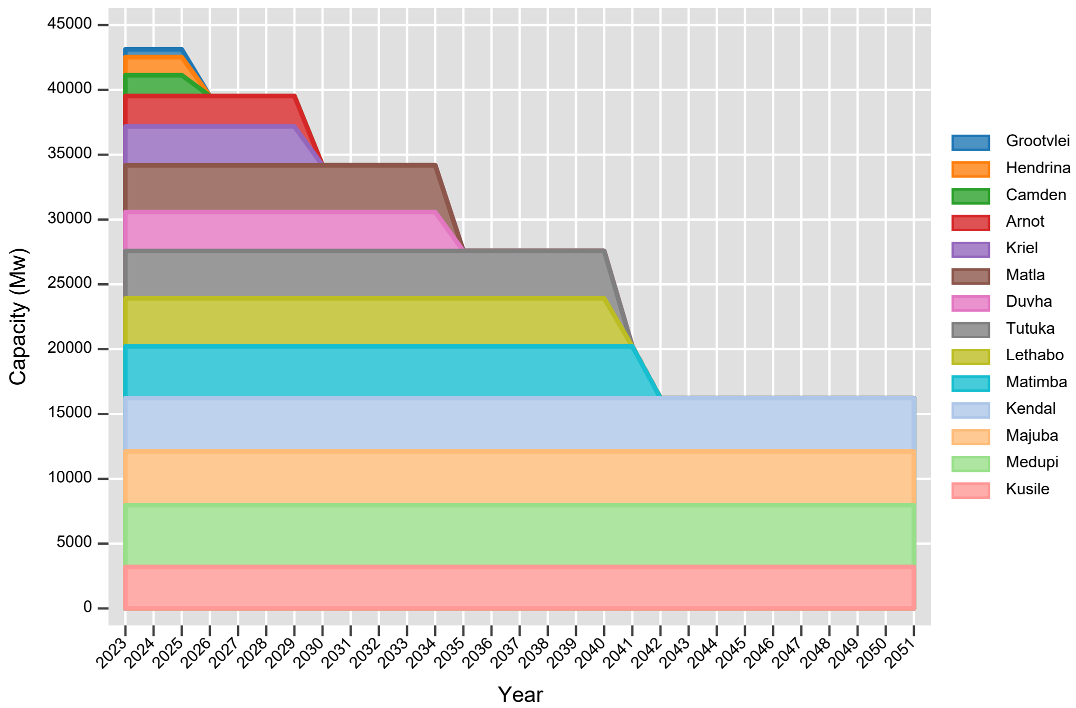


Source: Global Energy Monitor (2023a; 2023b)

Given the spatial concentration of coal mines, coal-fired power production is also concentrated in the Mpumalanga regional economy. Of the 14 coal-fired power plants operated by the national utility, Eskom, 11 are located within the Mpumalanga province. This corresponds with 70% of Eskom's total coal-fire powered operating capacity. We depict this spatial concentration in coal-fired power production denoted by red triangle markers in Figure 1. Many of these power plants are located in the same municipalities where one finds many of the coal mines – such as the Emalahleni and Steve Tshwete local municipalities.

South Africa has an aging coal fleet, with large shares of the fleet set to be phased out in the coming decade and a half. A number of the Eskom operated coal-fired power plants, such as Grootvlei, Hendrina, Camden, Arnot and Kriel, were constructed in the 1970s. As such, these power stations, accounting for 21.5% of current coal-fired production, are set for retirement by 2030 – less than a decade away. Matla and Duvha power stations are set to retire by 2034, which mesans that over a third (36.6%) of the national utility's coal-fired power production will be retired in just over a decade (12 years). By 2040 – in just over 15 years – approximately half (53.5%) of the coal fleet is set to be retired. We depict this retiring of coal-fired power plants over the coming decades in Figure 2. Thus, by virtue of the lifespan of these coal-fired power plants, there is a natural endogenous transition that is already underway.[7] (See details in Table A 1)

Figure 2: Planned retiring of coal-fired power plants



Source: Global Energy Monitor (2023b) and adapted from Cole et al. (2023).

[7] This natural endogenous transition is working in conjunction with the 'forced', or regulated, exogenous transition to renewables.

Two important points emerge from the spatial description of the coal mining industry and the coal-fired power plant industry: First, these industries are spatially concentrated within the Mpumalanga province, and thus the labour market analysis to follow is centred on this locality. The Mpumalanga province is one of South Africa's nine provinces, and one of two provinces where the mining sector is the largest sector in terms of contribution to provincial GDP (Box 1 provides a brief discussion on the Mpumalanga province's relative economic contribution to the national economy). Second, many of these mines and power stations are set to retire, or close, within the next decade and a half. The fact that this natural, or endogenous, transition is already underway means that the labour market transition and the explicit socio-economic challenges that this engenders are, in one sense, already emerging.

Box 1: Relative Contribution of Mpumalanga Provincial Economy

Mpumalanga is one of South Africa's nine provinces. In terms of its contribution to national gross domestic product, Mpumalanga is the 5th largest provincial economy, accounting for 7.4% of national GDP in 2019 (see Appendix Table A 2). The province's relative contribution to national GDP lies behind the three economic powerhouse provinces – Gauteng (33.8%), KwaZulu-Natal (16.5%) and Western Cape (14.2%) – and is almost on par with the Eastern Cape, which accounts for a similar share of national GDP (7.9%).

The Mpumalanga province accounts for 7.7% of national aggregate employment in 2019, and is thus the 6th largest province in terms of employment share – behind Gauteng (27%), KwaZulu-Natal (18.5%), Western Cape (12.1%), Eastern Cape (11.2%) and Limpopo (9.8%) (see Appendix Table A 2). The province has one of the highest unemployment rates sitting at 34.4% in 2019. Only the Free State (34.7%) and Eastern Cape (37.2%) provinces have higher unemployment rates.

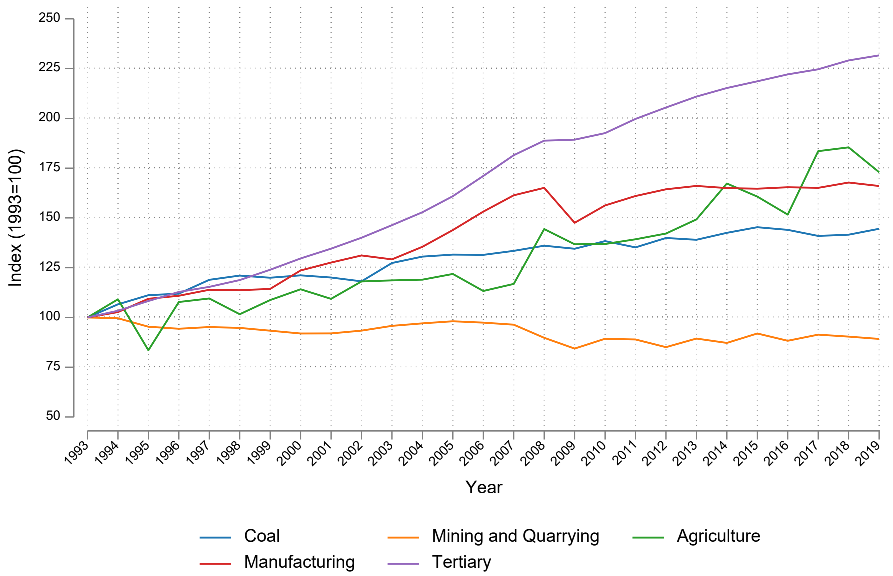
Mpumalanga is one of the four big mining provinces, where the mining sector is either the largest contributor to regional GDP – Mpumalanga (17.3%) and North West (22%) – or the second largest – Northern Cape (16%) and Limpopo (18.1%) (see Appendix Table A 3). With mining being a capital-intensive economic activity, the sector's contribution to provincial employment, while substantial, is relatively less pronounced than its contribution to GDP in these provinces – e.g. Mpumalanga (6%), North West (13.6%), Northern Cape (9.1%) and Limpopo (6.3%).

3.2 Economic footprint of coal mining industry in South Africa

The coal mining industry is a core component of the South African mining sector, and its relative importance has increased since the early 1990s. The coal industry accounts for approximately 20% of gross value-added (GVA) generated by the mining and quarrying sector. The coal industry's relative contribution to the mining sector has also grown since 1993, from accounting for approximately 13% of the mining sector's GVA in 1993, to about 20% in 2019.

The coal industry's expanding relative contribution is consistent with its growth, outpacing that of the rest of the mining and quarrying sector. This is evident in Figure 3, where the GVA index for the coal industry depicts growth (blue line in Figure 3), while the rest of the mining and quarrying industry has experienced declining growth (orange line in Figure 3). This pattern is consistent with the rising relative economic contribution of the coal mining industry and the declining relative contribution of the broader mining sector since the early 1990s. It is important to point out that the coal industry's growth over the period is by no means impressive. For instance, the South African manufacturing sector (red line), which is experiencing secular decline, grew faster over the same period (Bhorat et al., 2022).

Figure 3: Growth of value-added by industry



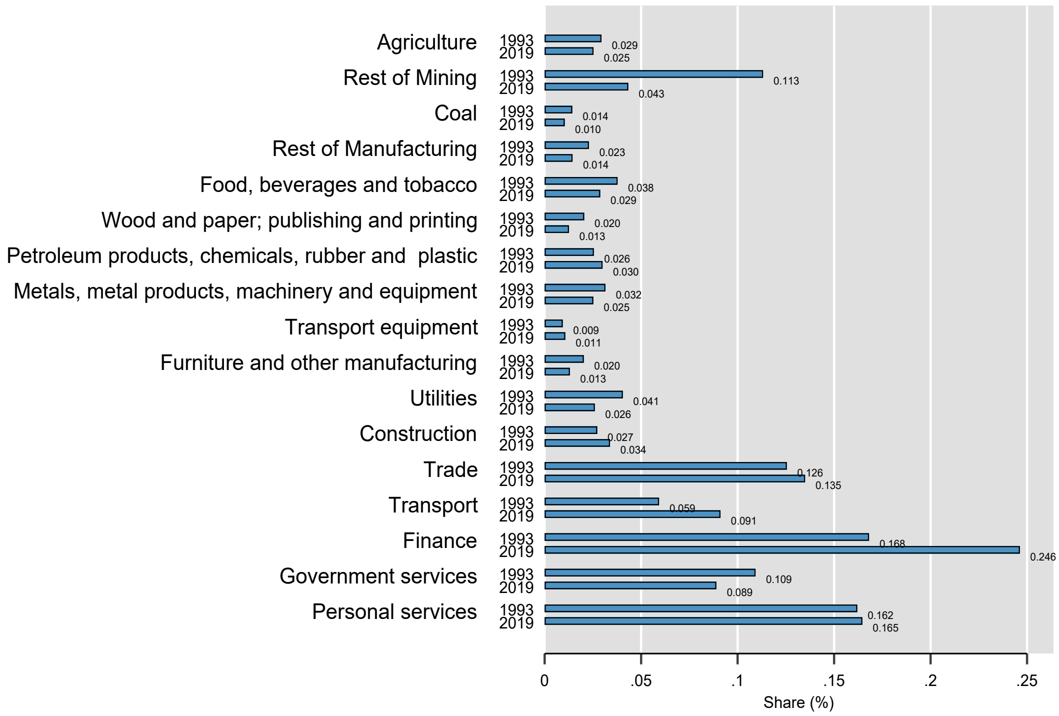
Source: Statistics South Africa (2022)

Notes: Value-added series reported in constant 2015 Rand indexed to 1993=100.

In relation to the broader South African economy, the coal mining industry's contribution to output is relatively small. In Figure 4 it is evident that the coal industry accounts for approximately 1% of gross value-added (GVA) in the South African economy in 2019 – down from 1.4% in 1993.[8] Over the period 1993 to 2019, the coal industry's share of GVA ranges between 1 and 1.5%. For a comparative perspective, in 2019, manufacturing industries, including food, beverages and tobacco; wood and paper; petroleum products, chemicals, rubber and plastics; metals, metal products and machinery and equipment; and the transport equipment industries, contributed 2.88, 1.26, 3.0, 2.52, and 1.07% to GVA, respectively. These manufacturing industries – key drivers of a country's industrialisation pathway – contribute substantially larger shares of GVA than the coal mining industry.

[8] More detail on industry contributions to gross value added in South Africa are provided in Appendix Table A 5.

Figure 4: Industry Contribution to Gross Value Added, 1993-2019



Source: Statistics South Africa (2022)

However, the coal mining industry's economic contribution is felt more acutely in its linkages to other sectors of the economy – particularly key components of South Africa's industrial structure that fall along the coal value chain. As noted by Bulmer et al. (2021), 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. Makgetla et al. (2019) state that in 2018, coal mining employed approximately 87 000 employees, Eskom's power generation workforce numbers approximated 12 000 employees, and Sasol employed approximately 26 000 workers in South Africa. Makgetla et al. (2019) show that the downstream users of coal include electricity generation (62%), petrochemicals (Sasol) (23%), general industry (8%), and Metallurgical industry (Mittal).

Coal production is ultimately destined for both the domestic and export markets, with the former being the largest in quantity terms. Given that approximately 83% of South Africa's electricity production comes from coal-fired power plants, and that coal feeds into a number of other industries (including downstream chemical applications), the domestic market is a large source of demand for coal mined in South Africa. As shown in Table 2, in quantity terms, the domestic market accounted for 74% of coal sales in 2019, and this market share has been relatively constant, averaging 72% since 1998. The export market accounted for 27% of the volume of coal sales in 2019, and this share has averaged 28% since 1998. The relative importance of the export market is more apparent when looking at coal sales in value terms. While in 2019 the export market accounted for 40% of coal sales – still relatively high in relation to domestic market sales – the average for the period 1998 to 2019 sits at 53%, with a high of 61% in 2001.

The values of coal sales are driven by price. It is evident in Table 3 that in quantity terms the growth of coal sales has been relatively stagnant. Over the period 1998 to 2019, domestic market sales grew at 1% per annum, while export market sales grew at 0.2% per annum. Over the same period, prices (unit values) grew at 10.2 and 8% per annum, in the domestic and export markets, respectively. This corresponds more closely with growth in coal sales in value terms of 11.3 and 8.2% per annum, respectively.

Table 2: Coal industry sales to domestic and export markets, price, value and quantity measures

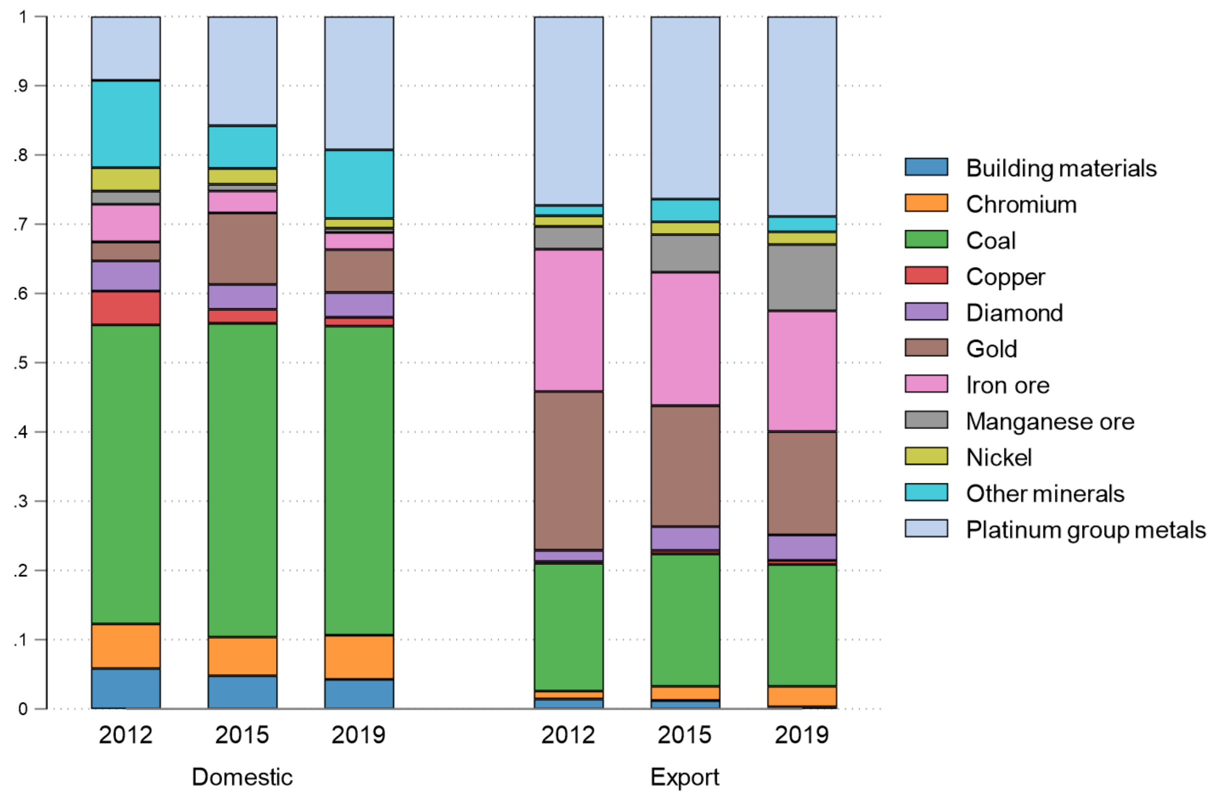
	Level			Share			Average Annual Growth Rate		
	1998	2008	2019	1998	2008	2019	1998-2008	2008-2019	1998-2019
Quantity (mass in kt)									
Domestic	156 814	197 033	194 818	0.700	0.765	0.735	0.021	-0.001	0.010
Exports	67 089	60 631	70 293	0.300	0.235	0.265	-0.009	0.012	0.002
Total	223 903	257 664	265 111				0.013	0.002	0.008
Unit value (R/t)									
Domestic	52	153	442				0.103	0.092	0.102
Exports	146	737	788				0.159	0.006	0.080
Value (R millions)									
Domestic	8 218	30 104	86 040	0.456	0.402	0.608	0.125	0.091	0.113
Exports	9 806	44 706	55 368	0.544	0.598	0.392	0.148	0.018	0.082
Total	18 024	74 810	141 408				0.138	0.054	0.098

Source: Department of Mineral Resources and Energy (DMRE) (2020)

Notes: Extracted from DMRE Statistical Bulletin Table B1.

As such, coal is a key mineral commodity in the South African economy. Coal accounts for the largest share of domestic commodity sales. In Figure 5 we observe that coal accounted for between 43 and 45% of domestic commodity sales – the next highest being platinum group metals, accounting for 19.3% of commodity sales in 2019. Coal's relative share in export sales of commodities is substantial but relatively less extreme compared to its domestic share. Coal sales account for 17.6% of export sales in 2019. Iron ore, gold and platinum groups metals also account for relatively larger shares of export markets sales, sitting at 17.4, 14.9 and 28.9%, respectively.

Figure 5: Mineral contribution to mining sector sales



Source: Statistics South Africa (2021a)

Coal is an important source of export revenue. In Table 3 we present export levels, shares and growth for South Africa's top 10 export products (at the HS 4-digit level) and sector aggregations. In 2019, coal was South Africa's fifth largest source of export revenue, accounting for 4.8% of South Africa's total merchandise exports. Notably, this is down from 6.5% in 1998, where coal was South Africa's fourth largest source of export revenue. Coal is exported extensively to the following destinations: India (29.51%), Pakistan (20.48%), China (9.44%), South Korea (5.68%) and Taiwan (3.57%) (Growth Lab at Harvard University, 2023). In terms of growth, coal exports have grown at 5.3% per annum over the period 1998 to 2019. We observe that coal exports have underperformed relative to all other top 10 products (apart from diamonds), and relative to the rest of the mining sector (6.3% p.a.), the agriculture sector (6.1% p.a.), commodity-based manufacturing (8.5% p.a.) and non-commodity-based manufacturing (6.8% p.a.), and aggregate exports (6.8% p.a.).

