Effect of Carbon Footprint on Profitability in Metals & Mining industry of South Africa

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Abstract

This study investigates the impact of the introduction of a carbon tax on the South African metals and mining industry using integrated financial reports. The introduction of the carbon tax in South Africa promises to be one of the greatest systemic policy changes in the country's history, putting together business costs/risks and revenues/opportunities. The carbon tax, by its design, is disincentive and has financial consequences; therefore, it is important to analyse corporate environmental management practices in light of the relationships between carbon emissions and firm financial performance. This study hypothesises that the introduction of carbon-tax will change investors' expectations of the possibility of potential cash flows and shareholder returns to the companies concerned. Applying a positivist approach, the study analyses a financial and emissions dataset of 12 metals and mining companies for a five-year period, from 2015 to 2019. Econometric techniques are applied to determine the nature of relationships between companies' emissions and profitability ratios. The correlation and regression analysis showed that carbon tax has a negative impact on net profit margin (NPM), return on assets (ROA) and return on equity (ROE). The study developed a relationship between financial performance (NPM, ROA, RE) and carbon emissions. It is recommended that companies should invest in environmentally friendly technologies not only to positively impact their bottom line, but also to alleviate environmental degradation. Companies must investigate the advantages of investing in cleaner technologies as this is one solution for reducing the effects of the carbon tax on profitability.

Keywords: Carbon emissions, carbon tax, financial performance, profitability, metals and mining industry, South Africa

Abbreviations

CDM	Clean development mechanism
CO_2	Carbon dioxide
GHG	Greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
JI	Joint implementation
NDC	Nationally determined contributions
NPM	Net profit margin
ROA	Return on assets
ROE	Return on equity
RSA	Republic of South Africa
UNFCCC	United Nations Framework Convention on Climate Change

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1 CHAPTER 1: INTRODUCTION AND BACKGROUND TO THE STUDY

1.1 Introduction

The purpose of this study is to investigate the effects of the carbon tax introduced by the Government of South Africa on the profitability of the metals and mining industries sector. This is because the recent introduction of carbon tax in South Africa is expected to affect the profitability and ultimately the competitiveness and of the metals and mining industry of South Africa. The Republic of South Africa Government Gazette gave a notice that the President had given assent to the Carbon Tax Act on 23 May 2019 (Government Gazette, 2019).

According to Zhao (2011), compared to rivals who do not have a carbon tax or who follow loose carbon tax policies without taking into account other considerations (international policy, trade barriers, etc.), levying a strict carbon tax on a country could lead to bad outcomes, such as decreasing competitiveness due to rising prices, losing market share, or relocation of the industry to other countries. Taxing of carbon results in an increase in price of produced goods as the cost of carbon is transferred to the consumer, making the commodity more expensive, and thereby reducing competitiveness.

South Africa has dedicated itself to lowering its total carbon emissions by adopting the Carbon Tax Act 15 of 2019, which was adopted on 23 May 2019 and enacted on 1 June 2019. The tax will naturally appear on the expense side of the income statement, and this theoretically reduces the profitability of any business entity. According to Vegter (2019), the metals and mining sector is emission intensive and contributes the biggest portion of SA exports. It consequently follows that the metals and mining sector will be hard hit by the carbon tax both in terms of profitability and competitiveness on the international market. The introduction of any particular environmental strategy, such as carbon tax, calls for immediate analysis and evaluation to determine its financial, environmental and economic impact.

In light of the facts stated above, it is essentially that we investigate the relationships between carbon tax and profitability in the metals and mining sector of South Africa. The analysis done in this study will focus on financial data and scope 1 and 2 emissions, which are the ones reported on in the companies' integrated reports.

1.2 Background to the study

Climate change is potentially one of the most important problems facing humanity. The problem is not just an environmental issue, but has escalated into an economic, trade and security concern that is expected to gradually dominate national and global policies (Steenkamp, 2017). South Africa is vulnerable to climate change as evidence has shown that it is among the topmost greenhouse gas emitters in Africa. In response to this perceived threat, the government has built a relatively robust strategic and policy response system aimed at developing a climate resilient economy (Moyo, 2016). In this respect, the South African carbon tax was signed into law in June 2019. According to the statuette, “The carbon tax must be levied in respect of the sum of the greenhouse gas emissions of a taxpayer in respect of a tax period expressed as the carbon dioxide equivalent of those greenhouse gas emissions resulting from fuel combustion and industrial processes, and fugitive emissions in accordance with the emissions factors determined in accordance with a reporting methodology approved by the Department of Environmental Affairs” (Government Gazette, 2019).

