**Did South Africa’s carbon pricing policy reduce emissions?**

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**Abstract**

With climate change threatening our environment, there is a global effort to mitigate its impact. South Africa is not left out in this global effort towards saving the future, having introduced a carbon pricing policy to help discourage emissions. I use a Difference-in-Differences (DiD) estimation method to assess the effect of the carbon pricing policy introduced in 2019 by the government of South Africa on its carbon emissions. I use data from Climate Watch on carbon emissions and compare periods before and after the implementation of the policy in 2019 with other Sub-Saharan African countries. I find that the introduction of the policy has reduced emissions by about 1.23 metric tons per capita on average. In preliminary results, my finding highlights the effectiveness of the policy from an African perspective, contributing to the global discourse on climate change mitigation strategies feasible to discourage emissions.

**Introduction**

Climate change has been at the heart of global conversations due to its impact on the fate of our planet's future. It poses both economic and environmental threat globally, particularly to regions such as sub-Saharan Africa which emits less of greenhouse gas (GHG) but are experiencing damaging impact of emissions from the global north. The global rise in temperature and environmental pollution, have necessitated a global conversation toward more sustainable practices in preserving our planet. Among the efforts being made by countries to address this threat is carbon pricing. This approach focuses on putting a cost on carbon emissions and making polluters pay for the environmental damage that they may cause. The purpose of internalizing the external cost of GHG emissions is to encourage the reduction in emissions and create a more sustainable and friendly environment for economic activities to thrive. The adoption of carbon pricing as a tool to mitigate climate change aims at preserving our planet for future generations.

My study focuses on assessing the effectiveness of the carbon pricing policy introduced by the government of south Africa in 2019, on carbon emissions in South Africa. I also delve into both the economic and environmental implications of this policy on sustainable development within the sub-Sharan Africa region. My research will provide insights that will guide policy formulation and environmental conservation efforts being made by countries in the sub-Saharan Africa region towards reducing GHG emissions. It will also help to analyze how market-based tools such as carbon pricing influences environmental outcomes.

The global effort to reduce co2 emissions proves to be very challenging as highlighted by international agreements such as the Kyoto Protocol and the Paris Accord, UNFCC (2015). However, carbon pricing has emerged as a promising tool in ensuring the reduction in emission. And to understand the impact of this policy within the heterogenous economic landscapes of Sub-Saharan Africa with relatively low emissions compared to the global north is a way to confirm the effectiveness of this climate mitigating tool or otherwise.

According to Le and Azhagaliyeva (2018) and World Bank (2022), carbon pricing policies covered 23.17% of global GHG emissions. Previous studies have assessed the impact of carbon pricing policy effectiveness on greenhouse gas emission and found that carbon policies effectively discourage the emission of GHG (Andersson, 2019., Dechezleprêtre et al, 2022, Gugler et al, 2023). Also, there is evidence that carbon pricing policy drives the reduction in emission of greenhouse gas. For instance, Andersson (2019) found that carbon taxes significantly reduced transportation emissions in Sweden, a pioneer of carbon tax in the world, by 11 percent. Mardones and Flores (2018) on the other hand posited that higher or lower taxes does not necessarily reduce emission but rather increases revenue for countries. These previous studies are limited in nature since they focus only on global north. A gap exists in the literature with regards to the impact of these policies within sub-Saharan Africa, a region with dire economic vulnerabilities. Building on previous empirical studies, I assess the effectiveness of the carbon pricing policy introduced in South Africa – the first and only African country to implement a carbon pricing policy- as a case study to throw light on the wider implication of carbon pricing policy for sub-Saharan Africa.

I rely on data from the World Development Indicators (WDI) and Climate Watch to analyze the effect of ab carbon pricing policy on CO2 emissions in south Africa through a difference-in-differences estimation technique. My finding will help to assess the effectiveness of the carbon pricing policy within south African and sub-Saharan African perspective. It offers a practical insight for policy makers and stakeholders within developing economies.

**Background of the study**

Nations worldwide are exploring and implementing a myriad of strategies to help mitigate the increasing global warming crisis. Among these efforts, carbon pricing is considered a critical tool aimed at discouraging greenhouse gas emissions. “Carbon pricing” is a term used to place a direct cost on carbon emissions, with the sole intention of discouraging greenhouse gas emissions by industries and consumers to reduce the carbon footprint. By setting a market price for emissions, the cost of emissions is internalized, and polluters are made to pay for their emissions.