Table 3: Coal export performance relative to other sectors and top 10 products, 1998-2019

Product/sector	Levels (USDm)		Shares		Growth (%p.a.)
	1998	2019	1998	2019	1998-2019
Top 2019 HS 4-digit products					
Gold	2 234	12 263	0.094	0.120	0.080
Platinum	1 698	9 589	0.071	0.094	0.082
Iron ores and concentrates	494	7 137	0.021	0.070	0.129
Cars	246	7 116	0.010	0.070	0.165
Coal	**1 553**	**4 883**	**0.065**	**0.048**	**0.053**
Diamonds	2 000	4 194	0.084	0.041	0.034
Ferroalloys	898	3 235	0.038	0.032	0.060
Motor vehicles for transporting goods	140	3 101	0.006	0.030	0.151
Manganese > 47% by weight	110	2 873	0.005	0.028	0.160
Chromium ore	90	2 058	0.004	0.020	0.153
Sector					
Agriculture	2 737	9 995	0.115	0.098	0.061
Mining (less coal)	7 848	30 131	0.330	0.295	0.063
Commodity-based manufacturing	3 793	22 829	0.159	0.223	0.085
Non-commodity-based manufacturing	7 826	33 480	0.329	0.327	0.068
Total	**23 807**	**102 247**			**0.068**

Source: Growth Lab at Harvard University (2019)

To summarise, while the coal mining industry may account for a relatively small share of overall GVA in the South African economy, the industry's footprint is felt more acutely in being an important source of export revenue and its many linkages with the broader coal value chain that encompasses the power generation and the downstream chemicals industries, to name but two.

4 Empirical Approach: Defining the Scope

In this section, we first briefly describe the coal value chain in South Africa. We then lay out constraints to measuring the quantum of employment across the entire coal value chain. In light of these constraints, we then detail the industry and spatial parameters that inform the boundaries of our analysis.

4.1 The South African coal value chain

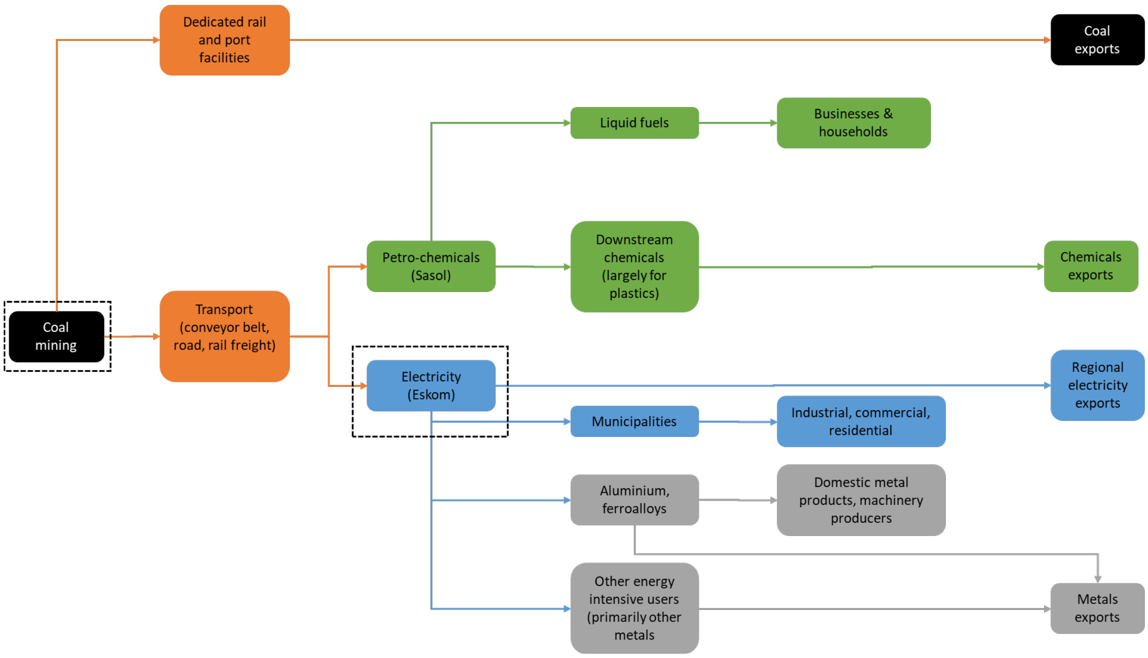
While this study is focused on understanding the nature and extent of employment in the coal mining industry, it is worth positioning the coal industry within its broader value chain. As a result of coal fuelling most of the South African electricity grid, the coal mining sector is at the centre of an extensive value chain.[9] We present the broad outlines of South Africa's coal value chain in Figure 6. There are four types of activities that comprise the coal value chain: power generation (blue), petro-chemicals (green), metals (grey) and transport (orange).

Approximately 25% of coal production is exported, with the remainder feeding domestic industries (Eskom, 2021). Power generation is dominated by the national utility, Eskom, which uses 53% of non-exported coal to supply power to businesses and households directly, as well as indirectly via municipalities. A small share of electricity production (7%) is exported, with the majority supplied to the Mozal aluminium smelter in Mozambique (Patel et al., 2020). The petrochemicals industry, and in particular, Sasol's coal-to-liquid fuel plant, uses 33% of non-exported coal (Eskom, 2021). The industry is further linked to other downstream chemicals producers, which are further linked to export markets. The metals industries, including producers of aluminium and ferro-alloys, such as ArcelorMittal, as well as other energy-intensive metals producers, service both domestic and international markets, and account for 12% of non-exported coal (Eskom, 2021). Further, given that the majority of electricity in South Africa is produced using coal, every electricity-dependent industry is ultimately linked to the coal value chain, to some degree.

The coal value chain represents an important set of interconnected industries that are linked to the coal mining industry. As such. shocks emerging from the coal mining industry driven by the transition away from fossil fuels are likely to have widespread ramifications across the labour market. Policy making with respect to ameliorating the impact of this transition is thus reliant on a detailed understanding of the characteristics of these workers and their employment, which requires robust analysis of good quality data.

[9] Approximately 80.1% of electricity produced in 2022 is produced using coal (Pierce & le Roux, 2023).

Figure 6: The coal value chain in South Africa



Source: Adapted from Makgetla and Patel (2021: 15)

However, robustly measuring the quantum and characteristics of all those employed across this value chain is, for the most part, not feasible. This is primarily due to the difficulty faced in identifying these workers in labour force survey datasets. Further, as we discuss below in Section 5, such analysis requires one to isolate very specific types of industries in specific geographical areas in datasets that are not necessarily designed to support this. For example, identifying workers linked to the manufacture of downstream chemical products that use feedstock chemicals manufactured using coal-intensive upstream processes, by Sasol for instance, is hard to achieve using labour force survey data. Even if one is able to accurately identify these workers in the data, it is likely that the analysis will still suffer from small sample bias. In other instances, the level of aggregation of the labour force survey data is inadequate. For example, in the case of coal truck drivers, such individuals would fall within the SIC code capturing *Other land transport (SIC712)*. However, within this 3-digit SIC category workers involved with freight transport by road are lumped together with minibus taxi drivers, safari drivers, transporters of furniture, etc.

The analysis in this paper uses industry and spatial dimensions to guide us on what elements of this value chain can be robustly measured and analysed using existing publicly available data. We now turn to discussing these dimensions.

4.2 Industry dimension

The industry dimension allows us to pinpoint parts of the coal value chain that we can focus on, and link to labour force survey data (discussed below). For this study we focus on two parts of the value chain that can be robustly measured – we use black dotted borders to denote these industries in Figure 6.

We first measure what can be termed direct employment. These are workers engaged in coal mining activity, and include workers spread across a variety of occupations. These can include individuals engaged in managerial, professional occupations, craft and related trade, and plant, machine operator occupations, and the like. The household survey data employed in our analysis assigns a worker's industry of employment according to the Standard Industrial Classification (SIC) nomenclature. In the case of coal industry workers, the appropriate industry code is *SIC210: Mining of coal and lignite*.[10]

We then measure a subset of indirect employment indirectly related to the coal sector, and which thus forms part of the broader coal value chain. More specifically, we measure the quantum of employment linked to the generation of electricity. The appropriate industry code capturing such employment is *SIC411: Production, collection and distribution of electricity*. Given that we want to measure an element of employment indirectly linked to the coal sector, we want to measure employment associated with coal-fired electricity production. We only measure electricity production in the Mpumalanga province because all the power stations operated by the national utility in the province are coal-fire powered. We are thus able to focus on electrical utility employees linked to coal-fired power production and thus an element of the coal value chain. The same cannot be applied to other provinces since these provinces either don't have coal-fired power stations, such as the North West province, or power is produced using an alternative energy sources – for example, nuclear, gas and wind in the Western Cape, solar in the Northern Cape, and wind and hydro in the Eastern Cape.[11]

One concern with using the SIC411 code is that it does not distinguish between the energy source used to generate electricity. It is thus possible that a worker who is assigned this industry code may be engaged in electricity production that uses an energy source other than coal – for example, nuclear, hydro, or renewables. However, given the concentrated spatial location of the coal mines and coal-fired power plants – which we discuss further below – we can be reasonably assured that our measurement of workers engaged in electricity production are those engaged in coal-fired electricity production.

It is worth noting that in existing employment estimates of the coal value chain, these two industries constitute the bulk share of employment. For example, drawing on estimates from Hermanus and Montmasson-Claire (2021), approximately 68% of employment falls within these industries. Thus, by focusing on these two industries, we are measuring a large segment of the coal value chain and arguably, the segments that are most likely to experience the most acute transition related shocks, and thus, those that require the greatest investment to ameliorate the impacts of the transition.

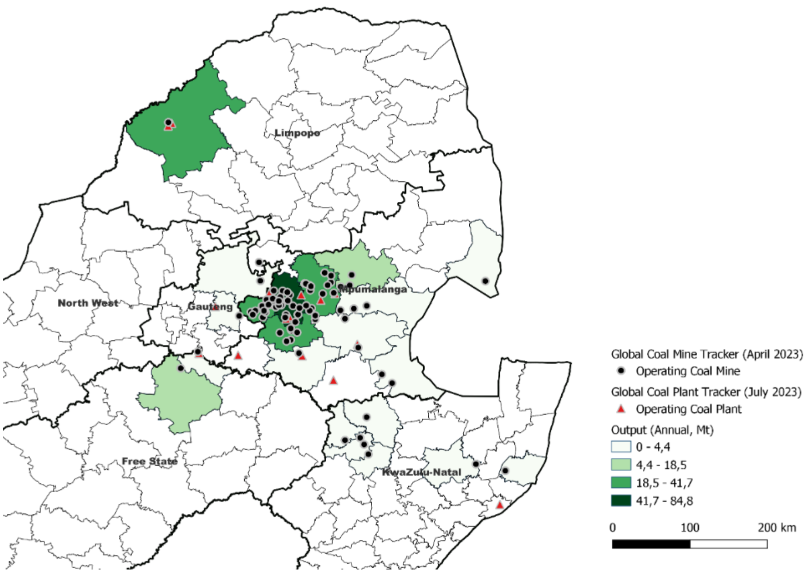
[10] We use the 3-digit SIC code because it balances the twin objectives of sufficient industrial aggregation, while ensuring as large a sample size as possible.

[11] Appendix Figure A 1 provides a map showing the spatial location of power stations operated by the national utility, Eskom, and the type of power source used. This confirms our assertions regarding coal-fire powered stations being concentrated in the Mpumalanga province, and that the energy mix in other provinces is relatively more diverse and not coal based.

4.3 Spatial dimension

The second dimension, which we use in combination with the industrial dimension, is the spatial dimension. Although the study examines the broader South African coal sector, the focus of the analysis is directed toward the coal mining industry (SIC210) and the electricity production industry (SIC411) in the regional economy of Mpumalanga. This is motivated by the following: First, the coal mining sector is heavily concentrated within the Mpumalanga Province. The coal industry in Mpumalanga accounts for 87% of South Africa's total coal production (Cole et al., 2023), approximately 86% of coal industry employment (see discussion below), and 53 out of South Africa's 66 coal mines (Cole et al., 2023). Second, coal-fired power production is also concentrated within the Mpumalanga Province. We note that of South Africa's 16 coal-fired power plants, 12 are in Mpumalanga, and these account for approximately 80% of electricity generated from coal-fired power plants (Cole et al., 2023). This agglomeration of coal mines and coal-fired power plants is illustrated in Figure 7. Third, we note that this coal mining and coal power generation is heavily concentrated within five municipalities within the Mpumalanga Province — eMalahleni (Witbank), Steve Tshwete (Middelburg), Govan Mbeki, Victor Khanye and Msukaligwa (Ermelo).[12] In Figure 7, these five spatial localities are those shaded in dark green.[13] In these five municipalities the industry is critical to those workers, their dependents, and the broader communities (Cahill, 2020; Strambo et al., 2019; WRI, 2021).

Figure 7: Spatial distribution of coal output, mines and power stations in South Africa



Source: Global Energy Monitor (2023a; 2023b)

[12] A vulnerability assessment performed by Patel et al. (2020) lists these municipalities as the most vulnerable to the decline of the coal value chain.

[13] These four municipalities have the largest number of observations in the 2011 Census where the surveyed individuals have stated that they are employed in the coal sector (SIC210) – consistent with higher coal sector employment in these localities.

4.4 Measurement focus

Therefore, the analysis in Section 5 estimates the quantum of jobs in, firstly, the South African coal industry (SIC210), and secondly, the coal industry in the Mpumalanga province. We also measure the quantum of jobs related to coal-fired electricity production (SIC411) in Mpumalanga. We estimate a set of employment ranges for these two industries by consulting a set of reliable publicly available datasets – we detail these datasets in Section 5. The analysis also explores the individual (e.g. age profile, education attainment), job (e.g. occupation profile, employment benefits), and household (e.g. number of dependents) characteristics of workers found in these two industries in the Mpumalanga province.

5 Data

In this section we detail the data sources used in the analysis. We discuss data limitations, the implications of these limitations, and our approach to dealing with these limitations.

5.1 Data sources

To provide a robust estimate of the quantum of jobs linked to the coal mining sector and coal-fired electricity production, we draw on several publicly available data sources – summarised in Table 4. These datasets fall into two groupings defined by their unit of analysis: First, we employ individual and household level information taken from household survey datasets. To derive a long-run quantification of coal industry employment, we draw on the Post-Apartheid Labour Market Series (PALMS). The PALMS dataset, developed by Kerr, Lam and Wittenberg (2019), is a harmonised series of South African household survey data for the years 1994 through 2019. The original data for the series are based on nationally representative, cross-sectional household surveys conducted by Statistics South Africa, and comprise three survey instruments: the October Household Surveys (1994-1999), Labour Force Surveys (2000-2007), and Quarterly Labour Force Surveys (2008-present). In the household surveys and Census the employed refers to all the respondents who reported engaging in employment activities in the week preceding the interview. These data provide a continuous uninterrupted series of employment estimates for both the coal mining industry (SCI210) and coal-fired electricity production (SIC411), for the period 1994 to 2019. We also use the three iterations of the South African Census to generate employment point estimates for the periods 1996, 2001 and 2011.[14]

[14] The OHS, LFS and QLFS were analysed using Post-Apartheid Labour Market Surveys (PALMS) data and weighted using cross entropy weights. This makes use of reweighted South African national household survey data to create a consistent series over time (Branson & Wittenberg, 2014), because the calculated weights are similar to the initial sample weights. This means that the data retains the survey design benefits.

Table 4: Data Sources

Publication	Source	Type of survey	Unit of analysis	Measurement objective
Post-Apartheid Labour Market Series (PALMS)	Developed by DataFirst (UCT). Harmonisation of existing household surveys conducted by Statistics South Africa.	Household	Individual	Employment estimate
Labour Market Dynamics (LMD) (2008-2019)	Statistics South Africa	Household	Individual	Individual characteristics Job characteristics
Census 10% sample (1996; 2001; 2011)	Statistics South Africa	Household	Individual + Household	Individual characteristics Household characteristics
Mining industry Report (N0201-01-02 (2009; 2012; 2015; 2019)	Statistics South Africa	Firm Census	Mine (plant)	Employment estimate
Bulletin B1/2020 Minerals Statistical tables (1998-2019)	Department of Mineral Resources and Energy (DMRE), Mineral Economics	..	..	Employment estimate

Second, we use industry level information that is sourced and aggregated from firm- or plant-level surveys.[15] We draw point estimates for 2009, 2012, 2015 and 2019, from the corresponding Statistics South Africa Mining Industry Report. These data emerge from mining Census', conducted every three to five years, by Statistics South Africa. The Census covers all mines that were registered for mineral rights with the Department of Mineral Resources and Energy (DMRE), and which were actively engaged in the mining industry. The mine level data from the Census' are not publicly available. However, one is able to extract industry level employment estimates from Statistics South Africa's Mining Industry Reports. Employment is defined as persons employed by a business or organisation who received payment (in salaries, wages, commission, piece rates, or payments in kind) for the last pay period ending on or before 30 June (including persons employed through labour brokers).[16] We also draw on a

[15] Given that these datasets aggregate information to the national level, we only use these data to measure employment in the coal sector (SIC210). Equivalent data for the electricity production sector (SIC411) do not report at the provincial level, which negates our ability to isolate employment in coal-fired electricity production.

[16] Employment can be disaggregated into four categories: mine employees, employees employed through labour brokers, employees of subcontractors, and capital employees.

series of point estimates, covering the period 1998 to 2019, from the DMRE's Bulletin B1/2020 Minerals Statistical Tables.[17]

The analysis detailing the individuals, job and household characteristics of those engaged in our two coal-related industries of interest, is informed by household survey data.[18] Data on individual and job characteristics is taken from the Statistics South Africa's Labour Market Dynamics data. The LMD is compilation of the four Quarterly Labour Force Surveys (QLFS) in a calendar year. We also draw on the Census (10% sample) data when detailing individual characteristics. We do not use the Census to inform our analysis on job characteristics because it does not contain the same level of detail on these characteristics as the LMD data. Data on household characteristics is taken from the Census data, for the periods 1996, 2001 and 2011.

5.2 Data limitations

When using existing household survey data, particularly data from the QLFS, to measure employment for highly disaggregated segments of the labour market, one does face the challenge of statistical representativity. At the spatial level, the QLFS is designed to allow for the measurement of labour market statistics that are representative at both the national and provincial levels. Data are also designed to be representative within provinces at the metro/non-metro levels. Within metros, the sample is representative of the four geography types that may exist within the metro: these include urban formal, urban informal, farms, and tribal. At the industry level, the QLFS data are designed to be representative at a 3-digit industry-level when estimating labour market statistics at the national level. However, this is not the case at the provincial level and municipal levels of spatial disaggregation.

Despite this, it is possible to restrict our sample to only analyse Mpumalanga without losing the generality of the data. This does not imply that it is representative, but we believe that we do not lose any information by restricting the data in this way. Typically, when we identify industries (at the 3-digit level: such as coal mining, SIC210) in the QLFS, these data are only representative at the national level, and not at the provincial level (i.e. Mpumalanga), or lower (i.e. municipal).[19] Disaggregating at lower levels would usually put the analysis at risk of small sample bias, which may produce statistically noisy results at these levels of industrial-spatial disaggregation. For example, in Table 5, the number of observations for coal mining industry workers is 83 nationally and 72 provincially in Mpumalanga. Put differently, 83 unweighted observations in data represent 76 200 workers in the coal mining industry. It is, however, worth noting that the majority of coal mining sector employees are located in Mpumalanga, making up approximately 80% of all observations for each dataset. This makes our estimates using

[17] The DMRE Bulletin does not publish any details on how these data are captured. However, one can assume that these data are aggregated from firm-level data that the DMRE captures from firms operating in the mining industry, which falls under its ministry.

[18] All household survey data accessed from the University of Cape Town's DataFirst Data Portal.

[19] Analogously, in the case of workers engaged in electricity production (SIC411) in Mpumalanga.

these data more plausible, since the disaggregated provincial-level figures result in a sample/number of observations that are close to the national level.

One approach to combating this small sample bias issue is to pool the quarterly data from the QLFS. As discussed earlier, the Labour Market Dynamics (LMD) dataset is compilation of the four Quarterly Labour Force Surveys (QLFS) in a calendar year. This pooled dataset provides a larger sample, thus providing a higher degree of statistical strength for our estimates. By making use of the LMD, we are able to increase the QLFS observations from 84 to 315 at the national level, and 72 to 272 at the Provincial level.

However, it is important to take note of the panel dimension of the QLFS data, which constitutes the LMD data, and be mindful that this complicates analysis at the household level. As there is a rotating QLFS panel within the pooled LMD, there are multiple observations for a subset of individuals within the sample, as individuals may be interviewed in multiple quarters of the year. For example, although the LMD provides 272 observations for the Mpumalanga province in the coal mining industry (SIC210), only 140 of these are unique individuals (129 unique households). As such, we only use Census data in our analysis of household characteristics of coal mine workers.