There is increasing interest in determining what kind of impact the carbon policing can have on competitiveness, productivity and profitability of companies and whole sectors to which they are applied. In their model on the effect of carbon tax on South Africa’s economy, the World Bank Group (2016) reported that the carbon tax will have a negative effect on exports of iron and steel and other mining products. The authors argued that the negative effects may be because carbon tax makes it more difficult for the industries to compete globally. However, overall, the modelling analysis suggests a limited effect on the country’s trade position with a projected export growth rate 0.2% between 2014 and 2035 (World Bank Group, 2016).

On the issue of loss in competitiveness due to introduction of the carbon tax, National Treasury Republic of South Africa (2018) reiterated that “the carbon tax system offers substantial tax-free allowances, including a general tax-free allowance for all industries (i.e. allowable emissions), process emissions allowances, and a trade exposure allowance, to overcome future competitiveness issues”. As the coverage of carbon pricing policies is expanding internationally, the impacts on market competitiveness are likely to decrease and the advantages and investment opportunities for emerging, low-carbon industries would improve (National Treasury Republic of South Africa, 2018).

1.3 Problem statement

The metals and mining industry of South Africa is very critical to the country's economy as it was the second biggest contributor (6%) to GDP in 2020 (Department of Statistics South Africa, 2020b). This means that any statuette introduced, which affects this industry, will have an overall bearing on the GDP. According to statistics released by Department of Statistics South Africa (2020a), the metals and mining sector is also the biggest commodity exporter in the country, accounting for more than 50% of the total exports. The significance of such a statistic is that it highlights the need to continuously monitor and improve the sector's competitiveness so as to maintain and exceed the current export levels.

In a model proposed by Van Heerden *et al.* (2016), the introduction of carbon tax in South Africa will lead to a decrease in exports due to a reduction in competitiveness. The implication of this model is the prediction that the mining sector will take a beating as the products will lose market share. During the period 2014 to 2019, the growth rate of the mining industry was a meagre -0.3 percentage points, and the contribution to national gross domestic product (GDP) was at -0.1 percentage points (Department of Statistics South Africa, 2020b). This observation means that the perceived risk of investing in the metals and mining industry is high. The implementation of the Carbon Tax Act 15 of 2019 will therefore further raise the cost burden on most mining activities, in particular on marginal businesses with a negative growth rate. The carbon tax is meant to help educate the decisions and actions of producers and consumers by demanding that polluters compensate for environmental harm (Machingambi, 2017). The tax therefore acts as a control measure for all stakeholders involved to ensure emissions are reduced. According to National Treasury (2018), the tax is R120 per ton of CO_2 at emission levels above tax-free thresholds. This level is the lowest when compared to the other 15 countries where carbon tax was implemented. There is no specific literature which investigates the effects of carbon tax on the metals and mining industry post carbon tax law implementation.

The introduction of the carbon tax is a welcome measure in as far as curbing environmental plunder is concerned, but is bad news to shareholders on the basis that shareholders are pursuing profits. Smale *et al.* (2006) put forward that it cannot be argued that owners are after profits, but the unanswered question is whether they have reasons other than profits. Given the plethora of challenges discussed above, it is reasonable that we analyse the potential impact of the carbon tax on the profitability of the metals and mining industry. The study will make use of correlations and regression analysis to investigate the impact of carbon emissions on a number of key corporate financial performance indicators of 12 South African companies in the metals and mining sector.

1.4 Objectives of the study

1.4.1 Primary objective

The main objective is to investigate the impact of a carbon tax on the profitability of the metals and mining industries in South Africa.

1.4.2 Secondary objectives

The secondary objectives are as follows:

- Investigate the effects of the carbon tax on net profit margin (NPM).
- Investigate the effects of a carbon tax on the return of assets (ROA).
- Investigate the effects of the carbon tax on return on equity (ROE).
- Investigate correlations between these variables and other independent variables.
- Investigate the effects of increasing the tax rate.

1.5 Research question

The main research question for this study is phrased as follows:

- What is the impact of the South African carbon tax on the profitability of the metals and mining industries?

To address this main research question, this study will have to respond to the follow up sub-questions listed below.

1.5.1 Sub-questions

- What is the effect of a carbon tax on net profit margin (NPM)?
- What is the effect of a carbon tax on return on assets (ROA)?
- What is the effect of a carbon tax on return on equity (ROE)?
- What are the effects of increasing the carbon tax?

