

**Climate Policy Beyond Borders: Labour Market Evidence from South Africa
under the EU Carbon Border Adjustment Mechanism**

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Table of Content

Abstract	2
Introduction.....	2
Section I: Theoretical Framework	4
The Carbon Border Adjustment Mechanism	4
Carbon pricing and carbon-efficient innovations	5
Carbon pricing and geographical disparities.....	6
Carbon pricing and the labour market.....	7
Carbon pricing in South Africa.....	7
Hypotheses	8
Section II: Methodology	9
Data collection	9
Data analysis method.....	10
Hypotheses identification.....	11
Assumption tests	13
Section III: Results.....	16
Linear regression results.....	16
Quadratic polynomial regressions	18
Section 4: Discussion	20
References	23

Abstract

The European Union's Carbon Border Adjustment Mechanism (CBAM) represents a major shift in global climate and trade policy, with significant implications for emission-intensive exporting economies. This paper examines the impact of the CBAM on labour market prospects in South Africa, which is among the largest economies in Sub-Saharan Africa with strong trade linkages to the EU and persistently high unemployment. Focusing on CBAM-targeted sectors (iron, steel, and electricity), this research analyses the extent to which the introduction of the policy affected employment levels, unemployment, and job satisfaction among South African workers. Using microdata from the South African Quarterly Labour Force Survey for the period 2021–2024, the analysis applies a regression discontinuity design, in which both linear and quadratic regressions are estimated to assess the robustness of the results. The findings indicate a small but statistically significant decline in employment in all industries around the policy cutoff, in 2023. No significant discontinuities are observed for employment or unemployment in emissions-intensive sectors, nor for job satisfaction. These results suggest that the initial phase of the CBAM, which primarily involved administrative constraints rather than financial obligations, has not yet generated substantial labour market disruptions in South Africa. More pronounced effects may emerge as the CBAM enters its full implementation phase in 2026, underscoring the importance of continued monitoring and complementary measures to support vulnerable labour markets in carbon-intensive industries.

Introduction

As one of the most powerful African economies, South Africa has been successful in diversifying its industries while constantly pushing for innovation through a comprehensive decarbonisation of its economy. Despite these successes, it has constantly been grappling with systemic unemployment, which reached a rate of 30% in 2025, one of the highest in the world (OECD, 2025). Over 500,000 jobs depend on energy-intensive markets, which face direct exposure to carbon pricing. This could mean that a sudden decarbonisation of the national industries could have a lethal

effect on the national labour market (Carbon Competitiveness: South Africa at the Net Zero–Trade Nexus, 2025). This vulnerability is heightened by the implementation of its trade partner’s climate policies, particularly from the EU.

Between 2005 and 2023, emissions from Europe’s power and industry sectors declined by 37%, primarily driven by the EU Emissions Trading System, an essential carbon pricing instrument in the continent’s green transition (Climate Action EU, 2023). Carbon pricing on energy-intensive products incentivises European economies to cope with the externalities of high-emission domestic production, thereby increasing the price of these products. Since EU ETS were only subjected to domestic emissions, most European economies started importing more from countries with less stringent carbon policies, shifting the issue of carbon emission to different areas of the globe, a mechanism coined as carbon leakage. Recognising the need for deeper decarbonization, the EU launched the European Green Deal in 2020, targeting at least a 50% emissions reduction by 2030 through a comprehensive set of climate policies (UNDT, 2021). The Carbon Border Adjustment Mechanism, CBAM, implemented in 2023 aims to mitigate carbon leakage by making imports from outside the EU for specific emission-intensive sectors also subject to carbon pricing, thereby increasing costs and incentivising companies to increase investment in sustainable supply chains, while making every economy around the globe accountable. The five emissions-intensive sectors targeted are cement, iron and steel, aluminium, fertilisers and electricity. The trade competitiveness of economies with a relatively high share of trade with the EU, particularly in emissions-intensive products, could be significantly impacted by this policy, such as South Africa. Carbon tariffs can create negative distributional effects while exacerbating regional inequalities. Exporters of fossil fuels face negative impacts from carbon border measures, as declining global fuel consumption exerts downward pressure on fuel prices (UNTD, 2021).

Influential research has been conducted on EU major trade partners, which are most impacted by carbon tax in absolute terms, such as India, China and Turkey, overlooking countries impacted in relative terms, mostly located on the African continent (Eicke et al., 2021). Many African economies may be unable to transition to cleaner energy at the pace required to remain competitive, making them extremely vulnerable to this new policy (Eicke et al., 2021). Unfortunately, as most research focuses on economic growth, creation of new decarbonised jobs, and environmental

gains in certain areas of the globe, little attention is directed at the impact of carbon tax policies on African economies (Hanto et al., 2021). Beyond macroeconomic vulnerabilities, national labour markets are expected to be heavily hit as well, and this thesis aims to uncover the mechanisms at play by zooming in on the impact of the European carbon tax CBAM on the South African national labour market. South Africa -SA- is predicted to be heavily hit by the CBAM, while being the one of the strongest economies in Africa, and ranking among the most carbon-intensive economies in the G20. The EU is its largest trading partner, representing 19% of total export share in 2019, making SA particularly vulnerable to the CBAM policy (South African Reserve Bank, 2024). Currently, the International Renewable Energy Agency (2023), IRENA, expects the mining and manufacturing fuels sectors to witness substantial job reductions of 47% in 2030 in SA. What is the extent to which workers from targeted sectors are going to be affected by CBAM?

This paper aims to analyse the job prospects of South African workers in CBAM-targeted sectors, understanding the extent to which the carbon tax influences their employment rate and satisfaction. What is the impact of the CBAM on job prospects in energy-intensive industries in South Africa? The hypotheses that guide this research are the following:

- *H1a: CBAM leads to a reduction in the number of people working in all industries*
- *H1b: CBAM leads to a reduction in the number of people working in emissions-intensive industries*
- *H2: CBAM leads to an increase in unemployment of people working in emissions-intensive industries*
- *H4: CBAM leads to a decrease in job satisfaction for people working in emissions-intensive industries*

A regression discontinuity analysis using both linear and quadratic functional forms is applied on the period from January 2021 to December 2024 to detect potential CBAM effects on the labour market. The dataset is a granular quarterly South African

labour market survey. Data is collected on the labour market activities of individuals aged 15- 64 years who live in South Africa, split into approximately 30,000-66,000 dwelling units, divided into four rotation groups, that have the same distribution as that of the whole sample. Our results demonstrate a visible impact on overall employment. Results for the other hypotheses are inconclusive, probably because of the very recent implementation of the policy. Yet, the discussion section provides valuable insights into such research and future implications.