Table 5: Sample Size by Data Source

Data Source	Period	Geographic locality	No. workers in coal mining		No. of Households linked to coal workers
			Unweighted	Weighted (000s)	Unweighted
Quarterly Labour Force Survey	2019: Q3	National	84	83.3	75
		Mpumalanga	72	72.8	64
Labour Market Dynamics	2019	National	315	76.4	153
		Mpumalanga	272	66.3	129
Census	2011	National	5503	68.9	5036
		Mpumalanga	4361	55.0	3960
		eMalahleni	2061	25.8	1858
		Steve Tshwete	931	11.8	840
		Govan Mbeki	269	3.5	254
		Msukaligwa	498	6.4	443

Source: Quarterly Labour Force Survey 2019:4 (Statistics South Africa, 2020); Census 2011 10% Sample (Statistics South Africa, 2015a)

Notes: 1. Individuals employed in coal mines defined as those working in industry SIC code 210 'Mining of coal and lignite'. 2. Weighted amounts are calculated using sampling weights. The weights are calculated by considering several factors, including original selection probabilities, adjustment for non-response, and benchmarking to the known population estimates from the Demography division of Statistics South Africa. The 2011 Census weights are based on a 10% sample. As the LMD combines the four QLFS for each year, the weights applied to the LMD are ¼ of the QLFS.

In combatting the small sample issue, we also employ Census (10% sample) data, which provides a much larger sample than the LMD. The Census dataset provides a national and provincial sample of 5 503 and 4 361 observations for coal mining workers, respectively. Further, one is able to consider employment of these workers at the local municipal level; particularly the four municipal localities where coal mining activity is heavily concentrated. The size of the sample also makes the Census the best available source of data to examine the characteristics of households within which coal mine workers reside.

However, a disadvantage of using the Census data is that it is only available for the periods 1996, 2001 and 2011, and thus, even its most recent iteration can be considered outdated. Nonetheless, we use the combination of these two sources of household survey data – the Census and LMD – to complement one another in an attempt to obtain a robust picture of the coal mining industry and the characteristics of the individuals and households linked to this industry. For example, we cross-check corresponding employment estimates across these two data sources. Given the large sample size, Census estimates should be more reliable, or exhibit less statistical noise, and should the LMD estimates align with corresponding estimates, we can infer that we're obtaining a reasonable picture of the coal industry labour market.

Overall, our approach to dealing with these data limitations, in relation to our research objectives, is as follows: To provide a robust quantitative estimate of coal industry jobs, we refer to a diverse set of publicly available datasets. To contend with small sample size bias, we use the PALMS and LMD household survey datasets, and cross-check the corresponding Census and LMD estimates to check that we are obtaining reasonable estimates from the LMD. We augment our measurement of the quantum of employment in the coal mining industry by also drawing on two firm-level data sources from Statistics South Africa – the Mining Census and the DMRE. To profile the individual characteristics of coal mining industry workers, we use LMD data and cross-check the corresponding estimates with the larger sample size Census data. To profile the job characteristics of coal mining sector workers we use LMD data, as this dataset is the only one with detailed job characteristics data. To profile the household characteristics of coal mining sector workers we use Census data, as this data source provides the largest sample size and is designed to capture household level data.

6 An Overview of the South African Coal Labour Market

In this section we provide a quantitative estimate of the number of coal mining industry jobs firstly in South Africa, and then for the Mpumalanga regional economy. We examine individual and job characteristics for coal mine workers, and then explore some household characteristics of households where a coal miner is located. We then apply a similar line of analysis for workers in the electrical utility industry in Mpumalanga.

6.1 Employment in the coal industry in South Africa

To provide a robust quantitative estimate of the number of coal mining industry jobs we compile employment estimates using several reliable statistical sources. As detailed in Section 5.1, these include data from household surveys and mine (plant) level surveys. In Figure 8, employment estimates for the coal mining industry (SIC210) are plotted for the period 1994 to 2019, using the following data sources: firstly, annual estimates from the constituent household survey instruments – OHS, LFS and QLFS – that comprise the PALMS dataset; secondly, point estimates from the three household Census' – 1996, 2001 and 2011 – carried out since 1994; thirdly, annual estimates for the period 1998 to 2019, taken from the Department of Minerals Resources and Energy (DMRE); fourthly, point estimates from the four firm-level mining Census' – 2009, 2012, 2015 and 2019 – conducted by Statistics South Africa.

In terms of quantifying coal mining industry employment, we believe that the estimates emerging from the QLFS (compiled in PALMS) are plausible.[20] Looking at both Figure 8, the PALMS estimates align quite closely to the more reliable Census estimates. The PALMS and Census estimates have moved closer to one another over time. The 1996 PALMS estimate was 24.88% lower than the corresponding Census estimate, while the 2001 PALMS estimate was 30.24% lower. The 2011 PALMS estimates converged with the 2011 Census estimates with just a 0.74% difference. We note further that when observing the trend in coal mining industry employment the estimates across the various sources of data track quite closely and are showing a consistent pattern. We do note that the PALMS estimates exhibit a degree of statistical noise. As mentioned in Section 5.2, this is to be expected given the potential for small sample bias.

The mine (or plant) level data tend to provide higher estimates than the household survey estimates. Looking at both Figure 8, the point estimates from Statistics South Africa's Mining Report (labelled StatsSA) lie above the household survey-based PALMS estimates in 2012,

[20] It is important that the PALMS estimates align relatively closely with the estimates from other potentially more reliable data sources; in particular, the Census estimates. This motivates for the use of the LMD dataset, which is an annual compilation of QLFSs, in the section describing the individual and job characteristics of coal mining industry workers.

2015 and 2019.[21] The difference between these estimates may be a result of how employment numbers are captured. The household surveys determine an employed individual's industry based on their response to the following question: What are the main goods and/or services produced at your place of work? In the case of a household survey response, for an employee engaged in coal mining activity at a coal mining company, the response is likely to confirm the individual's engagement in the coal mining industry. However, for an individual who is an employee for a sub-contractor 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.[22] This may explain why the mining Census estimates, once removing employees working for sub-contractors, shifts toward the household survey estimates.[23] It is worth noting that the DMRE employment estimates align more closely to the PALMS estimates. However, we are not able to dig any deeper into these numbers because the DMRE Statistical Bulletin does not provide details on the composition of their employment estimates.

Despite differences in level estimates, there is a consistent upward employment trend evident across the datasets. In Figure 8 we observe that employment in the coal mining industry is relatively stable in the 1990s going into the early 2000s. Thereafter, from the mid-2000s until the mid-2010s employment experiences a strong upward trend, falls in 2015 and 2016, and then proceeds upward from 2017 onward. This upward trend in employment growth coincides with growth in coal demand along both the domestic and export channels. The growth starting from the mid-2000s, with temporary drops during the 2009 financial crisis and the mid-2010s, is driven by the global commodities boom. This period of high global demand for commodities – particularly from China and India – lifted the global price for commodities such as coal. India is a key source of export demand over this period, constituting 2.84% of coal exports in 2006, and then three years later in 2009 accounting for 23.7% of coal exports, and more recently in 2019, 45.66% of coal exports (The Growth Lab at Harvard University, 2023). This growth is almost entirely driven by price growth, with little quantity response by South African producers (see Table 2).

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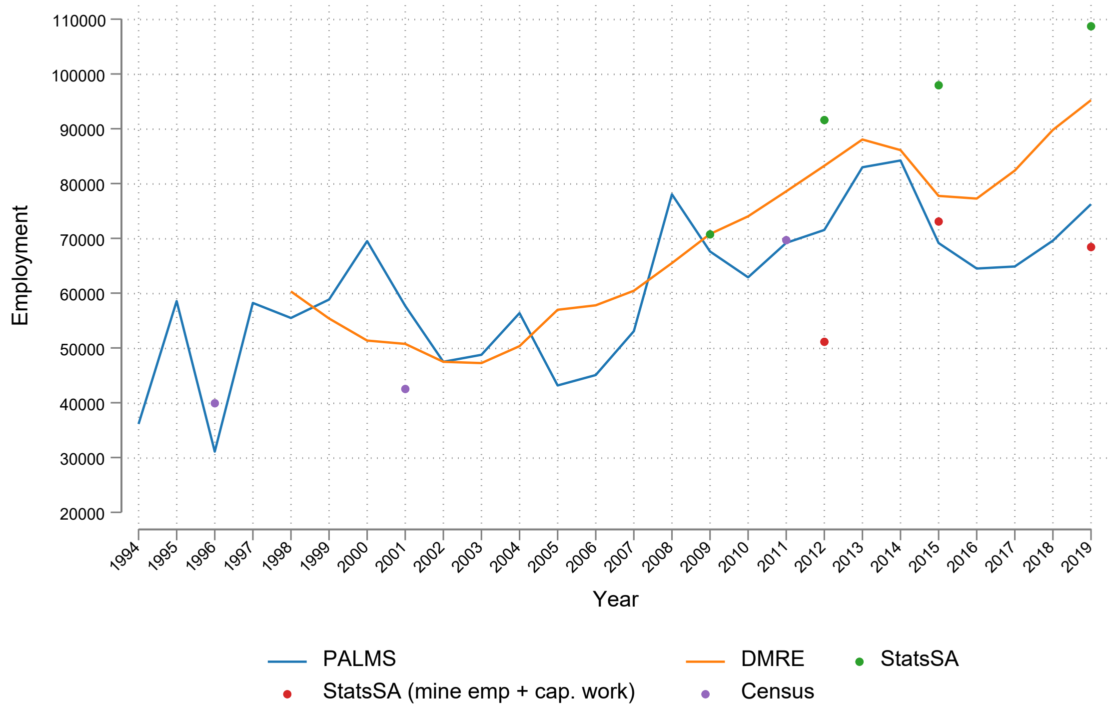
[21] Coal mine employment includes mining employees, employees of labour brokers, employees of sub-contractors, and capital employees.

[22] This line of argument is plausible since the total employment estimate from the 2019 mining census is 108 717, and when one subtracts employees working for sub-contractors (37 438), less employees working for labour brokers (2 859), less capital workers (5 882), one gets an estimate of 62 538, which is slightly closer to the PALMS estimates of 76 200.

[23] Interestingly, the 2009 mining census estimate aligns more closely to the household survey estimate from PALMS. As such, the gap between the firm survey and household survey estimates is not as apparent as in 2012, 2015 and 2019. It is not clear why this is the case, but it may a result of the household survey estimates that are noisy at this level of disaggregation – certainly the spike in the PALMS estimate in 2008 seems to suggest this.

Figure 8: Coal industry employment, 1994-2019



Source: Authors' calculations using PALMS (Kerr, Lam & Wittenberg, 2019); South Africa Census (Statistics South Africa, 1998; 2003; 2015a); Mining Census (Statistics South Africa, 2011; 2014; 2017; 2021a); Department of Mineral Resources and Energy (2020)

Notes: StatsSA Mining Census estimates comprise mining employees, employees of labour brokers, employees of sub-contractors and capital employees. StatsSA (incl. brokers) estimates comprise only mining employees.

In 2019, employment in the coal mining industry sits within the range of 76 000 to 108 000 workers, which represents approximately half a percentage point of total employment in South Africa.[24] With respect to formal employment, the industry accounts for approximately 0.62% of employment. The industry's share of total and formal employment has remained relatively constant over the period. In relation to the broader mining sector, the coal industry employment accounts for 19.05% of employment in 2019. Consistent with the upward trend in employment – depicted in Figure 8 – employment has increased from between thirty and forty thousand workers in the mid-1990s to the current level in 2019.

6.2 Employment in the coal mining industry in Mpumalanga

Mpumalanga is the hub of South Africa's coal mining industry. Of South Africa's 78 operating coal mines, 65 are located in Mpumalanga – see clustering of black circle markers in Figure 10. Together, these mines account for 80% of coal production in South Africa. We now detail coal mining industry employment levels in this regional economy.

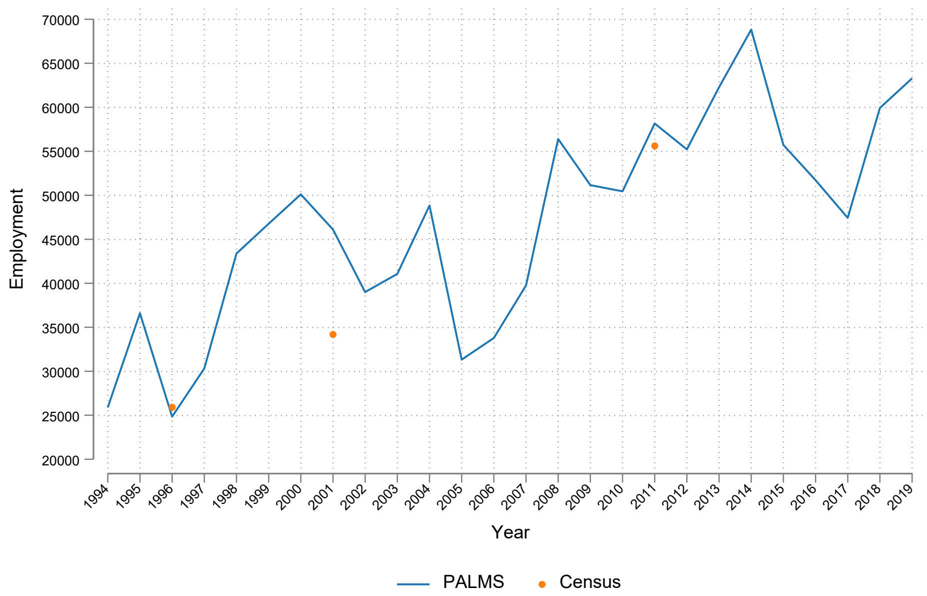
[24] The upper estimate of 108 717 workers represents approximately 0.65% of employment.

Unsurprisingly, the bulk share of employment in the South African coal mining industry works in the Mpumalanga province. In Table 6, using the Census data, we observe that in 2011, 55 619 of the 69 684 coal mining workers in South Africa are located in Mpumalanga. This corresponds with 79.8% of coal mining employment. This is further depicted in Figure 9 where, using 2011 Census data, we shade local municipalities according to a count of coal mining employment levels. It is evident that, apart from relatively small shares of coal mining employment in the Free State, Limpopo, KwaZulu-Natal and Gauteng provinces – cumulatively 20% in 2011 – coal mining employment is clustered in the Mpumalanga province. Using the LMD data, over the period 2011 to 2019, Mpumalanga's share of total coal mining employment has hovered between 72 and 86.7% of total coal mining employment.

Over the period 1994 to 2019, coal employment in Mpumalanga has grown both in absolute and relative terms. In Figure 9, we show the PALMS and Census employment level estimates for the coal industry. An upward trend is evident. Given that the province accounts for the major share of industry jobs nationally, the upward trend is consistent with that evident in national coal industry employment levels that are shown in Figure 9.

Mpumalanga's share of coal mining industry employment has grown since 1996, where the province accounted for 64.9% of coal industry jobs, and which has subsequently increased to 80.4% in 2001, and remained constant at 79.8% in 2011. The rising relative importance of coal mining in Mpumalanga is a combination of increased coal mining activity in the province and decreased coal mining activity in other parts of the country – particularly KwaZulu Natal (KZN), as a number of mines closed in the province in the 1980s and 1990s (Cole et al., 2023).This is further evident in Table 7, where we observe a decrease in coal industry employment in the KZN province between 1996 and 2001.

Figure 9: Coal Industry Employment in Mpumalanga, 1994-2019



Source: Authors' calculations using PALMS (Kerr, Lam & Wittenberg, 2019); South Africa Census (Statistics South Africa, 1998; 2003; 2015a)

As can be seen by the pattern of coal mining employment in Figure 9, the employment estimates from the labour force surveys (compiled in PALMS) do appear to successfully follow the same trend observed in the Census data. The Mpumalanga OHS estimates (from PALMS) also appear to match up well with the Census estimates in 1996, before following an upward trend until 2000. After this, we see a decline, which brings the 2001 estimate of the LFS closer to the 2001 Census estimate. Similar to national coal employment, we then observe an inflection point in 2007/08, followed by an increase in coal mining employment, with a dip between 2014 and 2018. The 2011 Census coal mining employment estimate is also closely matched by the QLFS estimate (from PALMS). This is an indication that, despite the data limitations discussed in Section 5.2, these survey data can be useful for our purposes.

Table 6: Employment Break down by municipalities using Census estimates

Municipality / Province	Level (000s)			Shares of total coal employment (%)		
	1996	2001	2011	1996	2001	2011
eMalahleni (Witbank)	8 774	18 069	25 935	22.0	42.5	37.2
Steve Tshwete (Middelburg)	4 439	5 318	11 964	11.1	12.5	17.2
Govan Mbeki (Highveld East)	4 491	5 687	3 473	11.3	13.4	5.0
Msukaligwa (Ermelo)	1 442	1 586	6 590	3.6	3.7	9.5
Mkhondo	276	594	2 937	0.7	1.4	4.2
Victor Khanye	529	614	1 555	1.3	1.4	2.2
Albert Luthuli	369	494	1 483	0.9	1.2	2.1
Total Mpumalanga	**25 923**	**34 192**	**55 619**	**64.9**	**80.4**	**79.8**
KwaZulu Natal	8 926	2 553	3 036	22.4	6.0	4.4
Limpopo	1 935	2 818	5 408	4.8	6.6	7.8
Gauteng	1 206	1 206	3 018	3.0	2.8	4.3
Free State	898	1 286	1 214	2.2	3.0	1.7
Total other provinces	**13 995**	**8 332**	**14 065**	**35.1**	**19.6**	**20.2**
TOTAL	**39 918**	**42 524**	**69 684**	**100**	**100**	**100**

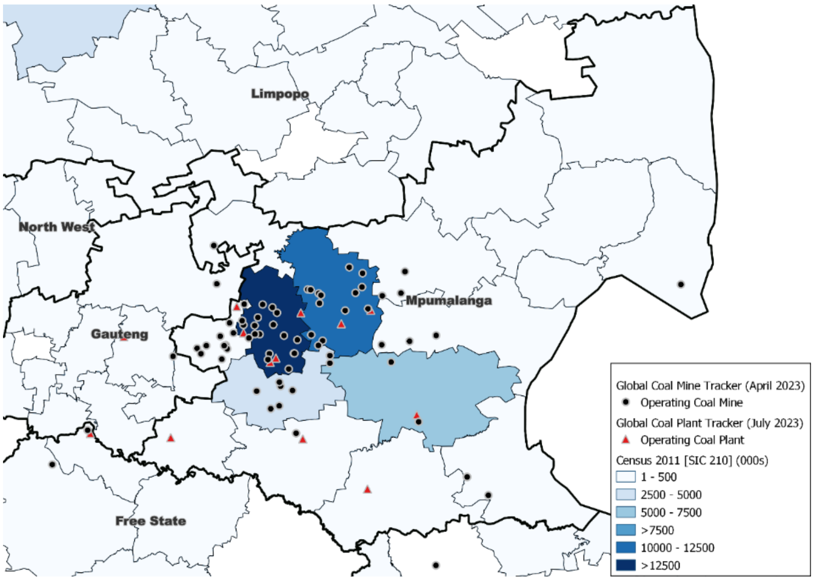
Source: Authors' calculations using South Africa Census (Statistics South Africa, 1998; 2003; 2015a)

Notes: Sum of local municipalities in Mpumalanga province does not add up to total for Mpumalanga because of small number of coal industry jobs in other parts of the province. Sum of coal industry jobs in KwaZulu-Natal, Limpopo, Gauteng and Free State does not add up to total for other provinces because of small number of coal industry jobs in remaining other four provinces. Shares refer to the contribution of a locality to total coal employment in South Africa.

Within the Mpumalanga province, coal mining employment is further concentrated within four local municipalities, and thus the bulk of the employment matches the output. The advantage of Census data is that we can disaggregate coal employment within Mpumalanga. Table 6 indicates that within Mpumalanga, in 2011, employment in the coal industry is concentrated within eMalahleni (37.2% of national coal industry employment), Steve Tshwete (17.2%), Govan Mbeki (5.0%) and Msukaligwa (9.5%), which together make up 86.2% of total coal industry employment in Mpumalanga (and 79.8% of coal industry employment in South Africa). This concentration of coal industry employment within these four Mpumalanga local municipalities is further depicted in Figure 10. A similar pattern is evident in 2001 and 1996. However, we do observe that coal industry employment in Govan Mbeki municipality declined between 2001 and 2011, while Msukaligwa experienced employment growth.

This pattern of employment changes over time is determined by the life of mine in each of these localities. Advantageously, from a policy perspective, this pattern of concentration – particularly the fact that 54.4% of employment is spatially concentrated within eMalahleni and Steve Tshwete – allows for spatially targeted interventions. However, this very same pattern of concentration can potentially become a disadvantage, because should the policy maker err, then the negative outcomes materialise in a highly concentrated area.