1.6 The rationale of the study

The carbon tax has a widespread global implementation in an attempt by countries to reduce emissions. Clarke (2011) observed that products from countries that tax carbon emissions on production basis will have higher costs to similar products from countries with no carbon mitigation measures. From an economic perspective, it is evident that the introduction of a domestic carbon tax may promote the production of carbon-intensive products to move to low-carbon tax countries. The company migrations compromise some local companies' competitiveness and therefore encourage local consumers to purchase cheaper carbon-intensive goods from reduced-tax countries. According to Cloete (2020), this, however, is not yet an issue of concern within the South African context, as the tax law includes a combination of measures that reduce carbon leakage such as the trade exposure allowance. It is also worth mentioning that investment decisions are informed by a variety of considerations, such as access to customers and vendors, regulatory frameworks, technology and intellectual property concerns with carbon tax being a minor cog in the big wheel.

In practice, a well-designed tax may combat climate change, decrease the cost of reducing emissions, promote innovation in low-carbon technology and create future public revenues (Marron & Toder, 2014). The National Treasury has suggested that most carbon tax proceeds would be used to deter increases in electricity price and promote energy efficient production during the first phase of the carbon tax.

After the implementation of the carbon tax in some countries, the following observations were noted:

- In Norway, carbon tax contributed to between 1.5 and 2.3% decreases in carbon emission exemption from the carbon tax for a wide range of fossil fuel-intensive sectors, exemptions that were primarily driven by concerns regarding productivity and product competitiveness (Bruvoll & Larsen, 2003)
- One model in China showed slightly negative implications on economic development, with GDP falling by 1.54 to 2.5% in Chongqing regions (Xie *et al.*, 2018).
- In the US, studies report that carbon tax causes significant increases in the usage of renewable energy and large reductions in coal consumption. A drop of 28 to 84% in coal production is estimated by the year 2030.

- There exists a myriad of predictions on the effects of a carbon tax on the SA economy, as well as the environment. However, as far as the current researchers are aware, there is no post-implementation report yet.

Pigou (2017) stated that state intervention is critical for rectifying negative externalities of taxes, and a scientifically determined selective taxation approach can achieve this. Reduction of emissions through a carbon tax can result in the mitigating country experiencing carbon leakages through a loss of competitiveness of its exports. Loss of competitiveness can be prevented by tax exemptions on export products and making some tax adjustments to untaxed imports, thereby maintaining competitiveness (Clarke, 2011)

1.7 Scope of the study

This study will cover the metals and mining sector companies domiciled in the Republic of South Africa and listed on the Johannesburg Stock Exchange (JSE). There are 388 companies listed on the JSE of which 46 are classified under the metals and mining sector. Secondary data from publicly available integrated company reports were used for determining the financial implications of the carbon tax. The study also only considered companies that submitted complete integrated reports for the period 2015 to 2019, containing both financial and emissions data.

1.8 The layout of the study

This study will follow a mini-dissertation format, which comprises five chapters, which are as follows:

Chapter 1: Introduction

This chapter introduces the research objectives, and presents the problem statement, research questions and the objectives of the study.

Chapter 2: Literature review

Global GHG emission reduction initiatives are discussed and then a focus on carbon tax from the global and South African context is discussed.

Chapter 3: Research design and methodology

This chapter focuses on the research methods and research design, followed by the sampling procedure used and data collection techniques.

Chapter 4: Results and discussion

Financial and emissions data obtained from integrated reports for the period 2015 to 2019 are analysed, interpreted and discussed.

Chapter 5: Conclusions and recommendations

This chapter concludes the study. Conclusions, recommendations and areas for future research are outlined in this chapter.

1.9 Summary

Despite climate change, there has been little cooperation between nations to reduce carbon levels in the atmosphere. South Africa has taken a stand against these issues with the implementation of a carbon levy, with various consequences for entrepreneurship and small and medium-sized enterprises. With the introduction of the carbon tax, it is predicted that all South African firms will have to change their market practices in order to conform to the tax. The research objectives of this study are aimed at determining the effect of the implemented carbon tax on the South African metal and mining industry.

2 CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The objective of this chapter is to critically discuss the existing literature pertaining to global emissions control measures and specifically the South African carbon tax. The section discusses the global initiatives taken to curb greenhouse gas pollution. Thereafter, the main strategy of curtailing emissions through the implementation of a carbon tax is discussed. The advantages and disadvantages of the carbon tax are presented and its effects within the context of South Africa are highlighted. Finally, aspects of cost and profitability and the profitability ratios that are used in the determination of business viability and competitiveness are outlined.