The remainder of this thesis is organised as follows. Section 1 contextualises the relevance of the present research within the academic fields. It also categorises keywords and patterns essential to the research while defining the hypotheses. Section 2 details the research method and explains the data. Section 3 compiles the analysis results, and finally, the Section 4 discusses the results.

Section I: Theoretical Framework

First, I explain the mechanisms of the CBAM, then I provide an overview of relevant previous research and findings on carbon tax and its impact on green transition, trade, and labour markets, and finish by formulating hypotheses. Not only does this section provide context for this thesis, but it also identifies some weaknesses and controversies in previous findings, which inspired the present research to be undertaken.

The Carbon Border Adjustment Mechanism

The Carbon Border Adjustment Mechanism, CBAM, aims to mitigate carbon leakage by making imports from outside the EU for specific emission-intensive sectors also subject to carbon pricing. In that way, it prevents the relocation of business activities to countries with less stringent climate policies (Eicke et al., 2021). This policy incentivises companies to increase investment in sustainable supply chains, while sending a signal to make more carbon-efficient technology choices. Companies importing non-EU goods must surrender carbon allowances equal to the carbon footprint of imported products. In this situation, European households and producers should reduce their consumption of carbon-intensive goods and inputs to mitigate the

cost increase. The sectors targeted by the CBAM are a short-list of high-emitting sectors exposed to carbon leakage: cement, aluminium, iron/steel, fertilisers and electricity, which represent 94% of industrial CO₂ emissions of the EU (UNTD, 2021). Both direct and indirect emissions are covered by CBAM, for the former, emissions arising from the production processes of goods, while the latter refers to the production of electricity consumed during the production processes. The CBAM is set to be implemented globally gradually from 2023 to reach full force by 2034. From 2023 onwards, importers are required to report the volume of goods imported into the EU during the previous year, along with the associated greenhouse gas emissions. Based on this data, from 2026, they will have to purchase digital CBAM certificates at a price to be calculated from the weekly average auction price of the EU Emission Trading System ETS allowance expressed in €/tonne of CO₂ emitted (Trade & Industrial policy strategies, 2022).

The impact of carbon pricing instruments is multifaceted, and understanding the mechanisms at play is essential to assess the CBAM, particularly on national labour markets.

Carbon pricing and carbon-efficient innovations

Carbon pricing instruments such as carbon taxes and emissions trading schemes aim at incentivising industries to tackle the negative externalities of fossil energy, while simultaneously improving the competitiveness of renewable energy. Xu & Yang (2024)'s research examines the practical implementation and subsequent effectiveness of these policies in renewable energy -RE- development, through a differences-in-difference panel data analysis from 196 countries. The economic reasoning behind the research is that such policies discourage fossil power generation while promoting investment in renewable energy. The findings confirm this theory: showing that carbon trading has increased non-hydro renewable electricity generation by 73.32%, while the carbon tax has increased it by 31.79%. Subsequently, Aghion et al. (2016)'s findings rest on the same theoretical assumptions, and they focus on the automobile industry's technology innovation by constructing a firm-level panel data set of automobile patents across 80 countries. Findings demonstrate that firms tend to innovate more in clean than dirty technologies when they face higher tax-inclusive fuel prices. For example, their baseline results suggest that an increase of 40% in fuel

prices with respect to the 2005 fuel price should allow RE innovation to overtake emissions-intensive ones after 15 years, highlighting the relevance of imposing a carbon tax to stimulate economic decarbonisation.

Carbon pricing and geographical disparities

As mentioned in the introduction, such a tax can, however, have negative distributional effects. The CBAM is controversial as many researchers accuse it of unilaterally projecting EU climate standards on its trading partners. The main issue is thought to be that it reduces their trade substantially without any effective mitigation and/or environmental sustainability objectives in their national development strategies. The UNTD (2021) report provides insight into such mechanisms on a systemic macro level. A general equilibrium model is used, which analyses economies by showing how markets interact and potentially reach a simultaneous balance. Findings show that through the CBAM, the EU should experience a substantial rise in intra-regional trade, while other regions will reduce their trade with the EU but probably expand trade among themselves or with alternative partners. In effect, the CBAM operates much like a tariff imposed by a trading bloc, by boosting trade within the bloc while diverting external trade toward other regions. Perdana et al. (2022), Magacho et al. (2023) and Eicke et al. (2021)'s research rests on the assumption that, despite representing a relatively small share of the EU's imports of energy-intensive goods, poorer countries could be negatively impacted by the CBAM, which would heavily reduce opportunities for export-led development, while creating huge welfare losses. Eicke et al. (2021)'s paper assesses emerging economies' exposure to the CBAM and their potential trade vulnerabilities by constructing a relative risk index. They map risks by encompassing the export structure of countries, their emissions intensity, emissions reduction targets, and institutional capacities to monitor and report product-based emissions in both short-term and long-term scenarios after the implementation of the CBAM. The quantitative analysis reveals that the impacts of CBAM are distributed unevenly across the globe, with higher risks located on the African continent. Supplementing Eicke et al. (2021)'s research, Magacho et al. (2023) complement previous findings by using trade data and multi-regional input-output matrices to analyse the geographically and sectorally uneven distribution of the policy's impact. Findings suggest that numerous

jobs, tax revenues and export revenues will be lost if the CBAM is implemented without taking into account vulnerable countries' specificities. Perdana et al. (2022) analyse complementary measures such as exemption and revenue redistribution to mitigate the impact of the CBAM on developing countries, by acknowledging and anticipating these countries' high exposure and vulnerability risks. The data used is a multi-sectoral calibration, in which the reference scenario is constructed based on the EU's current policies, enabling a global and comprehensive scope. The findings push for a reallocation of CBAM finance into mitigation strategies to tackle vulnerable countries' welfare loss.