Figure 10: Coal employment in 2011 Census data in Mpumalanga and South Africa

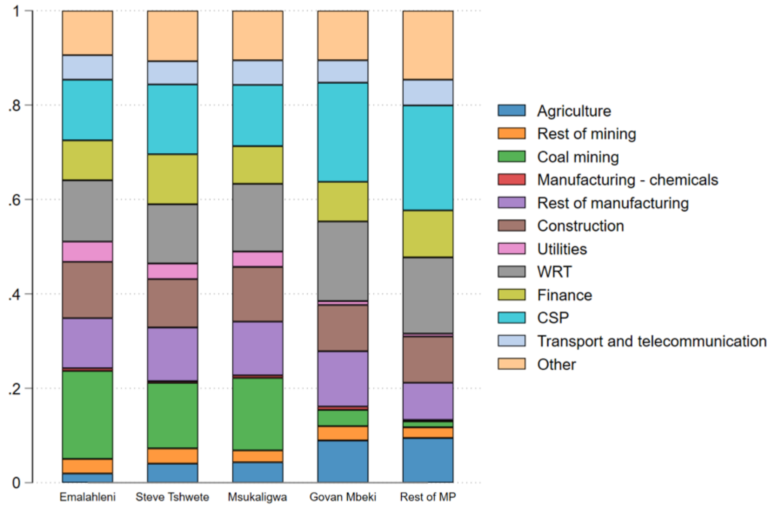


Source: Authors' calculations using South Africa Census (Statistics South Africa; 2015a)

The coal mining industry is a critical employer within the province and, more acutely, within these local municipal localities. In the 2011 Census results, coal employment made up 5% of employment in Mpumalanga. Using both the Census and LMD estimates – if we assume that Mpumalanga accounts for approximately 80% of the national coal industry employment – the range of coal employment in Mpumalanga alone is between 60 and 86 thousand workers. We observe a degree of heterogeneity in the coal industry's relative importance across these local municipalities. As illustrated by Figure 11, coal employment accounts for almost one fifth (19%)

of aggregate employment in Emalahleni, 15.3% in Msukaligwa, 13.7% in Steve Tshwete, 3.45% in Govan Mbeki, and 13% of all employment in the four coal mining municipalities. Coal employment also accounts for large shares of employment in some smaller municipalities. It accounts for 9.4% of employment in Mkhondo, 5.0% in Albert Luthuli, and 7% of employment in Victor Khanye.

Figure 11: Industry contribution to employment in Mpumalanga municipalities, 2011



Source: Authors' calculations using South Africa Census (Statistics South Africa; 2015a)

Notes: WRT is the Wholesale and Retail Trade sector, and CSP is the Community, Social and Personal services sector.

The distribution of employment across industries within municipalities in Mpumalanga suggests that alternative employment opportunities may be available in other industries. In particular, as detailed in Section 2.2.1, in past transition experiences coal mine workers have found jobs in the manufacturing and construction industries. In Figure 11, we observe that there are jobs in the manufacturing (purple and red) and construction (brown) industries in these local municipalities within the province. Of course, the extent to whether job opportunities in these industries present themselves to coal workers during the transition is a function of these industries growing and having employment vacancies that require filling – i.e. a demand issue. The Polish experience suggests that job opportunities for coal mining workers only arose once the broader economy, and the construction and manufacturing sectors, started to grow (Sokołowski et al., 2022). Further, the transition of coal workers to alternative job opportunities in these industries is dependent on the successful matching of these workers to related – based on similar tasks and skills – occupations in these industries – i.e. a matching issue.

6.2.1 The coal industry jobs

In this section we investigate the labour market profile of coal industry workers to get a sense of the types of jobs that are to be affected by the transition away from coal. This is important as it will inform the planning and policy decisions made during and after the transition.

Understanding the labour profile will allow policymakers to make targeted decisions in a way that will be most beneficial for these individuals.

In Table 7 we present estimates describing the average individual characteristics of employees in the coal mining industry in Mpumalanga. Columns (1) and (2) show estimates for the share of total coal mining employment by covariate for the 2011 period using the Census and LMD datasets, respectively. One can compare these estimates and gain a sense of whether the LMD estimates, with a smaller sample, are reasonably consistent with the larger sample of Census estimates.[25] The Census and LMD estimates showing the number of coal mining employees in Mpumalanga are closely aligned. The individual characteristics are broadly aligned, but with some compositional differences across certain profile categories. The younger youth group – 15-24 – in the Census estimates is relatively larger than the LMD estimates, while the older youth group – 25-34 – is larger for the LMD estimates. However, the overall compositional share of youth is relatively well aligned across the two surveys, as is the case with the non-youth age categories. With respect to the education profile, the LMD estimates seem to have a higher share of employees with a diploma, while the Census has a higher share of employees with a primary education or less. All other education categories are aligned.

Table 7: Individual characteristics of Mpumalanga coal mining industry employees (2011; 2019)

	Coal mining industry employment			Ratio Coal: Formal
	Census	LMD	LMD	
	2011	2011	2019	2019
Total No. of employees (weighted)	55 619	55 423	66 252	
Gender				
Male	0.81	0.85	0.80	1.33
Race				
African/Black	0.80	0.73	0.81	0.92
White	0.17	0.27	0.19	1.90
Age Group				
15-24	0.13	0.06	0.08	1.14
25-34	0.35	0.43	0.43	1.26
35-44	0.25	0.25	0.22	0.71
45-54	0.19	0.20	0.22	1.05
55-64	0.08	0.06	0.06	0.75
Educational Attainment				

[25] Given that we focus on the coal mining industry in Mpumalanga, we also show that the Mpumalanga coal mining industry estimates are consistent with the national coal mining industry estimates – i.e. the picture that emerges from Mpumalanga sufficiently represents the national picture. This is reported in Table A 7.

Primary or less	0.17	0.07	0.01	0.14
Secondary uncompleted	0.31	0.30	0.29	1.00
Secondary completed	0.38	0.37	0.43	1.19
Diploma	0.11	0.20	0.23	1.28
Degree	0.03	0.03	0.04	0.44

Source: Authors' calculations using South Africa Census (Statistics South Africa, 2015a) and Labour Market Dynamics (Statistics South Africa, 2011; 2021b)
Notes: Categories comprising negligible shares for race, age and education are omitted from the table. Shares represent the share of total coal employment by covariate.

In Column (3) we present the 2019 LMD estimates to gain a clearer sense of the more recent profile of coal mining industry workers. To better comprehend the relative characteristics of coal mining industry workers, we present a ratio of the employment share for coal mining industry workers to the employment share for total formal sector workers in Mpumalanga (see Column (4)). A ratio above unity indicates that coal mining industry workers are relatively more likely to exhibit a given characteristic.

The average coal mining industry employee in Mpumalanga is a Black African male, aged between 25 and 34 years, and has at least a complete secondary education. Depending on whether one uses the Census or LMD, the share of male employees in the coal mining industry is between 81 and 85%, and thus male dominated. Further, as per the ratio in Column (4), coal mining industry workers are relatively more likely to be male than the average formal sector worker in Mpumalanga. The 2019 LMD estimate suggests that the gender composition of the workforce has remained stable. Black Africans comprise the bulk share of coal mining employees, with the Census estimate indicating that this population group comprised 80% of the workforce. The next largest racial group is Whites at 17%. The LMD estimate for Black Africans is 7 percentage points lower at 73%, with a correspondingly higher estimate for Whites.

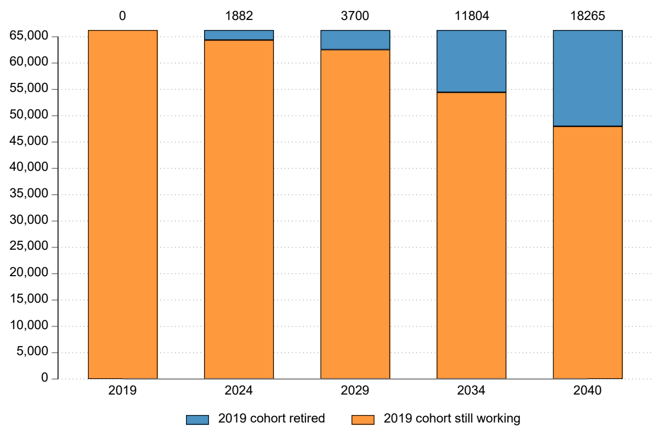
The coal mining industry workforce is relatively youthful. Almost half of employees fall within the two youth age groups. The Census data for 2011 show that cumulatively the 15 to 24 (13%) and 25 to 34 (35%) age group categories comprise 48% of employees in the coal mining industry.[26] The composition of the corresponding estimate for the LMD is skewed toward the older youth category (24-35), comprising 43% of employees, while the younger youth category (25-34) comprises 6% of employees. The corresponding 2019 LMD estimates suggest that the age composition of the coal mining industry has not changed materially. Ratios of 1.14 and 1.26 for the two youth age groups further indicates that coal mining industry workers are, on average, more likely to be youth age workers than other formal sector workers.

[26] In comparison, the manufacturing industry has a much older labour force, where the 15-24 and 25-34 age groups comprise 10.8 and 8.7% of employees, respectively – cumulatively 19.5%. The construction industry has a similar youth orientated age profile – the 15-24 and 25-34 age groups comprise 28.7 and 32.1% of employees, respectively – cumulatively 60.8%.

The youthful composition of the coal mining industry workforce suggests that a substantial number of coal mining industry workers will need to explore alternative employment opportunities as the transition unfolds. Thus, this portion of the workforce will need matching support interventions to link them to alternative avenues of employment. A well-designed just transition strategy should therefore prioritize retraining, reskilling, and offering pathways to sustainable employment for these individuals, ensuring that the broader impacts of transitioning away from coal mining are equitable and supportive of the affected workforce. Correspondingly, the youthful orientation of the workforce indicates that the natural retirement of employees is not a major avenue for dealing with the transition.

While the other half of the workforce is not classified as youth, the option for early retirement schemes, by 2040 for instance, is a realistic option for approximately a quarter of the 2019 cohort of the workforce.[27] By 2040 – 17 years from now – only five of South Africa's 14 national utility operated coal fired power plants will be in operation. Given that the main source of demand for coal is the domestic energy market, a large chunk of the coal mining industry is set to naturally (endogenously) phase-out over this period. Looking at the age profile of the 2019 cohort, in Figure 12 we show the number of coal industry workers in Mpumalanga set to retire in 5-year increments up to 2040 (shaded in blue). Assuming a retirement age of 65, by 2029, 3 700 workers (5.6% of the 2019 cohort) are set to retire. By 2034, 11 804 (17.8%) workers are set to retire. The corresponding figure for 2040 is 18 265 workers, or 27.6% of the 2019 cohort.[28] Thus, by 2040, approximately a quarter of the 2019 workforce will be retired. As indicated above, the remaining workforce – a relatively large chunk given that the median age of the workforce is 36.5 years – will need varying types of support to enable an equitable transition.

Figure 12: Phasing of Retirement for 2019 Cohort of Mpumalanga Coal Mining Workers



Source: Authors' calculations using Labour Market Dynamics (Statistics South Africa, 2021b)

[27] The point is not that workers won't get replaced, but that entrants will come in at lower wages. Further, the transition cost could possibly be reduced should coal mines be closed down prematurely.

[28] This estimate is an underestimate since standard retirement age for mine workers is 50-60 years for underground workers, and 53 to 63 years for surface workers.

Coal mining employees exhibit relatively high levels of educational attainment. More than half of the coal mining industry workforce have a completed secondary education or above in 2011 – the Census and LMD data estimates are 52% and 60%, respectively. The ratios above unity in Column (4) suggest that coal mining industry workers are more likely to have a completed secondary education or a diploma relative to the average formal sector worker in Mpumalanga. The corresponding estimates for two industries that have the potential to provide alternative employment avenues for coal mine workers, manufacturing and construction (see Section 2.2.1), exhibit relatively lower education levels with 45.81% and 26.8% of employees in these industries having a complete secondary education or above, respectively. In 2019, using the LMD data, there was a reduction in the share of employees with primary schooling or less, and an increase in the share of those with secondary schooling completed. This increasing educational attainment could be indicative of the current coal mining employees' ability to be reskilled or upskilled, and thereby succeed in shifting to alternative employment options for these individuals.[29]

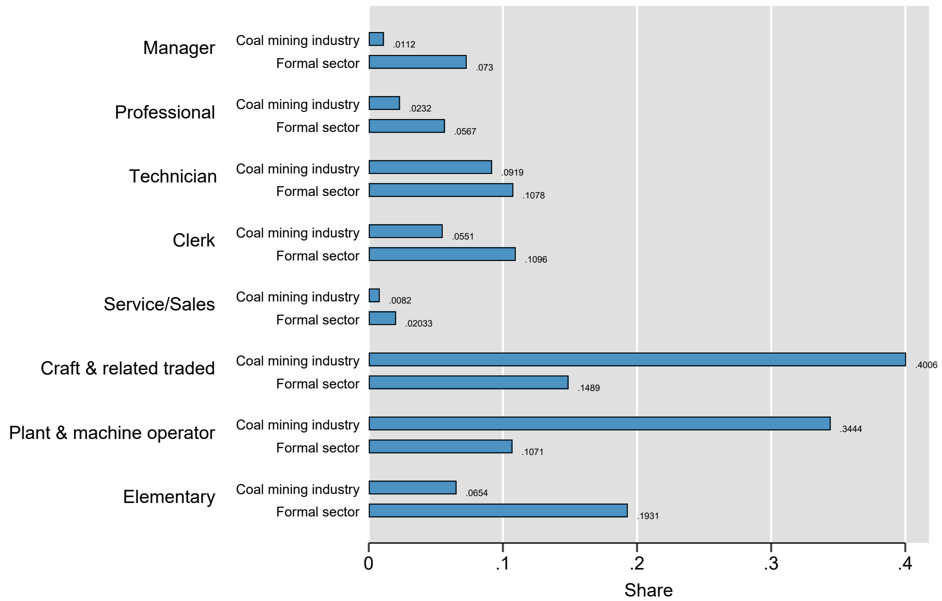
The bulk share of coal mining industry workers that may require transition support are employed in the semi-skilled craft and related trade and plant and machine operator occupations.[30] In Figure 13 we observe that 40% of coal mining industry employees work in craft and related trade occupations. At a more disaggregated occupation level, these occupations include miners and quarry workers (38% of employees in craft and related trade occupations), agricultural or industrial machinery mechanics and fitters (17%), motor vehicle mechanics and fitters (9.57%), shot-firers and blasters (9.57%), and sheet-metal workers (8.7%). In the case of plant and machine operators, which comprise 35% of jobs in the industry, occupations include: mining plant operators (25.81%), heavy-truck and lorry drivers (24.19%), crane, hoist and related plant operators (24.19%), lifting truck operators (9.68%), and earth-moving and related plant operators (8.06%). Skilled technician occupations comprise 8.7% of jobs, with the main occupations within this category including electrical engineering technicians (20%), electronics and telecommunications technicians (16%) and safety, health, and quality inspection (32%). Low skilled elementary occupations, which comprise 7.2% of jobs, include mining and quarrying labourers (51.85%) and helpers and cleaners in offices (37.04%). Further, coal mining industry workers are relatively more likely to fall in these two occupational groupings than the average formal sector worker in Mpumalanga. As evident in Figure 13, the corresponding shares for these occupation groupings for formal sector workers are substantially lower.

[29] It is, however, important to note that education is a poor proxy for matching a worker to an alternative employment opportunity. Future research will examine more carefully any occupational matching for coal mining workers based on occupational relatedness measures.

[30] Employment share estimates across occupational categories are well aligned when comparing Census 2011 estimates with LMD 2011 estimates. Appendix Table A 8 presents these estimates.

Given the predominantly semi-skilled[31] nature of the workforce, policy should look to firstly preserve these skills through matching to employment opportunities in alternative industries. When thinking about a matching policy intervention for coal workers, a key question that emerges concerns the extent to which the skills inherent in these two occupation groupings are transferrable to occupations in other industries – i.e. given their existing skills, how can coal workers naturally find their way into alternative employment? This matching approach will ultimately alleviate a purely fiscal solution to the just transition challenge.

Figure 13: Occupational profile of coal mining industry workers in Mpumalanga, 2019



Source: Authors' calculations using Labour Market Dynamics (Statistics South Africa, 2021b)

Notes: Formal sector accounts for total employment in the formal sector labour market.

We now examine the education profile of coal mining workers across occupation categories. In Table 8 we show the level and share of coal mining workers in the occupation-education level space. The cells are shaded according to the size of each of these occupation-education level combinations. Increasing shares and levels of employment are represented by cells being shaded from light to increasingly darker shades of green. One is able to get a sense of where the bulk share of coal mining workers reside within the occupation-education level space. This is useful because different occupation-education combinations require policy interventions that vary in nature and scope. Thus, using this occupation-education level space, we put together a first attempt at breaking up the just transition challenge, by dividing the coal industry workforce into three analytical groupings.[32]

[31] High-skilled occupations comprise managers, professionals, and technicians. Semi-skilled occupations comprise clerks, service and sale occupations, craft and related trades, and plant and machine operators. Low-skilled occupations comprise elementary occupations.

[32] We acknowledge that this approach is relatively simplistic and imperfect. However, its core function is to start putting down policy relevant numbers for the just transition.

The first grouping – defined as *no just transition challenge* – comprises workers with post-secondary education qualifications (i.e. diploma or degree), who work in high-skilled (i.e. manager, professional, technician) or semi-skilled (i.e. clerk, sales/services, craft and related trades, plant and machine operator) occupations. This grouping of workers, being both well-educated and working in high-skilled or semi-skilled occupations, can be characterised as relatively high-skilled, and as a result, more likely to find alternative employment opportunities as the transition unfolds. Quantifying this group – summing the cells lying in columns 5 to 6 and rows 2 to 8 – results in 17 203 workers or a quarter of the Mpumalanga coal industry workforce (25.97%). Given their high skill level and relatively higher likelihood of finding alternative employment, we do not consider this grouping to be a just transition challenge. From a policy standpoint, this grouping may require some marginal degree of employment matching intervention.

Table 8: Distribution of coal industry workers in Mpumalanga by occupation and education level, 2019

	Primary	Incomplete secondary	Complete secondary	Diploma	Degree	Total
Manager			199 0.30%	223 0.34%	282 0.43%	704 1.06%
Professional		187 0.28%	117 0.18%	1 149 1.74%		1454 2.19%
Technician		888 1.34%	2 340 3.53%	1 654 2.50%	874 1.32%	5756 8.69%
Clerk			1 403 2.12%	2 050 3.10%		3453 5.21%
Sales/services			513 0.77%			513 0.77%
Craft & related traded	187 0.28%	6 948 10.49%	10 095 15.24%	8 105 12.23%	1 189 1.79%	26 522 40.03%
Plant & machine operator	596 0.90%	7 888 11.91%	12 781 19.29%	1 677 2.53%		23 097 34.86%
Elementary	144 0.22%	3 160 4.77%	1 229 1.86%	221 0.33%		4 754 7.18%
Total	927 1.40%	19 0714 28.79%	28 677 43.28%	15 080 22.76%	2 344 3.54%	66 252 100.00%

Source: Authors' calculations using Labour Market Dynamics (Statistics South Africa, 2021b)

Notes: Levels (top figure) and shares (bottom figure) are reported for each occupation-education level combination (each cell). Summation of all occupation-education level combinations equals total coal industry employment in Mpumalanga. Increasing shares and levels of employment are represented by cells being shaded from lighter to darker shades of green.

The second grouping – defined as an *intermediate just transition challenge* – comprises those with at most a complete secondary education (i.e. primary, incomplete secondary, complete secondary), who work in high- or semi-skilled occupations. Given the combination of relatively lower levels of education and high- or semi-skilled occupations, this grouping of workers can be described, for the most part, as semi-skilled. Quantifying this grouping of workers – summing the cells lying in columns 2 to 4 and rows 2 to 8 – results in a total of approximately 44 142 workers (66.63%), and thus the bulk of the Mpumalanga coal industry workforce. Given the semi-skilled nature of this grouping, there is a degree of uncertainty regarding the appropriate policy intervention, as some have a reasonable likelihood of finding alternative employment opportunities. As such, this grouping may require a mix between employment matching mechanisms, skills top-up, income support interventions, or other forms of policy intervention.

The third grouping – defined as the *just transition challenge* – comprises those engaged in low-skilled elementary occupations. This grouping of low-skilled workers – summing cells lying in row 9 – number 4 754 workers, or 7.18% of the Mpumalanga coal industry workforce. Given that these workers have low levels of education and work in low-skilled occupations, their likelihood of finding alternative employment is low. As such, it is likely that the appropriate policy response for this grouping is social protection in the form of income support.