South Africa contributes about 38% of greenhouse gas emissions in Africa, (IEA, 2010). This trend in emission highlighted the need to strategize measures to discourage emissions and promote sustainable development within the region (Telsnig, 2013). Considering this, South Africa introduced a carbon tax policy in 2019 to discourage carbon emissions and to join the global effort to combat climate change. The carbon tax policy is set at 120 South African Rand (approximately USD 8) per ton of CO2 equivalent. The tax rate focuses on major industrial sectors that are the primary source of carbon emissions. These major industrial sectors were given allowances to adapt to new the varying costs in emission carbon. At the onset, lower tax rates were introduced to reduce the cost of emission and encourage the investment in cleaner technologies by these major industries. The policy is in line with both national and international commitments towards reducing emissions. The implementation of this policy signaled a shift towards a more economically driven approach to reducing emissions, unlike conventional policies that do not place market price or value on emission. The carbon tax policy provided an incentive for industries to reduce their carbon emissions and encouraged the adoption of cleaner technologies and behaviors. In order to assess the effectiveness of the carbon pricing policy, my study focuses on CO2 emissions, which are the main greenhouse gases produced by burning fossil fuels and the represents primary emission.

**Data**

I use data from World Bank’s World Development Indicator (WDI) and Climate Watch. The WDI has data on both socio-economic, financial, and environmental variables of various countries globally. Climate Watch takes annual data on greenhouse emissions of various countries globally.

Co2 emissions was sourced from Climate Watch whereas population growth and Gross Domestic Product Growth are from WDI.

Table 1: Descriptive statistics of Carbon Emission over time between South Africa and Other SSA

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | N | Mean | SD | Min | Max |
| Other SSA | 896 | 0.98 | 1.440 | .04 | 8.56 |
| South Africa | 32 | 8.492 | 0.660 | 7.09 | 9.95 |
|  | | | | | |

From Table 1, the average CO2 emissions for South Africa over the study period are about 8.5 metric tons per capita (mtpc), which is significantly higher than the average emissions within the Sub-Saharan Africa region. South Africa's emissions have increased on average, with a minimum emission of 7.09 mtpc and a maximum of 9.95 mtpc. Figure 1 confirms the vast variation in emission between South Africa and the control group. While South Africa's average emission hovers around 8 mtpc, other SSA average emission is less than 2 mtpc over the study period (1990-2021).

***Figure 1:*** Average emission of carbon over time for South Africa and other Sub-Saharan African Countries

A graph showing the amount of carbon emission over time

Description automatically generated

**Empirical strategy**

I employ the difference-in-differences model to estimate the effect of carbon pricing policy on emission in South Africa. I used this estimation technique by comparing the before and after outcomes of the carbon pricing policy in South Africa. Since South Africa introduced a carbon tax policy in 2019, I considered it as the treatment group whereas the other sub-Saharan African countries without the carbon policy are in the control group.

I hypothesize that the introduction of carbon pricing policy in South Africa will have a negative effect on CO2 emissions compared to other sub-Saharan countries without such a policy. The purpose of introducing the carbon tax is to discourage emissions; hence, polluters will reduce emissions since it becomes more costly to emit greenhouse gases.

My estimation model is as follows:

represents the CO2 emissions (metric tons per capita) in country ‘c’ at time ‘t.’ is a dummy variable showing the presence of carbon pricing policy with 1 for countries who implemented the policy and 0 otherwise. includes GDP growth rate and population growth as control variables to account for other economic variations that can affect emission. shows the country fixed effects, are the time fixed effects, accounting for shocks and trends affecting all countries over time globally and is the error term.

The causal effect of carbon pricing () is dependent on the assumption that the trend in C02 emission for South Africa will be like that of the control group (other sub-Saharan African countries) in the absence of the policy. This assumption has to get an unbiased estimate in understanding a policy impact after its implementation for both treated and non-treated groups.

**Results**

Table 2

|  |  |
| --- | --- |
| Treatment Variable | Coefficient |
| Carbon Pricing | -1.23\*\*\*  (0.12) |
| Number of observations | 928 |

From table 2, the coefficient for the carbon pricing variable is -1.23 and statistically significant. This gives evidence that the implementation of the carbon pricing policy has led to a reduction in carbon emissions. The negative coefficient of -1.23 implies that for every unit increase in the carbon pricing rate, carbon emissions reduces by 1.23 mtpc.

In order to check the parallel trend assumption that underlies my identification strategy, I estimate an event study. The parallel trend requires that both the treated and untreated groups in a study should have a similar trend before the introduction of a treatment; this way, we are able to confidently assess the impact of the treatment and attribute any change after the treatment to the treatment itself. In cases where this does not hold, it becomes difficult to ascertain the causal impact of a treatment. From my study, the parallel trend assumption does not hold, as is evident from Figure 2 below. Since South Africa accounts for about 65% of Africa’s emissions, it becomes difficult to find countries with emission trends similar to those of South Africa.

Figure 2: An event study of CO2 emissions over time.