2.2 The need for reducing carbon emissions

According to the United Nations Framework Convention on Climate Change (UNFCC, 1992), climate change is defined as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable periods". Climate change effects are a threat to humankind in this modern world. To curb the effects of climate change, states should act to combat the unescapable magnitudes that threaten extinction by means of following the global commitments (Change, 2014). Given this state of affairs, it is critical that national and global initiatives to reduce emissions be taken seriously.

Previous studies report that the global concentrations of greenhouse gases (GHG) such as CO_2, methane and nitrous oxide have markedly increased as compared to the pre-industrial era, which ranges between 280 and 379 ppm in 2005 (Gregory *et al.*, 2007). The increase has been attributed mainly to the burning of fossil fuel and agricultural activities. The increase in GHG emissions is associated with incontrovertibly evident warming of the climate. Climate change results in the increase in global air and ocean temperatures, substantial snow and ice melting and the ever-rising sea levels. From 1961, sea levels rose at an average of 1.8 millimetres per annum and the rate rose to 3.1 millimetres in 1993. Predictions say that the prevalence and increase of GHG concentration in the atmosphere will increase the likelihood and frequency of extreme climate conditions such as floods, tropical cyclones, droughts and wildfires (Kirby, 2009). The researchers noted that for the period 1900 to 2005, rainfall levels drastically increased in parts of the Americas, Europe and Asia, while there was a significant decline in the Sahel, Southern Africa and Asia. Most land areas are now prone to cold days, nights and frosts, and the prevalence of heat waves is prevalent at an increased frequency (Kirby, 2009). The observed effects of global warming include:

- Food shortages exacerbated by prolonged droughts most notably in tropical climates.
- Reduction in freshwater supply as rainfall patterns become erratic and water bodies dry up.
- Health hazards detrimental to human existence.
- Ocean acidification threatens global ecosystem as it destroys marine life, including diatoms, which are an essential source of oxygen.
- The melting of glaciers causes a rise in sea-levels, leading to flooding of coastal areas that humans inhabit.

All the above-mentioned status quo point to a real and present danger to human existence and it warrants immediate action with nations having to form a united front to solve and confront the predicament.

The Intergovernmental Panel on Climate Change (IPCC) was formed in 1988 to address the rising concern about the effects of global climate change. The panel was accompanied by a follow-up formation of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992. The mandate of UNFCC is to realise stabilisation in the atmospheric GHG concentrations and to avert attainment of dangerous anthropogenic intercession with the climate (RSA, 2004). According to the Department of Environmental Affairs (2018), the government of RSA ratified the UNFCCC in 1997. The obligations set out in the UNFCCC were insufficient to achieve its ultimate goal, and this led to the acceptance of the Kyoto Protocol in 1997, after much international mediation. Because of this scientific unanimity the increasing concentration of GHG in the atmosphere to climate change, nations of the world adopted the Kyoto Protocol in 1997 with RSA making a late entry in 2002 (Department of Environmental Affairs, 2018). These initiatives marked an ongoing global attempt to combat the threat to the climate and to human existence, which, however, have a long way to go in making significant impacts. Given that the structures and strategies are in place, what is left is to convince all countries to come on board and contribute in this war.

2.2.1 Kyoto Protocol

The Kyoto Protocol is a legally binding contractual agreement signed by 37 developed countries in 1997 to reduce GHG emissions and promotes sustainable development. It was much later, in 2002, that the Republic of South Africa yielded to the Kyoto Protocol (RSA, 2004). The objectives of the Kyoto protocol are to keep track of, limit and minimise climate change through targeting production of GHG. The Protocol listed the following six GHGs that the signatories agreed to reduce:

- carbon dioxide (CO_2)
- methane (CH_4)
- nitrous oxide (N_2O)
- sulphur hexafluoride (SF_6)
- hydrofluorocarbons (HFCs)
- perfluorocarbons (PFCs)

The different gases affect the atmosphere in varying degrees, and the extent to which a certain GHG contributes to global warming is known as its global warming potential (GWP). Under the Kyoto Protocol, a total of 37 industrialised nations and the European Community undertook to cut their emissions by 5% compared to 1990 levels spread over five years from 2008 to 2012 (UNFCC, 2011). However, under a scheme dubbed "common differentiated responsibilities", the Kyoto Protocol sets a heavier burden on developed countries. During the engagement period above, emission objectives for industrialised countries that are parties to the Kyoto Protocol expressed as permitted emission concentrations or equivalent quantities denoted in tonnes of CO_2 equivalent. The Protocol, however, allows some degree of flexibility in meeting their quotas through three innovative market-based mechanisms. To date, 192 countries out of a total of 195 countries have ratified the Kyoto protocol. The willingness shown by 98% of the world to commit to the reduction of GHG emission is a welcome move for the progress and perpetuation of mankind.