We now shift our attention to the average characteristics of coal mining industry jobs. This information gives one a sense of the quality of jobs that coal mining industry workers are going to have to move away from. In Table 9 we report the mean estimates for job quality indicators for coal mine workers in Mpumalanga in 2011 and 2019. In Column (3) we present a change in share for each job characteristic. To gain a better sense of the relative job characteristics of coal mining industry jobs, we present a ratio of the employment share for coal mining industry workers to the employment share for total formal sector workers in Mpumalanga (see Column (4)). A ratio above unity indicates that coal mining industry jobs are relatively more likely to exhibit a given characteristic.

When discussing coal mining industry jobs, one is looking at formal sector jobs. While not reported below, coal mining industry jobs are predominantly formal (see Appendix Table A 9). The enterprise definition used by Statistics South Africa indicates that 95% of coal mining industry jobs in 2019 are formal sector jobs.[33]

Consistent with the high share of jobs defined as being formal sector jobs, we observe jobs characterised by high levels of UIF contributions, pension contributions, and various forms of leave. All employees in the industry have a written contract, 99% of employees pay and have access to the Unemployment Insurance Fund (UIF), 83% pay a pension or retirement fund

[33] The enterprise definition defines an informal sector worker as an employee working in establishments that employ fewer than five employees, who do not deduct income tax from their salaries/wages; and employers, own-account workers and persons helping unpaid in their household business who are not registered for either income tax or value-added tax (Statistics South Africa, 2008).

contribution, and 72% enjoy medical aid benefits. Further, 93, 95 and 84% of employees in the industry are entitled to paid annual, sick and parental leave, respectively. However, it is worth noting that many of these job quality indicators have declined since 2011. This may be a function of declining union membership in the industry, where in 2011, 82% of employees were members of a union, and more recently in 2019, 67% were members of a union.

It is worth noting that coal mining industry jobs have, on average, better employment conditions than the average formal sector job in Mpumalanga. We observe in Table 9 that all job indicators have a ratio greater than unity. As such, a shift to another formal sector job is likely to result in a lower job quality outcome for the average coal mining industry worker.

Table 9: Job Characteristics of Coal Employees in Mpumalanga, LMDS 2011 and 2019

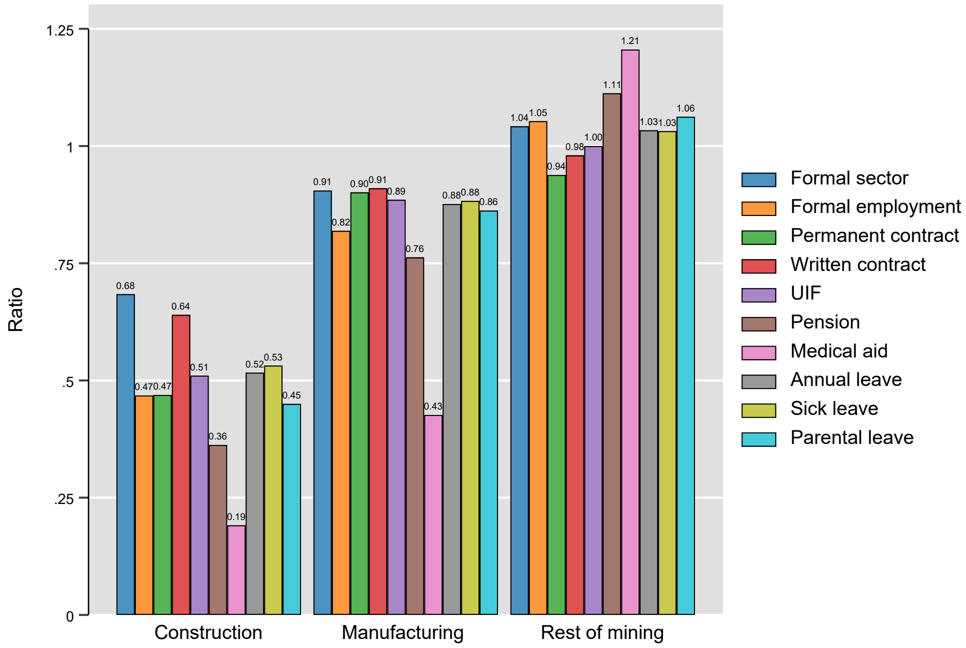
Job characteristic	LMD 2011 Share (%)	LMD 2019 Share (%)	Change (%)	Ratio Coal:Formal 2019
Total No. of employees (weighted)	55 423	66 252	10 829	
Duration of contract				
Contract	0.04	0.06	0.02	0.50
Permanent	0.91	0.84	-0.07	1.20
Employment status				
Written	1.00	1.00	0.00	1.06
UIF				
Yes	1.00	0.99	-0.01	1.48
Medical aid				
Yes	0.79	0.72	-0.07	1.89
Pension				
Yes	0.93	0.83	-0.10	1.38
Annual leave				
Yes	0.98	0.93	-0.05	1.21
Sick leave				
Yes	0.99	0.95	-0.04	1.16
Parental leave				
Yes	0.91	0.84	-0.07	1.35
Union membership				
Yes	0.82	0.67	-0.15	1.43

Source: Authors' calculations using Labour Market Dynamics (Statistics South Africa, 2011; 2021b)

Notes: 1. Duration of contract does not sum to 100% due to unspecified responses.

Taking this forward, in the face of job losses expected to emerge as a result of the transition, coal mining industry workers shifting to potential substitute industries are likely to, on average, experience a decline in job quality. In Figure 14 we present these job characteristics in relation to the industries that may offer alternative employment opportunities to coal mining workers.[34] We do this by presenting a ratio of the share of a job characteristic in the substitute industry relative to the corresponding share in the coal mining industry. Ratios above and below unity indicate more and less favourable job characteristics in the substitute industry, respectively.

Figure 14: Job characteristic ratio for coal mining industry relative to substitute industries



Source: Authors' calculations using Labour Market Dynamics (Statistics South Africa, 2011; 2021b)

The discussion in Section 2.2.1 revealed that post-transition employment opportunities typically resided in the manufacturing and construction industries. The ratios for these industries are all below unity, and thus contingent on demand, should coal mine workers shift to these industries, they are likely to face less favourable job-related outcomes (at least in terms of these measures).[35] It is worth noting that should coal mine workers be able to shift to alternative mining industries, they are likely to shift into jobs with similar employment conditions (formal employment, written contract, leave) and in some aspects better employment conditions (pension and medical aid).

6.2.2 Households linked to coal industry jobs

In this section we provide a profile of households linked to coal mining industry jobs. The Census 2011 10% sample records information on 4 361 coal mining industry employees

[34] Note, we are not discussing job matching at this stage – this is a future research project – but we are looking at industries that may offer job matching opportunities as the transition unfolds.

[35] There are, however, various adverse health effects associated with coal mining that we are not able to measure using the QLFS data. For example, Burton et al. (2018) note that more than 200 000 households use coal for heating and a further 100 000 use coal for cooking, and the use of coal for these purposes has extensive negative health impacts on these households in coal mining communities.

working in Mpumalanga, which equates to a weighted level of 55 619 workers. When matching these individuals to the households in the Census data, this equates to 46 100 households linked to coal industry employment. We refer to these as *coal households*. In the analysis to follow, we examine households with one of more coal mining industry employees and various lenses of dependency associated with these coal households. The mean household size of coal households is 3.4.

For most coal mining industry households (64.1%), the coal industry employee is the only employed person in the household. This suggests that many coal households are economically vulnerable to job losses that are likely to emerge from the transition. In Table 10 we report the share of coal households, which varies between single and multi-coal employee households (columns), according to the number of other employed individuals in the coal household (rows). We thus get an indication of the level of economic exposure that these coal households face in relation to the adverse labour market effects likely to emerge from the transition (i.e. closure of coal mines/retrenchment of coal employees). Hence, in approximately two-thirds (64.1%) of coal households in Mpumalanga, those who are employed in the household, are solely employed in the coal mining industry. The majority of these households (58.9%) are single coal-worker households with no other coal-employed individuals present in the household. In other words, these households are completely reliant on the income that they obtain from employment in the coal mining industry.

Table 10: Coal Household Composition in terms of employment, Census 2011

		No. Coal Employees in Coal Households		
No. Other Employed individuals in Coal HHs		1	>1	Total
	0	27.1 58.9%	2.4 5.2%	29.5 **64.1%**
	1	11.6 25.2%	0.8 1.7%	12.4 27.0%
	>1	3.6 7.8%	0.5 1.1%	4.1 8.9%
	Total	42.3 92.0%	3.7 8.0%	46.1 100%

Source: Authors' calculations using South Africa Census (Statistics South Africa; 2015)

Note: In each cell reporting numerical estimates, the first value reports the weighted number of households (in 000s), the second value reports the share of coal households. According to the Individual-level dataset, there are 3960 unique household IDs with a coal related employee, prior to weighting. When matching between the Individual-level and household-level data in the 2011 Census data, 136 coal workers in the individual-level data do not match up to a household. These individuals are lost when using the household specific weights, as they do not have a household weight attached. Thus, the total number of coal households used for the weighted values is 3824. Due to rounding, the shares of coal households may not sum up to exactly 100%.

We also observe that slightly more than a third of coal households in Mpumalanga (35.9%) have at least one other employed individual in the household that is employed outside of the coal mining industry (including SIC411 workers). This suggests that these households may be better placed to absorb the adverse employment shocks emerging from the transition, given that there is an alternative source of income. However, although these households are less exposed to the closure of coal mines or the retrenchment of coal workers, we must consider that for many of the towns in this region, the existence of the town is as a result of the existence of the coal mine. For example, should the individual be employed in the coal-fired energy industry, then they too may be at risk of losing their jobs as fossil-fuel based industries fall away. Furthermore, should individuals choose to move away from the areas around coal mines and coal power plants to search for alternative work, this will negatively impact businesses in these municipalities. As people move away, the consumer base of these businesses will shrink or be lost.

Most coal households (70.7%) do not have unemployed individuals in the household. In Table 11 we present estimates showing the prevalence of unemployed individuals in coal households. Approximately 29% of coal households have at least one unemployed dependent in the household. Of these households, just over one-quarter have multiple unemployed dependents present. Notably, the mean number of unemployed dependents in households with unemployed individuals present is 1.8. Households with unemployed individuals present also appear more likely to be single coal-worker households, rather than households with multiple coal workers. Correspondingly, 70% of coal households do not have any unemployed dependents. Given the mean coal household size of 3.6, this suggests that the remainder of individuals in these households are not economically active.

Table 11: Coal Household Composition in terms of Unemployed, Census 2011

		No. Coal Employees in Coal Households		
		1	>1	Total
No. Unemployed individuals in Coal HHs	0	29.7 64.6%	2.8 6.1%	32.5 70.7%
	1	9.2 20.0%	0.6 1.3%	9.8 21.3%
	>1	3.4 7.4%	0.3 1.3%	3.7 8.0%
	Total	42.3 92.0%	3.7 8.0%	46.1 100%

Source: Authors' calculations using South Africa Census (Statistics South Africa; 2015)

Note: In each cell reporting numerical estimates, the first value reports the weighted number of households (in 000s), and the second value reports the share of coal households. According to the individual-level dataset, there are 3 960 unique household IDs with a coal related employee, prior to weighting. When matching between the individual-level and household-level data in the 2011 Census data, 136 coal workers in the individual-level data do not match up to a household. These individuals are lost when using the household specific weights, as they do not have a household weight attached. Thus, the total number of coal households used for the weighted values is 3 824. Due to rounding, the shares of coal households may not sum up to exactly 100%.

In Table 12 we examine child dependency among coal households. We observe that more than half of all coal households do not have a child (57%). Of the 43% of coal households with child dependents, 43% of those households, have one child, while the remaining 57% have two or more children. The mean number of child dependents in coal households is 2.0.

Table 12: Coal Household Composition in terms of Child dependents, Census 2011

		No. Coal Employees in Coal Households		
		1	>1	Total
No. Child Dependents in Coal HHs	0	24.1 52.4%	2.1 4.6%	26.2 **57.0%**
	1	7.9 17.2%	0.6 1.3%	8.5 18.5%
	>1	10.3 22.4%	1.0 2.2%	11.3 24.6%
	Total	42.3 92.0%	3.7 8.0%	46.1 100%

Source: Authors' calculations using South Africa Census (Statistics South Africa; 2015)

Note: In each cell reporting numerical estimates, the first value reports the weighted number of households (in 000s), and the second value reports the share of coal households. According to the individual-level dataset, there are 3 960 unique household IDs with a coal related employee, prior to weighting. When matching between the individual-level and household-level data in the 2011 Census data, 136 coal workers in the individual-level data do not match up to a household. These individuals are lost when using the household specific weights, as they do not have a household weight attached. Thus, the total number of coal households used for the weighted values is 3 824. Due to rounding, the shares of coal households may not sum up to exactly 100%.

In Table 13 we consider another element of age-related dependency and measure the presence of elderly dependents in coal households. Almost all coal households – 95% – do not have an elderly dependent.

Table 13: Coal Household Composition in terms of Elderly dependents, Census 2011

		No. Coal Employees in Coal Households		
		1	>1	Total
No. Elderly Dependents in Coal HHs	0	40.3 87.6%	3.6 7.8%	43.9 **95.4%**
	1	1.7 3.7%	0.1 0.2%	1.8 3.9%
	>1	0.3 0.6%	0.0 0.0%	0.3 0.6%
	Total	42.3 92.0%	3.7 8.0%	46.1 100%

Source: Authors' calculations using South Africa Census (Statistics South Africa; 2015)

Note: In each cell reporting numerical estimates, the first value reports the weighted number of households (in 000s), and the second value reports the share of coal households. According to the individual-level dataset, there are 3 960 unique household IDs with a coal related employee, prior to weighting. When matching between the individual-level and household-level data in the 2011 Census data, 136 coal workers in the individual-level data do not match up to a household. These individuals are lost when using the household specific weights, as they do not have a household weight attached. Thus, the total number of coal households used for the weighted values is 3 824. Due to rounding, the shares of coal households may not sum up to exactly 100%.

The majority of coal households are single coal-worker households (92%) (see Table 10). When there is an individual employed elsewhere, this is typically only one other employed individual in the household. In addition, one third of coal households have at least one unemployed individual, but two-thirds of these households have only one unemployed dependent. In terms of children and elderly dependents, there are very few elderly dependents present in coal households relative to child dependents. Although the mean household size of all coal households is 3.4, when we isolate coal households with no age-related, not economically active or unemployed dependents, the average household size is 1.5. However, when we repeat this exercise for households with at least one type of dependent present, the mean household size increases to 4.6. Since 85% of households have either one or two employed individuals (including coal workers), this suggests that where dependents are present in a household, there are likely to be at least 2 of them.

Table 14 provides a breakdown of coal households, grouping them by the number of dependents and the number of individuals in the households employed elsewhere. The table is colour-coded to indicate the household's level of vulnerability to mine closures. Green and yellow households account for 38.3% of coal households (17 600 households) and can be considered less vulnerable in terms of additional income streams, and less exposed in terms of responsibilities to dependents. Orange and red households are the most exposed, because these households have additional dependents to consider when thinking of mine closures. Red households are also solely reliant on coal income, as they have zero individuals employed elsewhere. These households account for 61.6% of households, meaning that the majority of coal households (28 400 households) fall within the higher vulnerability categories.

There are approximately 4 700 green households, which have zero dependents and are not solely reliant on coal income, because they have individuals employed elsewhere. These households are less vulnerable because the closure of coal mines would mean that even if the coal employee(s) in the household lose their jobs, there are other individuals in the household with employment. To the extent that these jobs are not linked to the coal value chain, these households are less vulnerable to adverse employment shocks emerging from the transition. There are approximately 12 800 yellow households, which are made up entirely of coal-workers. Thus, despite not having any additional dependents, they also have no alternative sources of labour income. Therefore, these households are more vulnerable to the closure of mines than green households, as they will lose their only source of labour income.

Table 14: Overall Household Composition of Coal households, Census 2011

		No. Dependents (age-related, unemployed and not econ. active)				
		0	1	2	>2	TOTAL
No. Other Employed (incl. utils)	0	12.8 27.8%	4.7 10.3%	4.1 8.8%	7.9 17.2%	29.5 64.1%
	1	3.7 8.1%	2.3 5.0%	2.7 5.8%	3.7 8.1%	12.4 27.0%
	2	0.7 1.6%	0.4 0.8%	0.5 1.1%	1.1 2.3%	2.7 5.9%
	>2	0.3 0.7%	0.3 0.5%	0.2 0.4%	0.6 1.3%	1.4 3.0%
	TOTAL	17.6 38.3%	7.7 16.6%	7.4 16.1%	13.3 28.9%	46.1 100.0%

Source: Authors' calculations using South Africa Census (Statistics South Africa; 2015)

Note: 1. In each cell reporting numerical estimates, the first value reports the weighted number of households (in 000s), and the second value reports the share of coal households. 2. According to the individual-level dataset, there are 3 960 unique household IDs with a coal related employee, prior to weighting. When matching between the individual-level and household-level data in the 2011 Census data, 136 coal workers in the individual-level data do not match up to a household. These individuals are lost when using the household specific weights, as they do not have a household weight attached. Thus, the total number of coal households used for the weighted values is 3 824. 3. Due to rounding, the shares of coal households may not sum up to exactly 100%. 4. Colour-coding in order of vulnerability: Green households have 1 or more individuals employed outside of coal and zero dependents; yellow households have zero dependents, but also have zero individuals employed outside of coal employment; orange households have one or more age-related, unemployed or not economically active dependent(s) and one or more individuals employed outside of coal employment; red households have zero individuals employed outside of coal employment and have one or more dependents.

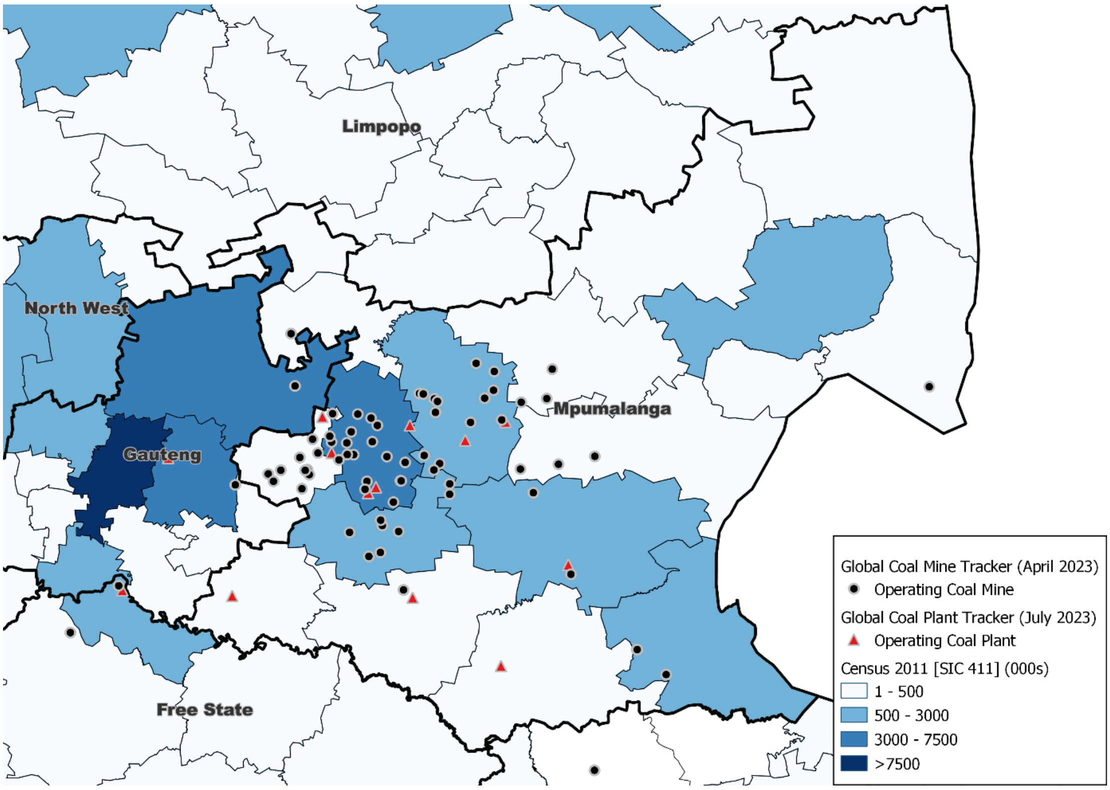
There are approximately 11 800 and 16 700 orange and red households, respectively. Although orange households have individuals employed elsewhere, they already have dependents to care for. The loss of the coal labour income, and the addition of those coal workers becoming dependents while they search for alternative work, will limit the ability of these households to cover costs and care for the dependents that they already have. However, red households will suffer the same problems of providing for existing dependents while searching for alternative work, together with the loss of their only source of labour income.