Carbon pricing and the labour market

Zooming in, the labour market effect of the carbon tax is also essential to understand, particularly how the market adjusts to a tax and whether employment precarity arises for emissions-intensive sectors. Wei & Yip (2025) analyse the 2008 British Columbia carbon tax using a differences-in-differences approach on a household survey of 10,000 individuals. They find that the tax decreases the average hourly wage rate by 2.5% and increases the unemployment rate by 1.3 percentage points in sectors related to emissions-intensive industries: as production in these sectors is set to decrease, labor demand decreases, increasing the unemployment rate, thereby triggering labor impacts on emission-intensive markets. Overall, the wage effect emerges gradually, contrasted with an immediate but short-lived unemployment effect. Further, Curties et al. (2024)'s research on job transition in the United States investigates the magnitude of the shifts in product and labor demand arising from carbon taxes, by contending that it is likely to be large. Similarly to the rationale just above, carbon taxes constrain emission-intensive sectors production by making it more costly, leading to a decrease in labor demand in these sectors. Using microdata representing 130 million online work profiles, Curtis et al. (2024)'s descriptive research demonstrates that the rate of transition from emissions-intensive jobs to greener jobs is relatively low, though rising rapidly, leading to a decrease in the number of people working in the former industry. In addition, there might be limits to the extent to which local labor markets will be able to absorb the workers who will be displaced by the move away from emission-intensive industries, leading to higher

unemployment for these workers. Additionally, Zaussinger et al. (2025) map the labour market exposure to the low-carbon transition across European regions and sectors using granular labour force surveys. They found that emissions-intensive industries' workers have significantly fewer skills and that their skills are less transversal compared to low-carbon sectors' workers, which creates uneven job transition possibilities and subsequent economic vulnerability for the former group of workers.

Carbon pricing in South Africa

Despite already having one of the highest unemployment rates in the world with around 30% unemployed individuals in 2025, being a high-emission economy and therefore vulnerable to the CBAM, South Africa has relatively little critical assessment of the carbon tax impact on its labour market. IRENA (2023)'s report assesses the socio-economic impacts of carbon tax in South Africa, zooming in on the effect on the job market in terms of job creation in absolute terms. Using a macro-econometric model that integrates the energy system and global economies into a single quantitative framework, highlighting trade-offs between economic prosperity and employment, while examining welfare aspects, the report argues that a carbon tax boosts innovation in the green sector and subsequent job creation. Additionally, Hanto et al. (2021) analyse the positive relationship between renewable energy and employment generation in the energy sector, through a cost-minimising, global energy system model, GENeSYS-MOD, used to project two energy mix scenarios and their associated employment implications at the provincial level in South Africa. They argue that green job creation can partially substitute for the decline in coal-related jobs in affected regions. However, it is not certain that the employment created by RE will directly benefit those negatively impacted by the transition.

Hypotheses

Energy transition and renewable energy development can lead to an increase in job creation overall, but it is crucial to observe whether this will include workers in emission-intensive sectors or not. South Africa's labour market is particularly precarious and volatile, while heavily relying on emissions-intensive industries. This

thesis attempts to provide a quantitative policy analysis by investigating the potential effect of a macro carbon tax on the national labor market of South Africa. Derived from previous empirical work, our three hypotheses' outcome variables are on the individual level.

H1a and H1b contend that CBAM leads to a decrease in the number of people working in all industries and in emissions-intensive industries respectively. We draw this hypothesis from Curties et al. (2024)'s research mentioned above, which contends that carbon taxes lead to a decrease in emission-intensive mining and production, therefore to lower demand for workers in those industries. There might be limits in the capacity of local labor markets to absorb the workers who will be displaced by the move away from emission-intensive industries, leading to higher unemployment for these workers.

H2 tests this assumption and asks whether CBAM leads to an increase in unemployment for those who worked in emissions-intensive jobs. Wei & Yip (2025)' study of British Columbia carbon tax impact on the Canadian labor market highlights an increase in unemployment due to higher layoffs in energy intensive sectors and hiring barriers in greener sectors due to skills specialisation. We infer our hypothesis from this paper.

Our third hypothesis H3 test whether CBAM leads to a decrease in job satisfaction for people working in emissions-intensive industries. By showing that less than 1% of all workers who leave the emission-intensive sector appear to make a transition to a green job, Curties et al. (2024) argue that climate stringent policies instill employment precarity anxiety for these workers, subsequently decreasing job satisfaction. Job satisfaction is often mentioned in literature on decarbonisation and employment yet often discredited as a subjective and hard-to-measure indicator. Still, it is essential to consider this variable to assess the impact of a policy on labor market, especially on the individual level.

Section II: Methodology

What is the impact of the CBAM on job prospects in energy-intensive industries in South Africa? Breaking down this question into a few different parts

facilitates the identification of variables, the intensity and direction of relationships between them:

1. To what extent do labor market adjustments caused by the CBAM affect South African workers?
2. To what extent is there a relationship between the implementation of the CBAM and employment stability in targeted sectors?
3. Finally, can we observe a relationship between the policy implementation and labour market vulnerability for workers in targeted sectors?

As mentioned previously, it is estimated that over 500,000 jobs in SA will still depend on these energy-intensive markets facing direct exposure to carbon pricing (Net Zero Tracker, 2025). Thousands of workers find themselves vulnerable to this trade policy, and to evaluate this vulnerability and potential job precariousness, the present analysis is conducted using a quarterly labour force survey.

Data collection

The Quarterly Labour Force Survey (QLFS) is a household-based sample survey conducted by Statistics South Africa. It has been designed to be representative at the provincial level and within provinces at urban, tribal and farm geographical types. It collects data on the labour market activities of individuals aged 15- 64 years who live in South Africa. Information is collected from approximately 30,000-66,000 dwelling units, divided into four rotation groups, that have the same distribution as that of the whole sample. Each sampled dwelling will remain in the sample for four consecutive quarters. The first part of the questionnaire comprises two general questions to establish household membership and five socio-demographic questions. These questions provide background information on the respondents. The second part contains questions that reflect labour market status and key labour market patterns.