A graph showing the results of a performance

Description automatically generated with medium confidence

My study is limited as it did not provide a sector-specific response to carbon pricing and emissions. Additionally, other factors can influence the emission of CO2, and their omission makes it difficult to fully accept that carbon pricing has led to a reduction in emissions in South Africa. Future research should consider examining the sector-specific impacts of carbon pricing on emissions. Furthermore, an extension should include other control variables that significantly influence carbon emissions. Another estimation technique, such as the synthetic control method, could be employed to assign equal weights to countries in assessing the impact of this policy.

**Conclusion**

By employing a difference-in-differences estimation technique, I assess the carbon pricing policy implemented in South Africa in 2019, comparing its effect on countries within the Sub-Saharan Africa region that did not implement this policy. I found that the implementation of the carbon pricing policy has significantly reduced emissions in South Africa by 1.23 metric tons per capita for every unit increase in the carbon pricing rate. This finding highlights the effectiveness of carbon pricing as a tool to discourage emissions while promoting sustainable environment.

However, my study had challenges in applying the differences-in-differences due to the absence of the parallel trend assumption. This makes it difficult to fairly interpret the result and confirm the effectiveness of the carbon pricing policy in South Africa.

Overall, my study provide insight for policy makers and the global community on the importance of climate mitigation schemes such as the carbon pricing policy. My study also provided an African perspective to existing literature on climate change and will add to global discourse on efforts being made to reduce greenhouse gas emissions.

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**Appendix**

Mardones and Flores (2018) used data from ENIA to conduct analysis on the effectiveness of carbon tax and industrial reaction towards these taxes in Chile. The paper employed an optimization problem that each industry faces in the presence of a carbon tax. The paper concluded that, higher taxes such as $10/ton CO2 and US$30/ton CO2 are implemented, emissions will be reduced rapidly whereas taxes around US$10/ton CO2 do not have any impact on emission. They concluded that higher or lower taxes does not necessarily reduces emission but rather increases revenue. While Chile ranks among the least emitters of GHG, primarily carbon dioxide, it has been so much committed to efforts towards reduction. This study reflects the extra efforts being made by countries that emits insignificant quantum of GHG towards climate change mitigation.

Gugler, et al., (2023), used data from the Department for Business, Energy and Industrial Strategy (BEIS) in the UK examined the impact of the introduction of carbon tax in British power sector on electricity-related emissions. Using a regression discontinuity design, the authors estimated the impact for the year the tax was introduced (2013) and subsequent years elevation and modification (2013 and 2014). The paper concluded that the causal effect of the policy on emission is dependent on the discontinuity created in electricity generation over the years because of the policy. The paper confirmed that the introduction of the policy changed the marginal cost of power plants base on emission intensities such that emissions are restrained. It also concludes that a minimal or moderate tax policy can cause a reduction in emission. This paper raises gives insight on how high or low South Africa’s carbon policy should be set such that it will serve it purpose of reducing emission other than just raising revenue.

Andersen (2019) uses data from the World Bank’s World Development Indicators and employed a synthetic control method to assess the impact of carbon taxes and value added tax on transport fuel in Sweden. The Sweden carbon tax currently stands at US$132 per ton which is the world’s highest tax imposed on non-trading sectors and households. The study revealed that the implementation of this policy significantly accounted for the reduction of emissions from transport by 11 percent. Anderson (2019) concluded that carbon tax elasticity demand for gasoline is about three times more than its price elastic and as such, using elasticates to measure emission reductions can be misleading. This study gives account of a sector-specific emission in the face of a carbon tax policy.

In their study, Xu, et al., (2023) used a dynamic general equilibrium model to confirm that changes in coal resource tax can go a long way to discourage co2 emission and promote sustainable environment for economic actives to thrive. They used data from China Energy Statistical Yearbook and the China Electric Power Yearbook for this study. According to the authors, coal resource taxes affect general price system and affects consumer behavior in the face of energy consumption. From their simulation, they predicted that increased coal resource tax will affect industrial consumption and optimize resource use by industries and hence reduce haze emissions and co2 emissions. Studies such as this informs for the purpose of policy the effectiveness of pricing on emission which South Africa is at the moment working towards it.

Dechezleprêtre, et al (2023) used the matching methodology and differences-in-differences estimation approach to investigate the impact of European Union Emissions Trading System (EU ETS) on carbon emissions and economic performance with data from France, Netherlands, Norway, and the United Kingdom. They found a statistically significant reduction in emissions by approximately 10% from 2005 to 2012, without decreasing economic performance of regulated firms. This study confirms that emission tools can help reduce emissions without distorting market structures. Implying that despite the bottlenecks with a pricing policy, it can still serve its purpose.