6.3 Employment in coal-driven electricity generation industry in Mpumalanga

We now analyse a subset of employment indirectly related to the broader coal value chain. More specifically, we focus on employment linked to the generation of electricity, as captured by *SIC411: Production, collection and distribution of electricity.* We focus on electricity production in the Mpumalanga province because all electricity production by the national utility (Eskom) is coal-fired (refer to Section 4.2 for further discussion).

In contrast to the coal mining industry, employment in the electrical utility industry is not as concentrated in a single province. However, coal-fired power stations are concentrated around the coal mines, as illustrated by Figure 1. As such, we do see that the share of employment in electricity generation is largest in the Gauteng province (33.2% of employment), where the national electricity utility's head office is located, and the Mpumalanga province (18.3% of employment), where 11 of South Africa's 14 coal-fired power stations are located (Statistics South Africa; 2015a). Figure 15 illustrates the concentration of employment in the production, collection and distribution of electricity industry (SIC411) within these provinces. Given the strong linkages between coal mining production and coal-fired power production in Mpumalanga, in the analysis to follow, emphasis is placed on the electrical utility industry in Mpumalanga.

Figure 15: Electrical utility industry employment in 2011 Census data in Mpumalanga and South Africa



Source: Authors' calculations using South Africa Census (Statistics South Africa; 2015a)

6.3.1 Jobs in the electrical utility industry

Table 15 presents characteristics of the electrical utility industry workers in 2011 for both South Africa and Mpumalanga. The table also presents the same characteristics for electrical utility industry employees in Mpumalanga in 2011 and 2019. This is important for our understanding of how the employee base has been changing and developing over time. We also present a ratio of the employment share for electrical utility industry workers to the corresponding employment share for other formal sector workers in Mpumalanga by covariate.

The electrical utility industry is Black African and male dominated, and this is consistently observed across all datasets and timeframes. According to the LMD dataset, between 2011 and 2019, the share of female electrical utility industry employees in Mpumalanga increased from 22 to 30%. This suggests an increase in gender diversity in the industry in Mpumalanga. Black African employees form the majority in all datasets, with their share of employment increasing from 68% in 2011 to 74% in 2019 in Mpumalanga. White employees' share of employment in the industry remained relatively stable between 2011 and 2019. However, the employment share ratio suggests that workers in this industry are relatively more likely to be White than the average worker in the formal sector in Mpumalanga.

Electrical utility industry workers tend to be aged between 25 and 44 years of age. In 2019, the 25 to 34 and 35 to 44 age group categories account for 41 and 33% of employment in the electrical utility industry, respectively. Both these age groups increased their share of employment. The share of workers aged 55-64 more than doubled, from 7% in 2011 to 18% in 2019, which is suggestive of an aging workforce. The age group categories that experienced rising employment shares are also those where there is a higher representation of electrical utility industry workers relative to other formal sector workers. The changing age distribution of employees is an important consideration for how the just transition and closure of power plants will take place.

Table 15: Individual worker characteristics in the electrical utility industry

	Employment in the electrical utility industry				**Ratio Coal:Formal**
	South Africa	Mpumalanga			Mpumalanga
	Census 2011	Census 2011	LMD 2011	LMD 2019	2019
Total No. of employees (weighted)	79 400	14 600	19 600	30 481	
Gender					
Male	0.71	0.74	0.78	0.70	1.14
Race					
Black/African	0.69	0.77	0.68	0.74	0.84
White	0.18	0.20	0.30	0.26	2.59
Other	0.13	0.03	0.02		
Age Group					
15-24	0.12	0.13	0.05	0.01	0.15
25-34	0.37	0.36	0.36	0.41	1.21
35-44	0.25	0.23	0.24	0.33	1.09
45-54	0.17	0.19	0.28	0.07	0.33
55-64	0.09	0.09	0.07	0.18	2.21
Educational Attainment					

Primary or less	0.11	0.12	0.03	0.01	0.16
Secondary uncompleted	0.25	0.26	0.54	0.29	1.00
Secondary completed	0.33	0.34	0.04	0.30	0.82
Diploma	0.19	0.20	0.37	0.24	1.30
Degree	0.12	0.07	0.02	0.16	1.92

Source: Authors' calculations using South Africa Census (Statistics South Africa, 2015a) and Labour Market Dynamics (Statistics South Africa, 2011; 2021b).

Note: Utilities refers to the Production, Collection and Generation of Electricity (SIC411). Due to rounding, the shares of utilities employees may not sum up to exactly 100%. Shares represent the share of total coal employment by covariate.

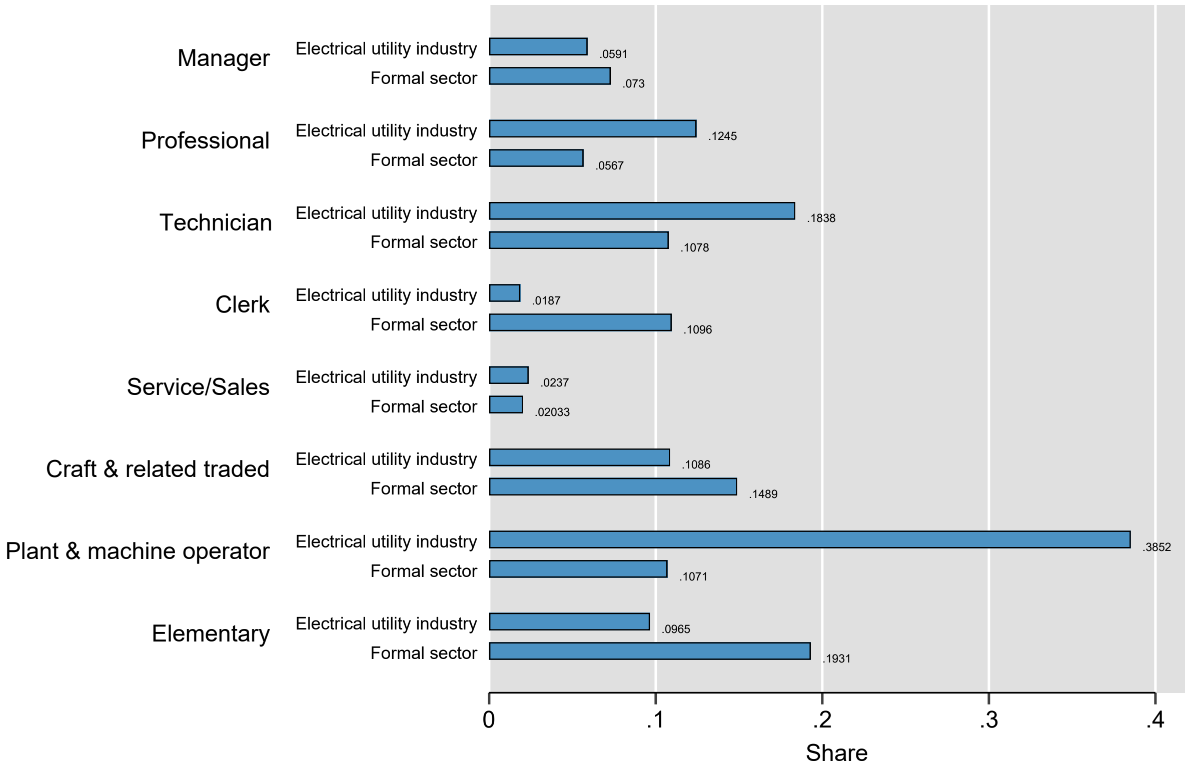
Electrical utility industry workers are relatively more educated than the average formal sector worker in Mpumalanga. Employment ratios for the diploma and degree education level categories are in excess of unity. Further, close to a quarter of workers in the industry have a diploma, and a further 16% have a degree (almost double the share for the formal sector in Mpumalanga). The proportion of employees with a degree increased by a factor of eight from 2% in 2011 to 16% in 2019. The share of individuals with a completed secondary education also increased. Thus, the level of education attainment in the electrical utility industry has increased over the period.

Electrical utility industry workers tend to be located in professional, technician and plant and machine operator occupations.[36] Figure 16 shows that 12.45, 18.38 and 38.52% of the workforce in the industry are located in these occupation groupings, respectively. Workers in the electrical utility industry are more likely to be found in these occupation groupings relative to other formal sector workers in Mpumalanga. This suggests that the electrical utility industry is an industry that can be characterised as relatively high-skilled. [37]

[36] Appendix Table A 10 provides employment share estimates by occupation for the Census and LMD datasets, the South African and Mpumalanga labour markets, and the periods 2011 and 2019.

[37] High skill occupations comprise managers, professionals, and technicians. Skilled occupations comprise clerks, service and sale occupations, craft and related trades, and plant and machine operators. Low-skilled occupations comprise elementary occupations.

Figure 16: The occupational profile of electrical utility industry workers in MP, 2019



Source: Authors' calculations using Labour Market Dynamics (Statistics South Africa, 2021b)

Notes: Formal sector accounts for total employment in the formal sector labour market.

In the context of the transition, the data presented in Figure 16 highlight some important considerations for workers. The majority of the workforce in the sector are high-skilled or semi-skilled employees. This is further evident in Table 16, where we see that 11.43% of the labour force have a degree and work in a professional occupation, 8.35% of the workforce have a diploma and work in a technician occupation, and a further 9.56% of the workforce have a diploma and work in a plant and machine operator occupation. The high shares of professional and technician workers in the electrical utility industry means that a large share of employees possess technical expertise, which may be beneficial when moving into new positions/occupations. These workers may be able to leverage the technical expertise that they already possess and find it easier to transition to new roles in emerging or low-carbon industries.

Table 16: Distribution of electrical utility industry workers in Mpumalanga by occupation and education level, 2019

	Primary	Incomplete secondary	Complete secondary	Diploma	Degree	Total
Manager		660 2.16%		995 3.26%		1 655 5.43%
Professional					3485	3485
Technician		1 224 4.02%	395 1.30%	2 544 8.35%	981 3.22%	5 144 16.88%
Clerk		346 1.13%		177 0.58%		523 1.71%
Sales/services		664 2.18%	353 1.16%			1 017 3.34%
Craft & related traded		1 620 5.32%	2 602 8.54%	783 2.57%		5 005 16.42%
Plant & machine operator	267 0.88%	3 573 11.72%	3 673 12.05%	2 914 9.56%	320 1.05%	10 954 35.94%
Elementary		721 2.37%	1 979 6.49%			2 700 8.86%
Total	267 0.88%	8 808 28.9%	9 002 29.53%	7 413 24.32%	4 786 15.70%	30 483 100.00%

Source: Authors' calculations using Labour Market Dynamics (Statistics South Africa, 2021b)

Notes: Levels (top figure) and shares (bottom figure) are reported for each occupation-education level combination (each cell). Summation of all occupation-education level combinations equals total electrical utility industry employment in Mpumalanga. Increasing shares and levels of employment are represented by cells being shaded from lighter to darker shades of green.

As with coal mining industry workers, electrical utility industry jobs are predominantly formal, and as such, jobs in the industry are characterised by high levels of UIF contributions, pension contributions, and various forms of leave.[38] All employees in the industry have a written contract, 82% of employees pay and have access to the Unemployment Insurance Fund (UIF), 86% pay a pension or retirement fund contribution, and 88% enjoy medical aid benefits. Further, 89, 98 and 82% of employees in the industry are entitled to paid annual, sick and parental leave, respectively. Additionally, the prevalence of unionized employees has increased over time, with 66% of employees belonging to a union in 2011 and rising to 88% in 2019. Overall, the data suggest that, on average, electrical utility industry jobs have better employment conditions than the average formal sector job in Mpumalanga. We observe in Table 17 that all job indicators have a ratio greater than unity. As such, a shift to another formal

[38] While not reported in the main text, electrical utility industry jobs are predominantly formal. This is shown in Appendix Table A 11.The enterprise definition used by Statistics South Africa indicates that 92% of electrical utility industry jobs in 2019 are formal sector jobs.

sector job is likely to result in a lower job quality outcome for the average coal mining industry worker.

Table 17: Characteristics of electrical utility industry jobs

Job characteristics	LMD	LMD	LMD	Ratio Coal:Formal
	Mpumalanga	South Africa	Mpumalanga	Mpumalanga
	2011	2019	2019	2019
Total No. of employees (weighted)	19 600	93 900	30 481	
Duration of contract				
Contract	0.04	0.06	0.09	0.75
Permanent	0.91	0.92	0.86	1.23
Employment Status				
Written	1.00	0.99	1.00	1.06
UIF				
Yes	0.90	0.76	0.82	1.22
Union membership				
Yes	0.66	0.81	0.88	1.87
Medical Aid				
Yes	0.87	0.87	0.88	2.32
Pension				
Yes	0.94	0.91	0.86	1.43
Annual leave				
Yes	0.95	0.91	0.89	1.16
Sick leave				
Yes	0.95	0.98	0.98	1.20
Parental leave				
Yes	0.94	0.90	0.82	1.32

Source: Authors' calculations using Labour Market Dynamics (Statistics South Africa, 2011; 2021b)

Note: Utilities refers to the Production, Collection and Generation of Electricity (SIC411). Due to rounding, the shares of utilities employees may not sum up to exactly 100%.

6.3.2 Households linked to the electrical utility industry

In total there were 1 152 observations for electrical utility industry employees working in Mpumalanga in the 2011 Census data sample, which equates to a weighted amount of 15 000 electrical utility industry workers. When matching these individuals to the households, this equates to 13 000 electrical utility industry households (1 030 observations in 2011 Census household data). The mean size of an electrical utility industry household is 3.7.

According to Table 18, there is not a substantial overlap between coal mining industry and electrical utility industry households in Mpumalanga. Just under 8% of electrical utility industry households in Mpumalanga have one or more coal mining industry employees present in the household. The vast majority of these households (86.2%) are single electrical utility industry worker households with no other coal mining industry workers present. Although these households are not directly exposed in the event of the closure of coal mines/retrenchment of coal employees, there is an indirect exposure, due to the relationship between coal mines and coal-powered stations. These households are reliant on coal mining because the power plants that employ them are reliant on coal power.

Table 18: Electrical utility industry household composition in terms of coal employment, Census 2011

		No. Utilities Employees in Utilities Households		
No. Coal Employees in Utilities HHs		1	>1	Total
	0	10.5	0.7	11.2
		86.16%	5.98%	**92.14%**
	1	0.7	0.1	0.9
		6.09%	0.88%	6.97%
	2	0.1	0.01	0.1
		0.80%	0.09%	0.89%
	Total	11.3	0.9	12.2
		93.05%	6.95%	100.00%

Source: Authors' calculations using South Africa Census (Statistics South Africa, 2015)

Note: In each cell reporting numerical estimates, the first value reports the weighted number of households (in 000s), and the second value reports the share of coal households. According to the individual-level dataset, there are 1 061 unique household IDs with a utilities related employee. When matching between the individual-level and household-level data in the 2011 Census data, 31 utilities workers in the individual-level data do not match up to a household. These individuals are lost when using the household specific weights, as they do not have a household weight attached. Thus, the total number of utilities households used for the weighted values is 1 030. Due to rounding, the shares of utilities households may not sum up to exactly 100%.

However, looking at Table 19, more than 40% of electrical utility industry households have at least one individual employed elsewhere (not in coal mining or electrical utility industry employment). This is slightly higher than the share of coal households that have at least one individual employed outside of the coal mining or electrical utility industries (35%). Almost one-tenth (9.5%) of electrical utility industry households also have more than one individual employed elsewhere, making these households less exposed to the closure of coal mines, and the decommissioning of coal-fired power stations. As with the coal households, the closure of mines and coal-fired power plants in the Mpumalanga province may still negatively impact businesses in these municipalities as coal industry and electrical utility industry workers search for alternative work, likely resulting in many individuals moving to different towns or provinces to find work. Thus, in addition to these households losing a portion of their income through the potential indirect negative impact of mine and power plant closures, those individuals in these households who are currently employed elsewhere may also be affected.

Table 19: Electrical utility industry household composition in terms of other employment, Census 2011

		No. Utilities Employees in Utilities Households		
No. Other Employed individuals in Utilities HHs		1	>1	Total
	0	6.7	0.4	7.1
		54.99%	3.61%	58.60%
	1	3.5	0.3	3.7
		28.55%	2.13%	30.67%
	>1	1.2	0.2	1.3
		9.52%	1.21%	10.73%
	Total	11.3	0.9	12.2
		93.05%	6.95%	100.00%

Source: Authors' calculations using South Africa Census (Statistics South Africa, 2015)

Note: In each cell reporting numerical estimates, the first value reports the weighted number of households (in 000s), and the second value reports the share of coal households. According to the individual-level dataset, there are 1 061 unique household IDs with a utilities related employee. When matching between the individual-level and household-level data in the 2011 Census data, 31 utilities workers in the individual-level data do not match up to a household. These individuals are lost when using the household specific weights, as they do not have a household weight attached. Thus, the total number of utilities households used for the weighted values is 1 030. Due to rounding, the shares of utilities households may not sum up to exactly 100%.

Similar to coal households, more than one-quarter (28.1%) of electrical utility industry households have unemployed dependents (Table 20). Of these households, a quarter (27%) have multiple unemployed dependents present (the mean number of unemployed dependents in households with unemployed individuals present is 1.4). Households with unemployed individuals present also appear more likely to have one electrical utility industry employee, rather than multiple electrical utility industry employees.

Table 17: Electrical utility industry household Composition in terms of unemployed, Census 2011

		No. Utilities Employees in Utilities Households		
No. Unemployed individuals in Utilities HHs		1	>1	Total
	0	8.2	0.6	8.8
		67.12%	4.86%	71.98%
	1	2.3	0.2	2.5
		18.98%	1.31%	20.29%
	>1	0.9	0.1	0.9
		6.96%	0.77%	7.73%
	Total	11.3	0.9	12.2
		93.05%	6.95%	100.00%

Source: Authors' calculations using South Africa Census (Statistics South Africa, 2015)

Note: In each cell reporting numerical estimates, the first value reports the weighted number of households (in 000s), and the second value reports the share of coal households. According to the individual-level dataset, there are 1 061 unique household IDs with a utilities related employee. When matching between the individual-level and household-level data in the 2011 Census data, 31 utilities workers in the individual-level data do not match up to a household. These individuals are lost when using the household specific weights, as they do not have a household weight attached. Thus, the total number of utilities households used for the weighted values is 1 030. Due to rounding, the shares of utilities households may not sum up to exactly 100%.

Table 21 and Table 22 introduce age-related dependency of the electrical utility industry households. Similar to the coal households, almost all (94.1%) of these households do not have elderly dependents, and just under half (47.6%) of these electrical utility industry households have at least one child dependent. As is the case with coal households, more than half of electrical utility industry households that have a child dependent (59.5%), typically have more than one child dependent, and the mean number of child dependents in electrical utility industry households is also 2.0.

Table 18: Electrical utility industry household composition in terms of child dependents, Census 2011

		No. Utilities Employees in Utilities Households		
No. Child Dependents in Utilities HHs		1	>1	Total
	0	6.0	0.4	6.4
		49.06%	3.36%	52.42%
	1	2.2	0.2	2.4
		17.69%	1.59%	19.28%
	>1	3.2	0.2	3.5
		26.30%	2.00%	28.30%
	Total	11.3	0.9	12.2
		93.05%	6.95%	100.00%

Source: Authors' calculations using South Africa Census (Statistics South Africa, 2015)

Note: In each cell reporting numerical estimates, the first value reports the weighted number of households (in 000s), and the second value reports the share of coal households. According to the individual-level dataset, there are 1 061 unique household IDs with a utilities related employee. When matching between the individual-level and household-level data in the 2011 Census data, 31 utilities workers in the individual-level data do not match up to a household. These individuals are lost when using the household specific weights, as they do not have a household weight attached. Thus, the total number of utilities households used for the weighted values is 1 030. Due to rounding, the shares of utilities households may not sum up to exactly 100%.