“Industry currently worked in” and “previously worked in” questions are essential as they enable us to identify and focus on the CBAM targeted sectors, which are cement, aluminium, iron/steel, fertilisers and electricity industries. Particularly, following Curtis et al. (2024)’s methodology, jobs belonging to such industries and among the most polluting are those in extraction and manufacturing, and the

researchers used keywords of emission-intensive industries to focus on those exclusively; for example “coal”, “petroleum”, “fossil fuel”, “shale”, or “petrol” to match by job title. I follow the same method, although I do not focus on all high-emitting industries but only those targeted by the CBAM. The QLFS contains 183 different industry specifications. In order to choose emissions-intensive sectors that are targeted by the EU carbon tax, I searched for any industries that would contain keywords of the sectors targeted, and combined them with words such as “mining”, “extraction” and “manufacturing”. I found three industries in the database: steel, iron and electricity sectors. Changes in job prospects in these sectors will be scrutinised. The focus is on these three because they also represent the largest portion of emissions-intensive exports to the EU from South Africa (Trade & Industrial policy strategies, 2022). The total bandwidth of the analysis is from 2021 to 2024, counting 4 quarters per year, so 16 in total. It is important to keep the same sample groups as much as possible to ensure uniformity and control background variables as much as possible.

Data analysis method

Our quantitative method is regression discontinuity -RD- which is grounded in the notion that rigid assignment rules, which at first appear to reduce or even eliminate the scope for randomness, create valuable experiments. The RD design helps estimate the causal effect of a treatment at the cutoff point of a continuous assignment or running variable. In our research, the running variable is time, identified through 16 quarters, because we want to determine whether there is a time effect on our outcome variables on the individual level. One of the key RD assumptions is identification, which requires that individuals positioned just above and just below this threshold are assumed to be similar in all respects except for their treatment status (Angrist & Pischke, 2014). This assumption is tested via the descriptive statistics table where each variable’s statistics are compared between the before period -year 2021-2022-, and the after period -year 2023-2024. We observe that all variables are similar, which is a prerequisite. Indeed, we compare the just barely treated variables against the just barely untreated to get the effect of treatment. Another important assumption is the possible anticipation of the CBAM implementation by firms and the South African

authorities. In 2021, the EU publicly announced the trade reforms to be undertaken from 2023 onwards. We want to check whether South African emissions-intensive firms, and/or authorities, did anticipate such regulations, and whether they might have adapted preemptively by laying off employees for example. To test this assumption, we ran an RDD for the year 2020-2022, with the cutoff date being the year 2021, marking the date of the official announcement. After running this test, any discontinuous jump at the cutoff for the 2021-2024 analysis can be attributed to the causal impact of the treatment that is exogenous to the people observed. Our coefficient of interest would capture whether the policy is effective by observing an overall variation in emission-intensive activities, which will be reflected in the labour activities of workers in these industries. We expect to observe an increase in unemployment, a decrease in employed workers in emission-intensive sectors, and a subsequent decrease in job satisfaction. In this setup, treatment assignment changes sharply at the cutoff; here, the South African economy is being targeted by the CBAM from 2023 onwards, allowing researchers to compare observations on either side of the threshold to identify causal effects. Essentially, the goal of this research method is to carefully select the variation that lets us ignore all other background variables without having to control for them, thus reducing selection bias (Angrist & Pischke, 2014).

Hypotheses identification

The running variable X is conceptualised as a time dummy, and the dummy for the sudden change as a consequence of the policy is the variable of interest. This variable determines the treatment assignment and enables the identification of specific periods, divided into quarters before and after the policy's implementation in South Africa. There is barely any randomness in the rule: by knowing the running variable, we know the treatment status with a certain degree of certainty. By deduction, the cutoff variable is quarter 1 of the year 2023, which is the date of the implementation of the CBAM. The running variables are divided into 16 quarters, 4 for each year. Q1 for 2021 is labelled -8, Q1 for 2023 is labelled 0 and Q4 for 2024 is labelled as 7, ensuring that quarters are dummy variables labelled from -8 to 7. This prevents collinearity

issues, and using quarters instead of years increases the granularity of the running variable. The treatment indicator is written as follows:

$D_i = 1$ when $X \geq 2023$, for the treatment group, after the implementation of the CBAM

$D_i = 0$ when $X < 2023$, for the control group, before the implementation of the CBAM

Four indicators are used to measure the dependent variable Y , which is job prospects in CBAM-targeted sectors in South Africa: being employed yes/no, being employed in emissions-intensive sectors yes/no, being unemployed from emission-intensive sectors and job satisfaction in the same sectors. The four indicators refer to three sample survey questions that have been selected to have a well-rounded overview of job prospects measurement. They are the ones mentioned in the hypotheses' descriptions. Two covariates are also tested with each hypothesis to improve precision: age and race. These variables were chosen due to their primary dividing force between South African individuals on the labour market (OECD Economic Surveys South Africa, 2025). Our variable identification and specification heavily draw from Curties et al. (2024)'s research on job transition from emissions-intensive jobs to green jobs in the United States.