Table 19: Utilities Household Composition in terms of Elderly dependents, Census 2011

		No. Utilities Employees in Utilities Households		
No. Elderly Dependents in Utilities HHs		1	>1	Total
	0	10.7	0.8	11.5
		87.69%	6.43%	94.12%
	1	0.6	0.1	0.6
		4.57%	0.43%	5.00%
	>1	0.1	0.01	0.1
		0.79%	0.09%	0.88%
	Total	11.3	0.9	12.2
		93.05%	6.95%	100.00%

Source: Authors' calculations using South Africa Census (Statistics South Africa, 2015)

Note: In each cell reporting numerical estimates, the first value reports the weighted number of households (in 000s), and the second value reports the share of coal households. According to the individual-level dataset, there are 1 061 unique household IDs with a utilities related employee. When matching between the individual-level and household-level data in the 2011 Census data, 31 utilities workers in the individual-level data do not match up to a household. These individuals are lost when using the household specific weights, as they do not have a household weight attached. Thus, the total number of utilities households used for the weighted values is 1 030. Due to rounding, the shares of utilities households may not sum up to exactly 100%.

The majority of electrical utility industry households are single electrical utility industry worker households (93%). When there is an individual employed elsewhere – whether this is a coal worker or not – there is usually only one other employed individual in the household. However, almost 10% of households have more than one individual employed elsewhere. In addition, just over one-quarter of electrical utility industry households have at least one unemployed individual, but most households with unemployed individuals have only one unemployed dependent. In terms of children and elderly dependents, there are very few elderly dependents present in electrical utility industry households relative to child dependents. The mean household size of all coal-worker households is 3.7. However, electrical utility industry households with no age-related, not economically active, or unemployed dependents have an average household size of 1.7. Similar to observations with coal households, when we observe households with at least one type of dependent present, the mean household size increases to 4.7. When there are child dependents present, there are two children, meaning that households are likely made up of two adults and two children.

Table 23 provides a breakdown of the households, grouping them by the number of dependents and the number of individuals in the household employed outside of utilities (where those employed elsewhere excludes those employed in coal). The table is colour-coded to indicate the household's level of vulnerability and exposure to coal-powered plant closures. Green and yellow households account for 33% of electrical utility industry households (4 000 households) and have a lower level of vulnerability and exposure than orange and red households. Orange and red households are the most vulnerable and exposed, because these households have additional dependents to consider when considering the closure of coal-powered plants. These households account for 67% of households (8 100 households), meaning that most electrical utility industry households fall within the two higher vulnerability categories.

Table 20: Overall Household Composition of Utilities households, Census 2011

		No. Dependents (age-related, unemployed and not econ. active)				
		0	1	2	>2	TOTAL
No. Other Employed (excl. coal)	0	2.6 21.6%	1.2 10.1%	1.0 8.5%	2.2 18.4%	7.1 58.6%
	1	1.1 8.8%	0.8 6.6%	0.9 7.2%	1.0 8.0%	3.7 30.7%
	2	0.2 1.4%	0.1 0.9%	0.2 1.4%	0.5 3.7%	0.9 7.4%
	>2	0.2 1.2%	0.1 0.6%	0.0 0.3%	0.1 1.2%	0.4 3.3%
	TOTAL	4.0 33.0%	2.2 18.3%	2.1 17.3%	3.8 31.4%	12.2 100%

Source: Authors' calculations using South Africa Census (Statistics South Africa, 2015)

Note: 1. In each cell reporting numerical estimates, the first value reports the weighted number of households (in 000s), and the second value reports the share of coal households. 2. According to the individual-level dataset, there are 1 061 unique household IDs with a utilities related employee. When matching between the individual-level and household-level data in the 2011 Census data, 31 utilities workers in the individual-level data do not match up to a household. These individuals are lost when using the household specific weights, as they do not have a household weight attached. Thus, the total number of utilities households used for the weighted values is 1 030. 3. Due to rounding, the shares of utilities households may not sum up to exactly 100%. 4. Colour-coding in order of vulnerability: Green households have 1 or more individuals employed outside of coal and zero dependents; yellow households have zero dependents, but also have zero individuals employed outside of coal employment; orange households have 1 or more age-related, unemployed or not economically active dependent(s) and 1 or more individuals employed outside of coal employment; red households have zero individuals employed outside of coal employment and have 1 or more dependents.

There are approximately 1 500 green households, which have zero dependents and are not solely reliant on income from electrical utility industry employment, because they have individuals employed elsewhere. These households are vulnerable because the closure of coal-fired power plants would mean that the utilities employee(s) in the household would become unemployed and will need to find work elsewhere. There are approximately 2 600 yellow households. These are households made up entirely of electrical utility industry workers. Thus, despite not having any additional dependents, they also have no alternative sources of labour income. Therefore, these households are more vulnerable to the closure of mines than green households, as they will lose their only source of labour income as a result of plant closures.

There are approximately 3 600 orange electrical utility industry households (29.9% of all electrical utility industry households) and 4 500 red electrical utility industry households (37.0% of all electrical utility industry households). Although orange households have individuals employed elsewhere, they have other dependents to care for. The loss of labour income from the electrical utility industry workers, in addition to those workers becoming dependents while they search for alternative work, will limit the ability of these households to cover costs and care for the dependents that they already have. Orange households will be limited to the labour income of the individuals employed elsewhere, while the electrical utility industry workers find alternative employment. Red households will suffer the same problems of providing for existing dependents while searching for alternative work. However, these households will lose their only source of labour income.

7 Concluding remarks and discussion on Transition Numbers

This paper aimed to quantify the number of individuals set to be impacted by the transition away from a fossil fuel-based economy. In particular, to calculate a quantum of those employed in the coal mining and the electrical utility industries, and a quantum of the households dependent on wage income from those employed in these industries. We also explored the labour market profile and characteristics of the individuals and households linked to these industries. In this section, we address these research objectives by consolidating the numbers reported in Section 6.

The coal mining industry's direct economic footprint is relatively small. The industry accounts for approximately 20% of the mining and quarrying sector's GVA, and this share has been growing over the past two decades. Nationally, the industry accounts for approximately 1% of national GVA, which is relatively small. For a comparative perspective, the food, beverages and tobacco, the wood and paper, the petroleum products, chemicals, rubber and plastics, the metals, metal products and machinery and equipment, and the transport equipment industries, contributed 2.88, 1.26, 3.0, 2.52, and 1.07% to GVA, respectively. These manufacturing industries – key drivers of a country's (re)industrialisation pathway – contribute substantially larger shares of GVA than the coal mining industry.

However, while the coal mining industry may account for a relatively small share of national GVA, the industry's footprint is felt more acutely in its many linkages with the broader coal value chain that encompasses the power generation and the downstream chemicals industries, to name but two. In addition, the industry is an important source of export revenue. Coal exports account for 4.8% of total merchandise exports. Despite the global transition away from coal, the coal mining industry and the broader coal value chain remains very important in South Africa and will need careful consideration when transitioning.

Mpumalanga is the hub of South Africa's coal mining industry. Of South Africa's 78 operating coal mines, 65 are in Mpumalanga, and together, these mines account for 80% of coal production in South Africa. Consequently, the bulk share (between 72.3 and 86.7%) of employment in the South African coal mining industry is located in the Mpumalanga province. Coal employment in Mpumalanga is further concentrated within four local municipalities: eMalahleni, Steve Tshwete, Govan Mbeki and Msukaligwa, which together make up 86.2% of total coal industry employment in Mpumalanga, and 79.8% of coal industry employment in South Africa (in 2011).

In terms of our quantification of coal industry jobs, we find that, in 2019, the industry accounts for 76 406 jobs nationally (see Table 24). Employment correlates with production, and thus the bulk share of these coal industry jobs – 66 252 jobs (86.7%) – are located in Mpumalanga. The remaining 10 154 coal industry jobs (13.3%) are located in the rest of South Africa.[39] A further 30 481 electrical utility jobs, linked to coal-fired power production, are located in Mpumalanga. Thus, we estimate approximately 106 887 direct and indirect jobs linked to the coal value chain.[40]

Table 21: Quantification of coal mining industry employment in South Africa and electrical utility industry employment in Mpumalanga, 2019

	Coal mining industry		Electrical utility industry	Total
	Mpumalanga	Rest of South Africa	Mpumalanga	
Total	66 252	10 154	30 481	106 887
Gender				
Male	53 204 *80.3%*	*9 582* *94.4%*	21 341 *70.0%*	84 127 *78.7%*
Race				
Black/African	53 556 *80.8%*	10 037 *98.8%*	22 468 *73.7%*	86 061 *80.5%%*
White	12 697 *19.2%*	117 *1.2%*	8 012 *26.3%*	20 709 *19.4%*
Age groups				
15-24	5 284 *8.0%*	215 *2.1%*	177 *0.6%*	5 676 *5.3%*
25-34	28 297 *42.7%*	4 004 *39.4%*	12 588 *41.3%*	44 889 *42.0%*

[39] Most of these residual coal industry jobs are located in Gauteng (3 565) and KwaZulu-Natal (4 267).

[40] Noting that this is an underestimate of the broader coal value chain.

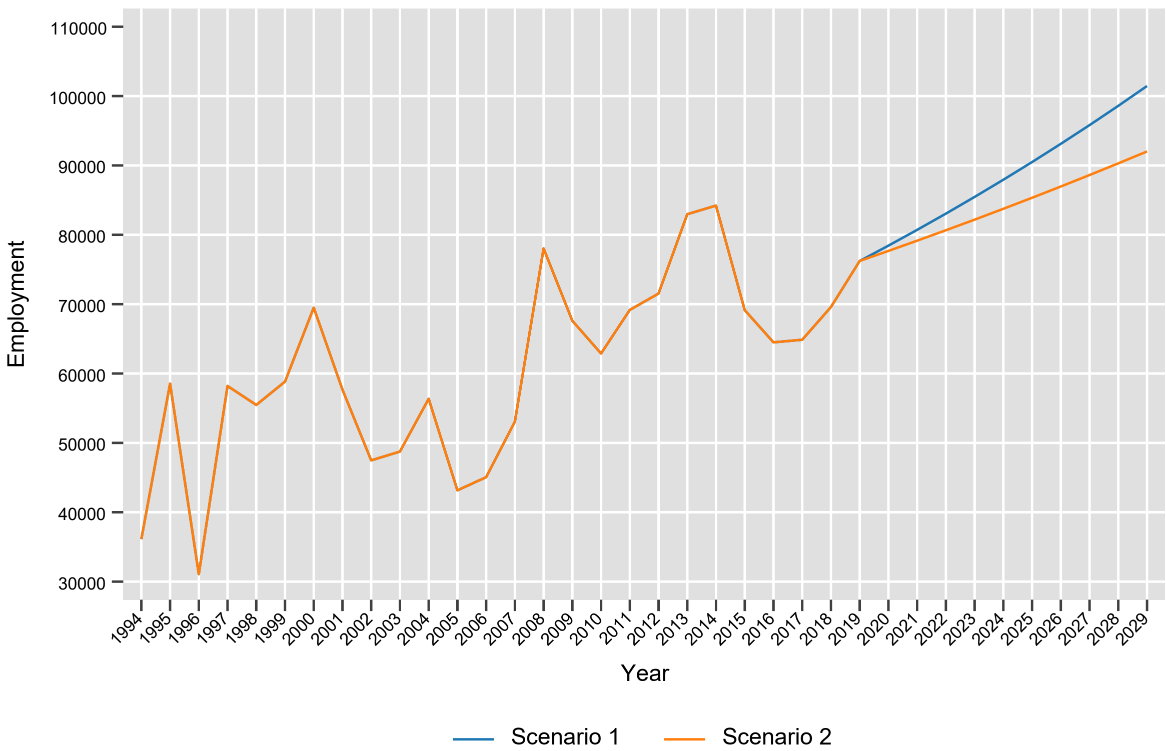
35-44	14 407 *21.7%*	2 532 *24.9%*	10 034 *32.9%*	26 973 *25.2%*
45-54	14 565 *22.0%*	2 432 *24.0%*	2 215 *7.3%*	19 212 *18.0%*
55-64	3 700 *5.6%*	971 *9.6%*	5 468 *17.9%*	10 139 *9.5%*

Source: Authors' calculations using Labour Market Dynamics (Statistics South Africa, 2021b)

The average worker across these two industries is Black African, male and young. Looking at Table 25, we observe that 84 127 workers across these industries are male, with the relative shares of male workers being greater in the coal mining industry (80.8% in Mpumalanga and 94.4% in other provinces). Black Africans comprise the bulk of the workforce – 86 061 employees – while white employees comprise approximately a fifth of the workforce. The workforce is young, with almost half of those employed – 50 565 workers or 47.3% of the workforce – in these two industries, falling within the two youth age group categories; with the majority residing in the older youth age group (25-34).

The transition is a process, and thus the quantum of jobs in the coal industry, and associated policy cost, will change over time. In Figure 17 we present two simplistic scenarios to project the level of employment in the coal industry in 2029. Scenario 1 projects employment growth based on annualised growth rate of 2.9% for the full period of data (1994 to 2019), while Scenario 2 projects employment growth based on annualised growth rate of 1.9% for a more recent period (2010 to 2019). While it is difficult to accurately make such projections, we can get a sense of where employment in the industry will stand at the end of this decade. Assuming a growth rate consistent with that achieved since 1994, coal industry employment should stand at approximately 101 456 jobs in 2029. Should a lower growth rate, similar to that achieved over the past decade, be realised, then employment should stand at approximately 92 016 jobs in 2029. Given the endogenous and exogeneous forces impacting on the coal industry, and hence driving the transition, the lower estimate evident in Scenario 2, may be the more realistic of the two.

Figure 17: Employment Projection for Coal Industry Employment - 10-year period



Source: Authors' calculations using PALMS (Kerr, Lam & Wittenberg, 2019)

Notes: Projections based off PALMS estimates. Scenario 1 projects employment growth based on annualised growth rate of 2.9% between 1994 and 2019. Scenario 2 projects employment growth based on annualised growth rate of 1.9% between 2010 and 2019.

Again, using the occupation-education level space, we put together a first attempt at breaking up the just transition challenge by dividing the coal and coal-related workforce into three analytical groupings. The first grouping, defined as the *no just transition challenge* grouping, comprises workers with a post-secondary education qualification, who work in high-skilled or semi-skilled occupations, and can thus be considered as relatively high-skilled. Across the two industries, this grouping accounts for 29.28% of the workforce or 31 187 workers. Given the relatively high skill level of workers in this grouping, it is likely that they will be able to find alternative employment opportunities, and thus the market is set to resolve the transition challenge for this grouping of workers.

Table 22: Distribution of coal mining and electrical utility industry employment in Mpumalanga by occupation and education level, 2019

	Primary	Incomplete secondary	Complete secondary	Diploma	Degree	Total
Manager		660 0.62%	199 0.19%	**1 722** **1.62%**	**724** **0.68%**	3 305 3.10%
Professional		187 0.18%	117 0.11%	**1 149** **1.08%**	**3 485** **3.27%**	4 938 4.64%
Technician		2 112 1.98%	2 735 2.57%	**4 198** **3.94%**	**1 855** **1.74%**	10 900 10.23%
Clerk		346 0.32%	1 403 1.32%	**2 482** **2.33%**		4 231 3.97%
Sales/services		664 0.62%	866 0.81%			1 530 1.44%
Craft & related traded	411 0.39%	9 231 8.67%	14 412 13.53%	**9 136** **8.58%**	**1 525** **1.43%**	34 467 32.59%
Plant & machine operator	2 352 2.21%	13 246 12.43%	17 987 16.88%	**4 591** **4.31%**	**320** **0.30%**	38 496 36.14%
Elementary	298 0.28%	4 689 4.40%	3 208 3.01%	221 0.21%		8 416 7.90%
Total	3 061 2.87%	31 135 29.23%	40 927 38.42%	23 499 22.06%	7 909 7.42%	106 531 100.00%

Source: Authors' calculations using Labour Market Dynamics (Statistics South Africa, 2021b)

Notes: Levels (top figure) and shares (bottom figure) are reported for each occupation-education level combination (each cell). Total does not add up to aggregate number reported above due to omission of unspecified education category in data. Summation of all occupation-education level combinations equals total coal industry employment in South Africa and electrical utility industry employment in Mpumalanga. Increasing shares and levels of employment are represented by cells being shaded from lighter to darker shades of green.

The second grouping, defined as an *intermediate just transition challenge*, comprises those with at most a complete secondary education, and who work in high- or semi-skilled occupations. This grouping of predominantly semi-skilled workers numbers 66 928, or almost two-thirds of the workforce (62.82%). Given the semi-skilled nature of this large grouping of workers, there is a degree of uncertainty regarding the appropriate policy intervention. The relatively more skilled workers within this grouping may require a skills top-up intervention, which may facilitate a more successful match into alternative employment opportunities. The less skilled workers within this grouping may require a special allocation from government into green jobs.

The third grouping, defined as the *just transition challenge*, comprises those engaged in low-skill elementary occupations. This low-skilled grouping is comprised of 8 416 workers (7.9% of the workforce). These low-skill workers are unlikely to successfully match into alternative employment opportunities, and thus social protection in the form of income support, offers the best policy response for this grouping.

A fourth grouping of workers, defined as the *retirement cohort*, are those who are set to exit the workforce through retirement over the coming decade. This group constitutes those who are set to naturally exit as they reach retirement age – those aged 55 and 64 years of age – and those who may warrant early retirement packages – those aged 45 to 54 years of age. Drawing on the former quantifies 10 139 employees (9.5%), and the latter 19 212 employees (18%). It is worth noting that the older contingent within the electrical utility industry pushes up the aggregate for the two industries. The age distribution of the coal industry is skewed toward the younger cohorts, and early retirement interventions are likely to be less prevalent in the coal industry.

According to the 2011 Census, the number of households in Mpumalanga with incomes derived from jobs in the coal mining and electrical utility industries totals 57 300 – see row 1 of Table 26. This is made up of 45 100 households with coal mining industry workers, 11 200 households with electrical utility industry workers, and 1 000 households with workers from both industries. Interestingly, there is only a small overlap between coal mining industry and electrical utility industry households, making up only 1.75% of total households.

Table 23: Overall Household Composition, Coal and Utilities Households in Mpumalanga, Census 2011

	Coal mining industry only	Electrical utility industry only	Coal and electrical utility industry	Total
Total households	**45 100** **78.71%**	**11 200** **19.55%**	**1 000** **1.75%**	**57 300**
... with dependents	27 700 61.4%	7 500 67.0%	700 70.0%	35 900 62.7%
... with only coal value chain labour income	29 500 65.4%	6 500 58.0%	600 60.0%	36 600 63.9%
... with both dependents and only coal value chain labour income	16 700 37.0%	4 000 35.7%	500 50.0%	21 200 37.0%
... with no dependents and only coal value chain labour income	12 800 28.4%	2 500 22.3%	100 10.0%	15 400 26.9%

Source: Authors' calculations using South Africa Census (Statistics South Africa, 2015)

Table 26 provides a breakdown of these households, grouping them by factors that make them vulnerable and exposed to closure of coal mines and coal-fired power plant closures resulting from the transition. Of the total number of households, 35 900 (62.7%) have dependents, which include children, elderly, unemployed or not economically active individuals. A similar proportion of households are solely reliant on incomes derived from coal mining industry and electrical utility industry work, with approximately 36 600 households (63.9%) falling into this category. Of these, 21 200 households are solely reliant on incomes derived from coal mining industry and electrical utility industry work, as well as needing to provide for dependents. The economic stability of these households is highly vulnerable when considering mine and coal-powered plant closures, and accounts for 37% of all households. A smaller proportion of households are those that have no dependents but are still completely reliant on incomes derived from coal mining industry and electrical utility industry work. Although these households are less vulnerable than those with dependents, they still account for more than one quarter (26.9%) of total households.

Driven by both endogenous forces – natural closure of coal-fired power plants – and exogenous forces – regulatory policy shifting energy production toward renewables – the transition is set to continue, and likely accelerate. It is vital that appropriate policy interventions are devised in order to ensure a just transition. This paper contributes to the ongoing policy debate surrounding the just transition in South Africa, by carefully deriving a robust empirical estimate of the coal labour market in South Africa, and the related coal-based electrical utility industry in Mpumalanga. We further provide measures of coal and electrical utility household dependency. These initial empirical insights into the size and shape of the coal labour market can inform the scale and scope of these policy interventions. Given the heterogenous nature of the labour market, a diverse suite of policy interventions is likely to be required.