H1a is whether the *individual is employed or not*, regardless of the industry. H1b looks at those who are employed and this time, specifically working in emissions-intensive industries, yes or no. The outcome variable *being employed in an emission-intensive industry* is obtained by combining two survey questions. The first survey questions are "industry currently working in" and "employment status". For the industry currently worked in, we selected iron, steel and electricity in manufacturing and mining, as they are part of the CBAM targeted sectors and are the emission-intensive sectors specified in the dataset. H1a is tested through a regression with the outcome variable as a dummy where $H1a_i=1$ and $H1a=0$ with 1 being employed and 0 unemployed and/or looking for a job. H1b is tested through a regression with the outcome variable as a dummy where $H1b_i=1$ and $H1a=0$, with 1 being employed in an emission-intensive sector and 0 unemployed and/or looking for a job in that same sector. Covariates are added for both regressions. To this purpose, I estimate the following equations:

$$(1) H1i(a) = \alpha + \beta Xi + \rho Di + \gamma Zi + \epsilon i$$

$$(2) H1i(b) = \alpha + \beta Xi + \rho Di + \gamma Zi + \epsilon i$$

Where $H1i(a) = 1$ when the individual is employed, regardless of sectors and 0 otherwise, $H1i(b) = 1$ when the individual is employed in an emission-intensive sector and 0 otherwise. α is the intercept. Xa is the running variable, as its value determines the treatment or non-treatment for individuals. The treatment dummy Di is included. The parameter ρ captures the jump in employed individuals after 2023, it is the main variable of interest because it estimates the impact of the CBAM on individuals' employment situation. Z is the vector of the covariates age and race, and γ reflects the slope of the number of employed individuals. Finally, i is the error term, capturing unobserved effects. The equations are the same for each hypothesis, only the outcome variables change.

For H2, the outcome of *being unemployed in an emission-intensive industry* is obtained by combining two survey questions. The first one is "employed status," and we select when it corresponds to being unemployed. Within the second survey question, we select iron, steel and electricity from "industry previously worked in". H2 is tested through a regression with the outcome variable as a dummy with 1 being unemployed and 0 employed, essentially $H2_i = 1$ and $H2_i = 0$ otherwise. The following equation represents H2:

$$(3) H2i = \alpha + \beta Xi + \rho Di + \gamma Zi + \epsilon i$$

Where $H2 = 1$ when the individual is unemployed while having previously been employed in emission-intensive industries, and 0 otherwise. γ reflects the slope of the number of unemployed individuals, and the parameter ρ captures the jump in unemployed individuals after 2023. Finally, i is the error term.

For H3, the outcome variable *being satisfied in working in an emission-intensive job* is obtained by combining the outcome variable from H1 *being employed in an emission-intensive industry* and the survey question about job satisfaction. Job

satisfaction is not unpacked by the dataset variable explanation. The question itself is whether you are satisfied or not, thereby leaving the job satisfaction interpretation to the workers themselves. H3 is tested through a regression with the outcome variable as a dummy with 1 being satisfied with the job and 0 otherwise. To this purpose, I estimate the following equation:

$$(4) H3i = \alpha + \beta Xi + \rho Di + \gamma Zi + \epsilon i$$

Where H1 is the outcome H1ia= 1 when the individual is employed in an emission-intensive sector and satisfied, and 0 otherwise. The treatment dummy Di is included. γ reflects the slope of the number of employed individuals satisfied with their jobs, and the parameter ρ captures the jump in employed individuals satisfied after 2023. Finally, i is the error term.

The functional form of the running variable is assumed to be a linear relationship between Xi and Di, to serve as the baseline model. However, using a functional form that does not truly fit the model can lead to biased treatment effects. In the case that the relationship is nonlinear, we test this contingency using polynomial functions of the running variable with a quadratic function of Xi. Ideally, the results that will emerge from this approach are insensitive to the degree of nonlinearity the model allows. The equation specifications for each hypothesis now become:

1. $H1i(a) = \alpha + \beta_1 Xi + \beta_2 Xi^2 + \rho Di + \gamma Zi + \epsilon i$
2. $H1i(b) = \alpha + \beta_1 Xi + \beta_2 Xi^2 + \rho Di + \gamma Zi + \epsilon i$
3. $H2i = \alpha + \beta_1 Xi + \beta_2 Xi^2 + \rho Di + \gamma Zi + \epsilon i$
4. $H3i = \alpha + \beta_1 Xi + \beta_2 Xi^2 + \rho Di + \gamma Zi + \epsilon i$

We keep the same equations as for the baseline models, but we add Xi2 which is the quadratic polynomial for the running variable quarters, with 2 as a parameter for the change in Xi2.

Assumption tests

Table 1 Descriptive statistics

	N	Mean	SD	Min	Max	Mean Difference
Before CBAM: 2021-2022^a						
Age ^b	417485	30.164	21.067	0	119	
Population white ^c	417485	.046	0.209	0	1	
Population coloured	417485	.085	0.279	0	1	
Population Asian/Indian	417485	.018	0.132	0	1	
Employed all industries ^d	417485	.224	0.417	0	1	
Employed in emissions-intensive industries ^e	417485	.002	0.047	0	1	
Unemployed in emissions-intensive industries ^f	417485	.003	0.051	0	1	
Satisfaction in emissions-intensive industries ^g	417485	.002	0.044	0	1	
After CBAM: 2023-2024 ^h						
Age	530490	30.503	21.031	0	119	.33
Population white	530490	.055	0.227	0	1	.008
Population colored	530490	.096	0.294	0	1	.01
Population Asian/Indian	530490	.019	0.136	0	1	.001
Employed all industries	530490	.249	0.433	0	1	.025
Employed in emissions-intensive industries	530490	.003	0.053	0	1	.001

Unemployed in emissions-intensive industries	530490	.003	0.057	0	1	.001
Satisfaction in emissions-intensive industries	530490	.002	0.049	0	1	.001

a The sample includes all individual observations for the control group, meaning observations before the implementation of the CBAM in 2023.

b This is a discrete variable

c The population groups: White, Colored, Asian/Indian are dummies for which in each category 1 represents the population of interest and 0 otherwise. Black is the omitted variable

d is a dummy variable representing whether someone is employed, all industries combined which is 1 and 0 if not

e is a dummy variable for when someone is employed in an emissions-intensive CBAM targeted industries when 1 and 0 otherwise

f is a dummy variable where 1 is when someone is currently unemployed after working in an emissions-intensive CBAM targeted industries and 0 otherwise

g is a dummy where 1 is when the individual is satisfied with their work and 0 otherwise

h the sample includes all individual observations for the treatment group, meaning observations after the implementation of the CBAM in 2023.

The mean difference column shows the t-test results and the subsequent difference in means for each variable between pre-CBAM and post-CBAM periods

Descriptive Statistics and the identification assumption

Table 1 reports summary statistics for the sample of the outcome variables and covariates in 2021-2024. We have two panels, divided between the control and treatment group, with panel A for the former and panel B for the latter. This enables us to test the key assumption of RD: identification. In addition, the table presents the t-test results comparing the sample's differences in mean, and every value has a significant p-value. Although the mean differences are statistically significant, their magnitudes are small, reflecting the large sample size rather than substantial labour market changes after 2023. For example, the mean for employment in emission-intensive industries increased by 0.1 percentage points after the implementation of the CBAM, which is very small. I can infer that statistical significance is driven almost entirely by sample size. Therefore, the table shows that the control and treatment groups are relatively similar on the dependent and control variables, validating the identification assumption. The difference in the number of individuals surveyed between both groups, with around 417,000 and 530,000 for the control and treatment

groups, respectively, is noticeable and acknowledged in the analysis. In fact, this is merely due to post-COVID measures and subsequent surveys having to be conducted using computer assisted telephone interviewing, largely reducing the number of respondents for the period 2021-2022. The number sharply increased after the removal of such measures. We see that the average age of the sample is 30 years old, and regarding population groups, black being the omitted category in the population variable, we observe 5% white, 8-9% colored, 1% asian individuals, and by deduction, 85% of the sample are black individuals. The numbers are in accordance with South Africa's characteristics (OECD Economic Surveys South Africa, 2025). Finally, we observe around 0.3% of individuals employed in emission-intensive industries, a similar value for unemployed individuals and a value of 0.2% for satisfied people in emission-intensive industries.

Anticipation assumption

Table 2 Assumption tests 2020-2021

	N	RD Estimate	p-value
Linear Regressions ^a			
Employed all industries ^b	392469	.01438	0.000
Employed in emissions-intensive industries ^c	392469	.00052	0.670
Unemployed in emissions-intensive industries ^d	392469	.00067	0.614
Satisfaction in emissions-intensive industries ^e	392469	.00047	0.457
Quadratic polynomial regressions ^f			
Employed all industries	392469	-.03807	0
Employed in emissions-intensive industries	392469	-.00027	0.491
Unemployed in emissions-intensive industries	392469	-.00034	0.447

Satisfaction in emissions-intensive industries	392469	-.00045	0.851
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a each RD estimate in this panel is from a different linear regression

b is a dummy variable representing whether someone is employed, which is 1 and 0 if not

c is a dummy variable for when someone is employed in an emissions-intensive CBAM targeted industries when 1 and 0 otherwise

d is a dummy variable where 1 is when someone is currently unemployed after working in an emissions-intensive CBAM targeted industries and 0 otherwise

e is a dummy where 1 is when the individual is satisfied with their work and 0 otherwise

f each RD estimate in this panel represents a different quadratic regression

For this assumption test, all three hypotheses were examined using both linear and quadratic polynomial regressions for the year 2020-2021. This way, we could observe a potential anticipation mechanism, or lack thereof, within the industries studied after the announcement of the CBAM in 2021. We then observe whether there are tangible and relevant differences in the number of employed individuals, employed individuals in CBAM-targeted industries, unemployment and job satisfaction in these same industries. Although we do observe a shift for employed industries, it is small in magnitude. In addition, the year 2020-2021 was the midst of the COVID-19 pandemic and restrictive measures, which contributed to plummeting employment rates and labour conditions in South Africa. For the rest of the results, the p-values are statistically insignificant. Our results enable us to reject the anticipation assumption. These assumption tests enable us to argue that they hold in this present research setting, ensuring the stronger validity of our analysis results.

Section III: Results

The results of the analysis are summarised in Table 3 for linear regressions and Table 4 for quadratic regressions.

Linear regression results

In this section, linear regressions are executed to gauge the effect of the CBAM on the SA labour market. Table 3 estimates the equation for each hypothesis with the default bandwidth and with and without covariates to test robustness.

Table 3 Results for linear relationship regression

	RD estimate	P-value	N
Panel A: H1a & H1b			
Employed all industries	.00086	0.039	947975
Employed all industries	.00038	0.092	947975
			<ul style="list-style-type: none"> Race and Age
Employed in emissions-intensive industries	0.00012	0.698	947975
Employed in emissions-intensive industries	0.00012	0.793	947975
			<ul style="list-style-type: none"> Race and Age
Panel B: H2			
Unemployed in emissions-intensive industries	-5.2e-05	0.408	947975
Unemployed in emissions-intensive industries	-5.4e-05	0.469	947975
			<ul style="list-style-type: none"> Race and Age
Panel C: H3			

Satisfaction in emissions-intensive industries	.00027	0.922	947975
Satisfaction in emissions-intensive industries	.00027	0.814	947975

- Race and Age

The RD estimates reported are for each outcome variables, with the default bandwidth of $h(8)$, meaning all quarters between Q1 2021 to Q4 2024.

For each outcome variable, an additional line includes the covariates race and age

The two outcome variables (a) being employed in all sectors and (b) being employed in emissions-intensive sectors' coefficient estimates are summarised in Panel A. The first row evaluates whether crossing the policy cutoff quarter is associated with a change in the likelihood of being employed in any industry. The RD estimate is 0.00086, indicating that crossing the cutoff changes the probability of being employed by 0.086 percentage points. Although the p-value suggests statistical significance, the magnitude of the effect is small. This implies that although the estimate is statistically detectable, it has no practical relevance, so employment status remains essentially unchanged around the cutoff. Row 2 highlight an RD estimate of 0.038 percentage points that shows that even after adding covariates, there is no evidence of a discontinuous change at the cutoff. Row 3 which summarises the estimated causal effect of CBAM on employment in an emission-intensive industry is 0.012 percentage points, combined with a p-value of 0.698, which shows that the results are statistically insignificant and small in magnitude. The data provide no evidence of a discontinuous change at the cutoff. Adding covariates did not significantly change the RD estimate, nor the significance of p-values. These results indicate that the CBAM had detectable impact on employment levels in all industries, but not in emission-intensive sectors around the implementation date in South Africa.