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Appendix

Table A 1: Operating coal-fired power plants in South Africa - location, operating capacity, and lifespan

Power Station	Owner	Province	Municipality	Units	Operating capacity (MW)	Share of total operating capacity (%)	First unit start	Last unit retirement	Combined capacity to be retired (MW)	Share of total operating capacity to be retired
Grootvlei	Eskom	Mpumalanga	Dipaleseng	3	600	1.4	1969	2025	8 952 by 2030	21.5
Hendrina	Eskom	Mpumalanga	Steve Tshwete	7	1 400	3.2	1970	2025		
Camden	Eskom	Mpumalanga	Msukaligwa	8	1 600	3.7	1967	2025		
Arnot	Eskom	Mpumalanga	Steve Tshwete	6	2 352	5.4	1971	2029		
Kriel	Eskom	Mpumalanga	Emalahleni	6	3 000	6.9	1976	2030		
Matla	Eskom	Mpumalanga	Emalahleni	6	3 600	8.3	1979	2034	6 600 by 2035	15.1
Duvha	Eskom	Mpumalanga	Emalahleni	5	3 000	6.9	1980	2034		
Tutuka	Eskom	Mpumalanga	Lekwa	6	3 654	8.4	1985	2040	7 362 by 2040	16.9
Lethabo	Eskom	Free State	Metsimaholo	6	3 708	8.5	1985	2040		
Matimba	Eskom	Limpopo	Lephalale	6	3 990	9.1	1987	2041	8 160 by 2045	18.6
Kendal	Eskom	Mpumalanga	Emalahleni	6	4 116	9.4	1988	2043		
Majuba	Eskom	Mpumalanga	Pixley Ka Seme	6	4 143	9.5	1996	2051	4 143 by 2051	9.5
Medupi	Eskom	Limpopo	Lephalale	6	4 769	10.9	2015	2071	7 969 by 2071	18.3
Kusile	Eskom	Mpumalanga	Victor Khanye	4	3 200	7.3	2018	2071		
Eskom Total					**43 132**	**98.9**				

Kelvin	Anergi Int. Ltd	Gauteng	Ekurhuleni	7	420	1.0	1962	2026		
Richards Bay Mill	Mondi Ltd	KwaZulu-Natal	uMhlathuze	2	72	0.2	1984			
Total				**90**	**43 624**					

Source: Global Energy Monitor (2023b) 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.

Table A 2: Provincial Contribution to National GDP and Employment, 2013 and 2019

Province	Gross Domestic Product							Employment						
	Level (Rm constant 2015 prices)		Shares		Change		Contribution to change	000s		Shares		Change		Contribution to change
	2013	2019	2013	2019	Level	Share		2013	2019	2013	2019	Level	Share	
Western Cape	544 555	585 732	0.140	0.142	41 177	0.001	0.158	4 096	4 653	0.118	0.121	557	0.003	0.150
Eastern Cape	313 563	326 992	0.081	0.079	13 429	-0.002	0.052	4 044	4 295	0.116	0.112	251	-0.005	0.068
Northern Cape	82 348	88 657	0.021	0.021	6 309	0.000	0.024	748	803	0.022	0.021	55	-0.001	0.015
Free State	193 252	200 796	0.050	0.049	7 544	-0.001	0.029	1 843	1 907	0.053	0.050	64	-0.003	0.017
KwaZulu-Natal	635 309	683 043	0.164	0.165	47 734	0.001	0.184	6 514	7 122	0.187	0.185	608	-0.002	0.164
North West	247 694	251 772	0.064	0.061	4 078	-0.003	0.016	2 340	2 604	0.067	0.068	264	0.000	0.071
Gauteng	1 290 985	1 397 494	0.333	0.338	106 509	0.005	0.409	9 114	10 384	0.262	0.270	1 270	0.008	0.342
Mpumalanga	289 268	305 802	0.075	0.074	16 534	-0.001	0.064	2 649	2 952	0.076	0.077	303	0.001	0.082
Limpopo	280 005	296 802	0.072	0.072	16 797	0.000	0.065	3 442	3 786	0.099	0.098	344	-0.001	0.093

Source: Statistics South Africa (2019); Statistics South Africa (2023)

Notes: Shares refer to provincial share of total GDP/employment. Contribution to change refers to a province's percentage contribution to growth in GDP/employment over the period 2013 to 2019.

Table A 3: Provincial GDP and Employment Shares by Province, 2019

	Western Cape	Eastern Cape	Northern Cape	Free State	KwaZulu-Natal	North West	Gauteng	Mpum-alanga	Limpopo	South Africa
GDP										
Agriculture	0.035	0.017	0.073	0.050	0.042	0.027	0.005	0.033	0.029	0.025
Mining	0.002	0.002	0.160	0.071	0.011	0.220	0.016	0.173	0.181	0.054
Manufacturing	0.147	0.134	0.036	0.109	0.156	0.057	0.165	0.138	0.037	0.135
Utilities	0.022	0.015	0.028	0.029	0.025	0.030	0.026	0.046	0.021	0.026
Construction	0.048	0.034	0.023	0.024	0.037	0.023	0.033	0.029	0.027	0.034
Trade	0.145	0.162	0.118	0.135	0.133	0.129	0.128	0.135	0.140	0.135
Transport	0.112	0.063	0.102	0.081	0.114	0.065	0.099	0.054	0.060	0.091
Finance	0.314	0.183	0.155	0.209	0.193	0.188	0.315	0.167	0.159	0.246
Personal services	0.116	0.276	0.193	0.188	0.210	0.182	0.109	0.169	0.252	0.165
Govt services	0.059	0.114	0.111	0.104	0.079	0.080	0.104	0.056	0.094	0.089
Employment										
Agriculture	0.086	0.064	0.113	0.075	0.054	0.059	0.007	0.074	0.096	0.053
Mining	0.002	0.001	0.091	0.021	0.002	0.136	0.012	0.060	0.063	0.025
Manufacturing	0.134	0.090	0.050	0.080	0.130	0.076	0.123	0.082	0.058	0.108
Utilities	0.005	0.005	0.006	0.013	0.004	0.006	0.009	0.027	0.008	0.009
Construction	0.082	0.109	0.059	0.071	0.089	0.066	0.074	0.085	0.096	0.082

	Western Cape	Eastern Cape	Northern Cape	Free State	KwaZulu-Natal	North West	Gauteng	Mpum-alanga	Limpopo	South Africa
Trade	0.199	0.207	0.156	0.208	0.209	0.185	0.205	0.210	0.233	0.205
Transport	0.057	0.053	0.034	0.048	0.069	0.041	0.074	0.054	0.046	0.061
Finance	0.180	0.100	0.072	0.103	0.129	0.104	0.221	0.122	0.076	0.154
Personal services	0.199	0.282	0.338	0.255	0.230	0.248	0.203	0.200	0.244	0.224
Private households	0.056	0.089	0.081	0.126	0.085	0.078	0.073	0.085	0.079	0.078

Source: Statistics South Africa (2019); Statistics South Africa (2023)

Notes: GDP shares based on GDP estimates using constant 2015 prices. Top panel reports an industry's share of total provincial GDP. Bottom panel reports an industry's share of total provincial employment.

Table A 4: Employment Break down by municipalities using Census estimates

Municipality/Province	Level (000s)			Shares of total coal employment (%)		
	1996	2001	2011	1996	2001	2011
eMalahleni (Witbank)	8 774	18 069	25 935	22.0	42.5	37.2
Steve Tshwete (Middelburg)	4 439	5 318	11 964	11.1	12.5	17.2
Govan Mbeki (Highveld East)	4 491	5 687	3 473	11.3	13.4	5.0
Msukaligwa (Ermelo)	1 442	1 586	6 590	3.6	3.7	9.5
Mkhondo	276	594	2 937	0.7	1.4	4.2
Victor Khanye	529	614	1 555	1.3	1.4	2.2
Albert Luthuli	369	494	1 483	0.9	1.2	2.1
Total Mpumalanga	**25 923**	**34 192**	**55 619**	**64.9**	**80.4**	**79.8**
KwaZulu Natal	8 926	2 553	3 036	22.4	6.0	4.4
Limpopo	1 935	2 818	5 408	4.8	6.6	7.8
Gauteng	1 206	1 206	3 018	3.0	2.8	4.3
Free State	898	1 286	1 214	2.2	3.0	1.7
Total other provinces	**13 995**	**8 332**	**14 065**	**35.1**	**19.6**	**20.2**

TOTAL	**39 918**	**42 524**	**69 684**	**100**	**100**	**100**

Source: Authors' calculations using South Africa Census (Statistics South Africa, 1998; 2003; 2015a)

Notes: Sum of local municipalities in Mpumalanga province does not add up to total for Mpumalanga because of small number of coal industry jobs in other parts of the province. Sum of coal industry jobs in KwaZulu-Natal, Limpopo, Gauteng and Free State does not add up to total for other provinces because of small number of coal industry jobs in remaining other four provinces. Shares refer to the contribution of a locality to total coal employment in South Africa.

Table A 5: Industry contribution to value added in the South African economy, 1993-2019

	Levels (R millions)				Shares				Change in share	Average annual growth rate			
	1993	1999	2009	2019	1993	1999	2009	2019	1993-2019	1990s	2000s	2010s	Full
Agriculture	61 191	66 547	85 439	104 841	0.029	0.027	0.025	0.025	-0.004	0.012	0.021	0.021	0.020
Mining (Excl. Coal)	200 848	187 480	169 454	179 213	0.097	0.077	0.049	0.043	-0.053	-0.010	-0.009	0.000	-0.004
Coal	**29 733**	**35 666**	**39 999**	**42 975**	**0.014**	**0.015**	**0.011**	**0.010**	**-0.004**	**0.026**	**0.011**	**0.004**	**0.014**
Primary industries	291 773	289 694	294 891	327 029	0.141	0.119	0.085	0.079	-0.061	-0.001	0.002	0.007	0.004
Manufacturing	336 029	384 268	495 829	557 941	0.162	0.158	0.142	0.135	-0.027	0.019	0.018	0.006	0.019
Utilities	84 121	97 434	117 527	107 574	0.041	0.040	0.040	0.034	-0.007	0.021	0.016	-0.011	0.009
Construction	56 562	59 038	138 550	140 161	0.027	0.024	0.040	0.034	0.007	0.006	0.083	0.000	0.034
Secondary industries	476 713	540 739	751 906	805 677	0.230	0.222	0.216	0.195	-0.035	0.018	0.027	0.003	0.020
Trade	260 587	321 001	471 718	558 261	0.126	0.132	0.135	0.135	0.009	0.030	0.031	0.013	0.029
Transport	123 125	180 480	309 374	376 918	0.059	0.074	0.089	0.091	0.032	0.056	0.047	0.018	0.042
Finance	349 097	450 314	794 793	1 018 520	0.168	0.185	0.228	0.246	0.078	0.037	0.055	0.024	0.040

Government services	226 971	233 697	288 326	368 065	0.109	0.096	0.083	0.089	-0.020	0.004	0.022	0.023	0.018
Personal services [1]	336 398	421 444	589 545	680 955	0.162	0.173	0.169	0.165	0.003	0.033	0.029	0.014	0.026
Tertiary industries	1 296 177	1 606 937	2 453 755	3 002 719	0.624	0.660	0.704	0.726	0.102	0.031	0.039	0.019	0.032
Value added at basic prices (total)	2 076 251	2 435 394	3 485 479	4 135 425						0.023	0.032	0.014	0.026

Source: Statistics South Africa (2022)

Notes: GVA levels reported in millions of constant 2015 Rand. Shares refer to an industry's share of total GVA at basic prices. Change in share refers to the percentage point change in GVA share for the period 1993 to 2019.

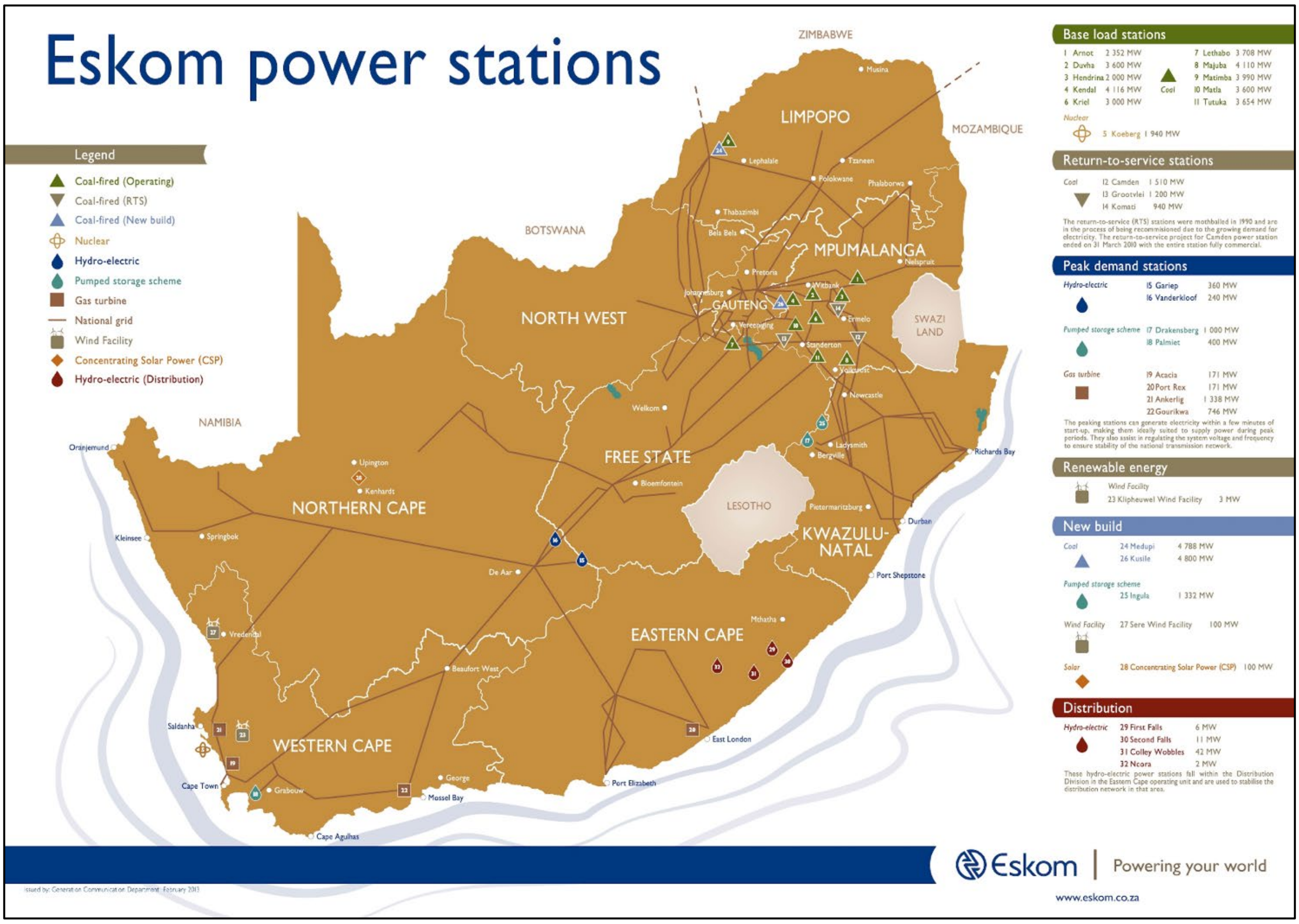
Table A 6: Differences in Employment Figures between Data Sources, 1996-201

Year	Household surveys			Firm Surveys		Emp. range	Share of		
	PALMS	Census	Diff between PALMS and Census (%)	Mining Census	DMRE		Total emp.	Formal emp.	Mining emp.
1996	31 085	39 918	-24.88%	..		31-40k	0.30%	..	11.2%
2001	57 676	42 524	30.24%	..	50 740	42-57k	0.48%	0.71%	10.81%
2011	69 173	69 684	-0.74%	..	78 579	68-78k	0.49%	0.65%	20.11%
2012	71 530	..		91 605	83 244	71-92k	0.51%	0.65%	19.43%
2019	76 230	..		108 717	95 221	76-108k	0.46%	0.62%	19.05%

Source: Authors' calculations using PALMS (Kerr, Lam & Wittenberg, 2019); South Africa Census (Statistics South Africa, 1998; 2003; 2015a); Mining Census (Statistics South Africa, 2011; 2014; 2017; 2021a); Department of Mineral Energy (2020)

Note: Difference between PALMS and Census employment estimates expressed as percentage difference. Shares for total emp, formal emp and mining emp refer to the share of coal employment in relation to total, formal sector and mining sector employment, respectively. These shares are calculated using the PALMS data.

Figure A 1: Spatial Distribution of South Africa's Power Station



Source: Eskom (2023)

Table A 7: Individual characteristics of national and Mpumalanga coal mining industry employees. 2011

	Census data 2011	
	Coal mining South Africa	**Coal mining Mpumalanga**
Total No. of employees (weighted)	69 684	55 619
Gender		
Male	0.80	0.81
Race		
African/Black	0.79	0.80
White	0.17	0.17
Age Group		
15-24	0.13	0.13
25-34	0.35	0.35
35-44	0.25	0.25
45-54	0.20	0.19
55-64	0.08	0.08

Educational Attainment		
Primary or less	0.17	0.17
Secondary uncompleted	0.31	0.31
Secondary completed	0.37	0.38
Diploma	0.11	0.11
Degree	0.04	0.03

Source: Authors' calculations using South Africa Census (Statistics South Africa. 2015)

Notes: Categories comprising negligible shares for race. age and education are omitted from the table.

Table A 8: Occupation Categories of Mining and Coal Mining Employees

1-digit Occupation categories	Census 2011	LMDS 2011	LMDS 2019
High skilled occupations			
Managers	0.02	0.06	0.01
Professionals	0.03	0.03	0.02
Technicians	0.02	0.06	0.09
Skilled occupations			
Clerks	0.08	0.04	0.05
Service & sales	0.08		0.01
Craft & trades	0.28	0.32	0.40
Operators	0.36	0.35	0.35
Low skilled occupations			
Elementary	0.1	0.14	0.07

Source: Authors' calculations using South Africa Census (Statistics South Africa. 2015a) and Labour Market Dynamics (Statistics South Africa. 2011; 2021b)

Table A 9: Coal mining industry jobs and informality

Job characteristic	LMD 2011	LMD 2019	Change (%)
	Share (%)	Share (%)	
Informality (enterprise definition)			
Formal sector	1.00	0.95	-0.05
Informal sector	-	0.05	0.05
Informality (worker definition)			
Formal employment	0.99	0.94	-0.04
Informal employment	0.01	0.05	0.05

Source: Source: Authors' calculations using Labour Market Dynamics (Statistics South Africa. 2011; 2021b)

Notes: The enterprise definition defines an informal sector worker as an employee working in establishments that employ fewer than five employees. who do not deduct income tax from their salaries/wages; and employers. own-account workers and persons helping unpaid in their household business who are not registered for either income tax or value-added tax (Statistics South Africa. 2008). Statistics South Africa define informal employment as all persons in the informal sector (see enterprise definition). employees in the formal sector. and persons working in private households who are not entitled to receive basic benefits such as pension or medical aid contributions from their employer. and who do not have a written contract of employment (Statistics South Africa. 2008).

Table A 10: Occupational composition of electrical utility industry employees

Occupation categories	Census	LMD	LMD	LMD
	Mpumalanga	Mpumalanga	Mpumalanga	South Africa
	2011	2011	2019	2019
Total No. of employees (weighted)	14 600	19 600	30 500	93 300
Managers	0.06	0.08	0.05	0.16
Professionals	0.04	0.08	0.11	0.08
Technicians	0.06	0.18	0.17	0.14
Clerks	0.11	0.10	0.02	0.09
Service	0.06	0.09	0.03	0.02
Craft & trade	0.40	0.29	0.16	0.33
Operators	0.14	0.14	0.36	0.13
Elementary	0.12	0.05	0.09	0.04

Source: Authors' calculations using South Africa Census (Statistics South Africa. 2015a) and Labour Market Dynamics (Statistics South Africa. 2011; 2021b)

Note: Utilities refers to the Production. Collection and Generation of Electricity (SIC411). Due to rounding. the shares of utilities employees may not sum up to exactly 100%.

Table A 111: Electrical utility industry jobs and informality

Job characteristics	LMD	LMD	LMD
	Mpumalanga	South Africa	Mpumalanga
	2011	2019	2019
Total No. of employees (weighted)	19 600	93 900	30 400
Informality (worker definition)			
Formal sector	0.99	0.96	0.92
Informal sector	0.01	0.03	0.08
Informality (enterprise definition)			
Formal employment	0.99	0.97	0.92
Informal employment	0.01	0.03	0.08

Source: Authors' calculations using Labour Market Dynamics (Statistics South Africa. 2011; 2021b)

Note: Utilities refers to the Production. Collection and Generation of Electricity (SIC411). Due to rounding. the shares of utilities employees may not sum up to exactly 100%.

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