Next, Panel B reports the results from the analysis of the effect of CBAM on unemployment in emission-intensive industries. This section relies on comparing unemployed individuals who, before being unemployed, worked in emissions-intensive industries. We observe a change of -0.0052 percentage points in the

probability of being unemployed in an emission-intensive industry at the cutoff. This is a small estimate that is statistically insignificant with a p-value of 0.408. Adding covariates shows that unemployment remains smooth across the cutoff still.

Finally, Panel C illustrates results for the impact of the CBAM on job satisfaction in emission-intensive industries. Similar to previous results, the RD estimates are uniformly very small, all below 0.03 percentage points with insignificant p-values. Overall, the results indicate that the period after 2023 has no measurable effect on job satisfaction, since it appears smooth around the threshold, suggesting that CBAM does not influence how satisfied workers feel about their jobs.

Across all specifications, the RD cutoff shows only one statistically significant effect on overall employment. However, this effect is extremely small and disappears once additional controls are introduced. The other RD estimates for H1b, H2 and H3 do not enable us to reject the null hypotheses.

Quadratic polynomial regressions

In this section, results from the quadratic polynomial equations are analysed. Table 4 reports the results for each hypothesis with and without covariates. We find stronger estimates for H1a employed in all industries and inconclusive results for H1b, H2 and H3, similar to the results with the linear regression.

Table 4 Results for quadratic relationship regressions

	RD estimate	P-value	N
Panel A: H1a & H1b			
Employed all industries	-.00657	0	947975
Employed all industries	-.00514	0.001	947975

- Race and Age

Employed in emissions-intensive industries	-0.00015	0.336	947975
Employed in emissions-intensive industries	-9.9e-05	0.373	947975

- Race and Age

Panel B: H2

Unemployed in emissions-intensive industries	-0.00034	0.573	947975
Unemployed in emissions-intensive industries	-0.0003	0.618	947975

- Race and Age

Panel C: H3

Satisfaction in emissions-intensive industries	3.4e-05	0.212	947975
Satisfaction in emissions-intensive industries	8.2e-05	0.242	947975

- Race and Age

The RD estimates reported are for each outcome variable, with the default bandwidth of $h(8)$, meaning all quarters between Q1 2021 to Q4 2024.

For each outcome variable, an additional line includes the covariates race and age

We observe a negative RD estimate for employed individuals in all sectors. We infer from these values that after the implementation of the CBAM, the number of employed individuals decreased by 0.6%, with a statistically significant p-value of 0 and 0.001 with covariates. Employed individuals in emission-intensive sectors have insignificant p-values, not enabling us to reject the null hypothesis.

For the second hypothesis on unemployment, results are small in magnitude and statistically insignificant with p-values larger than 0.5. We still can observe a negative RD estimate of -0.3% of the number of unemployed individuals with and without covariates.

For the third hypothesis on job satisfaction in emission-intensive industries, we observe a positive relationship between post-2023 and employed individuals in emission-intensive industries's job satisfaction, although with a very small and insignificant p-values.

The RD estimates reveal statistically significant but small discontinuities in overall employment near the cutoff. These effects change direction across specifications, indicating limited robustness. For employment and unemployment in emissions-intensive sectors, and for satisfaction outcomes, the estimated effects are small and statistically indistinguishable from zero.

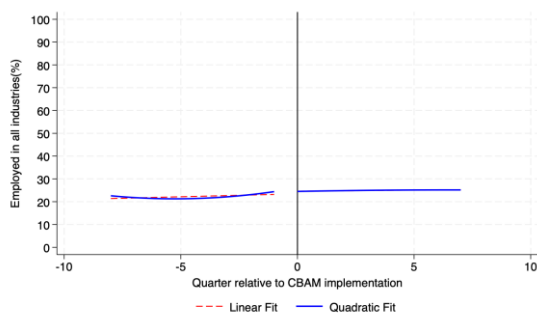


Figure 1: Employed individuals in all industries

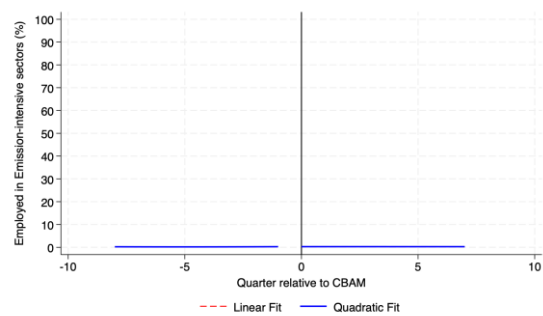


Figure 2: Employed individuals in emissions-intensive industries

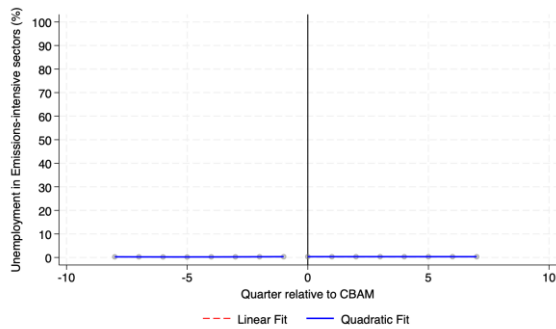


Figure 3: Unemployed individuals in emissions-intensive industries

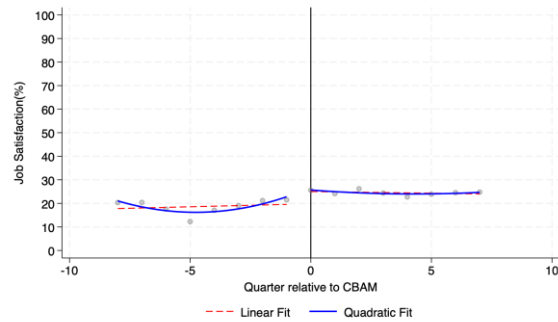


Figure 4: Job satisfaction in emissions-intensive industries

These plots graphically represent the results for each hypothesis for both linear and quadratic fits. The y-axis is expressed in percentage, and the x-axis represents the different quarters with Q0 being Q1 in 2023. The vertical line represents the policy cutoff. As touched upon in the results interpretation, we can only observe a very small in magnitude variation for H1a. We can also observe that the quadratic fit for H3 vary a bit along the line. For the other hypotheses, both the linear and quadratic fits remain unchanged.

Section 4: Discussion

Despite being the second-largest economy in Sub-Saharan Africa, South Africa constantly grapples with unemployment issues which reached a peak of 30% in 2025, one of the highest in the world. The gradual implementation of the Carbon Border Adjustment Mechanism from 2023, posed a challenge to an already vulnerable national labour market. Trade with the EU, representing 19% of total export share in 2019, is pivotal to the South African economy, implying that the CBAM could have significantly impacted the country's economy.

This paper aimed to analyse the job prospects of South African workers in CBAM-targeted sectors, as a way to understand the extent to which the carbon tax influences their employment rate and satisfaction. The sectors analysed were iron, steel and electricity mining and manufacturing, which are regulated by the CBAM, and the dataset used was the South African Quarterly Labour Force Survey (QLFS) for year 2021-2024. The analysis strived to provide some answers to the question: What is the impact of the CBAM on job prospects in energy-intensive industries in South Africa? In order to ensure a complete overview of the trends observed, I ran both linear

and quadratic regressions discontinuity analyses as a way to capture all potential variations in the dataset after the implementation of the CBAM in 2023.

The RD estimates showed only one statistically significant effect of the implementation of the CBAM for the first hypothesis H1a, on overall employment in all industries. However, this effect is extremely small and disappears once additional controls for race and age are introduced. Curtis et al (2024) predict such a trend to be an automatic mechanism of market adjustment after the implementation of a carbon tax. Indeed, the whole economy needs to re-organise itself by having to absorb workers who will be displaced by the move away from emission-intensive industries. Wei & Yip (2025) contend that it is often followed by an immediate, short-lived decrease of employment in all industries: the tax creates a domino effect on the whole economy in which emission-intensive and less intensive industries are often intertwined.

My other three hypotheses which argued that: (H1b) employment in emission-intensive sectors would decrease, that (H2) unemployment for workers in these sectors would increase and (H3) job satisfaction would decrease are rejected because of insignificant results. Such inconclusive results can partially be explained by the fact that the CBAM is implemented gradually, with a transitional phase from 2023 to 2025 and a definitive regime in 2026. 2023 marked the CBAM first phase implementation, which only implied administrative constraints. From 2023 onwards, importers are only required to report the volume of goods imported into the EU during the previous year, along with the associated greenhouse gas emissions. They will have to purchase certificates for emission-intensive products from 2026 onwards. It could thereby be argued that administrative constraints were not enough to trigger significant changes on our hypotheses' outcome variables. What this means, on the other hand, is that significant impact on employment, unemployment and job satisfaction in CBAM targeted sectors in South Africa could be observed from 2026 onwards, after complete implementation of the CBAM. In the longer run, stricter rules would force South African industries to follow more stringent re-structuration policies, leading to an immediate market distortion and significant impact for the workers in these sectors. A reduction of employment in targeted-sectors, an increase in unemployment and decrease in job satisfaction could be observed due to lower production in these sectors, leading to lower demand for labour and higher job stability anxiety and precarity for targeted

workers. As highlighted in Eicke et al. (2021) and Magacho et al. (2023)'s research, if the CBAM is implemented without taking into account vulnerable countries' specificities, such as a vulnerable labor market in South Africa, numerous jobs, tax revenues and export revenues will be lost. Workers would need to move to less emissions-intensive sectors, which often require different skills. However, research shows that these jobs have a high-level cognitive skills requirement, and hence require more formal training, more work experience and higher education levels, making the transition for emission-intensive sector workers to other sectors challenging (Bohlmann et al. 2019).

Few limitations may have hindered the present research from drawing conclusive results. First of all, although very complete and holistic, the QLFS only looks at formal jobs, despite the informal sector being essential to the South Africa economy (OECD, 2025). This way, thousands of informal jobs in emissions-intensive sectors may have been invisibilised by the dataset used, hindering the observation of tangible variations in the analysis. In addition, as stated above, only mining and manufacturing of CBAM targeted sectors were scrutinised. It could thus be relevant to draw a more complex typology of targeted sectors, including services and finance for example. Similarly, geographical regions could be added as covariates, as they have notable impacts on employment opportunities in South Africa (OECD, 2025). In order to capture individual variation over time, an individual fixed effect analysis could be undertaken. Finally, job satisfaction could be an entire research on its own. The term in this dataset is not formally explained and is a binary question (yes/no), meaning that the interpretation is up to the respondent and the researcher. Are we measuring work insecurity? The stress due to higher layoffs and subsequent anxiety of losing one's job? The precarity and arduousness of the job? Is it that the most unsatisfied workers have already left, and that now I measure the impact of those workers who stayed and were therefore overall satisfied with their work? These questions could be addressed in further research.

This research contributes to the growing literature on the economic and labour-market implications of climate policies by shifting the focus away from macro-outcomes toward employment dynamics in a strong, yet vulnerable African economy. While a substantial body of research examines the effects of the green transition on

economic growth and green job creation, less attention has been paid to labour market outcomes in African countries, where the structure of employment and adjustment capacity differ significantly to that of European markets. In this respect, the present analysis provides novel micro-level evidence on how an external climate policy instrument affects workers in an economy with high unemployment and a dependence on emissions-intensive industries. The relevance of South Africa as a case study extends beyond its national context. Many African economies share key structural characteristics with South Africa, including reliance on carbon-intensive production for exports and formal labour markets characterised by high unemployment. Already the second most populous continent in the world, while hosting one of the youngest workforces in the world, Africa is set to host 25% of the world's population by 2050, making analyses on the job market and climate transition more essential than ever (Stanley, 2023). From a normative perspective, broader concerns regard the CBAM as a rigid extension of European climate norms to the global trading system. While the policy aims to address carbon leakage, it does not explicitly account for its adverse distributional effects, differing local development priorities, and labour market vulnerabilities of trading partners. As such, this research highlights the need for climate policies that are not only environmentally effective but also equitable, inclusive and considerate of EU local trading partners contexts.

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