2.2.2 Kyoto Protocol mechanisms

Nations with obligations under the Kyoto Protocol to eliminate or cut emissions must achieve their goals mainly by national initiatives. As an alternative way of achieving these goals, the Kyoto Protocol adopted three market-based strategies to establish what has become known as the carbon market. There are three mechanisms to the Kyoto Protocol, which are listed below.

2.2.2.1 Emissions trading

Parties with obligations under the Kyoto Protocol have negotiated goals for restricting or reducing emissions. Such goals are expressed as the rates of permitted emissions or allocated quantities over the 2008 to 2012 commitment periods. Emissions trading, as provided for in Article 17 of the Kyoto Protocol, enables countries with emission units to save emissions permitted but not 'used' – the additional capacity is saleable to parties that are using more than their targets.

As a consequence, the creation of a new product in the form of emission trading or carbon points resulted. Because carbon dioxide is the most significant greenhouse gas, people are merely thinking about trading in carbon, which is now being monitored and exchanged like every other resource a phenomenon is known as the 'carbon market'. (United Nations Climate Change, 2020b). The significance of emissions trading is that it will undo the reduction in emissions in one region as they trade their saved emissions to high polluters. Looking at it holistically, the system is a step back in the whole picture of global carbon reduction.

2.2.2.2 Clean development mechanism (CDM)

There are expectations that countries with emission limitation commitment will undertake emission reduction projects in developing countries. These projects can then earn the member country certified emission reduction (CER) credits equivalent to one tonne CO_2. The mechanism enhances sustainable development, reduces emissions, while providing some flexibility to industrialised countries in how they meet their objectives for reducing emissions or limiting emissions (United Nations Climate Change, 2020a). Although this mechanism appears good in its intentions, in some cases companies will be compensated for projects that do not, in turn, contribute to an overall decrease in pollution or may result in emissions leakage.

2.2.2.3 Joint implementation (JI)

Joint implementation requires a country with an emission reduction or restriction obligation under the Kyoto Protocol to receive emission reduction units (ERUs) from an emission reduction project in another, each equal to one ton of CO_2, which count against achieving its Kyoto target. The joint implementation provides the parties with a flexible and cost-effective means of meeting part of their Kyoto obligations, while the host party profits from international trade and technology transfer (United Nations Climate Change, 2020c).

2.3 The introduction of carbon taxes

Carbon levies, also known as Pigovian taxes, are instruments meant to regulate the global costs of carbon emissions and compensate for the detrimental effects of carbon dioxide, which are precursors for climate change. The levy is a fee evaluated against private people or corporates for carrying out operations with deleterious side impacts. The idea of placing a price on carbon internalises the social costs associated with the use of fossil fuel and other GHG emitting activities (Larsen *et al.*, 2018). Carbon taxes work by affecting the prices of commodities produced via carbon-intensive inputs, thereby forcing consumers to opt for other substitutes or complementary products (Clarke, 2011). According to Pigou, negative externalities that hinder the market economy from equilibrating can be removed by internalising production. Negative externality happens when a financial entity does not completely internalise the cost of their operation. In this case, the burden of economic activity is borne by society, including the environment.

The main advantage of the Pigouvian model is that it results in commodity prices that mirror the social costs of production, such as external costs, so that consumers and businesses take these factors into account in their decision-making (Diamond & Zodrow, 2018). State intervention is critical for rectifying negative externalities through a scientifically determined selective taxation approach (Pigou, 2017). The crux of the theory is that the cost of carbon can transcend to the consumer through an increase in product price and this can have an impact on profitability.

In an attempt to mitigate emissions through a carbon tax, the mitigating country can experience carbon leakages through a loss of competitiveness of its exports. This negative impact is offset by tax exemptions on export products and making some tax adjustments to untaxed imports. The move will discourage export-orientated companies from relocating to pollution havens (Clarke, 2011). Non-carbon-intensive goods will generally be priced lower than their carbon-intensive counterparts. A carbon tax will only accelerate inevitable changes in society and make them more orderly. We can consequently conclude that corporate behaviour will be moulded by market forces in their attempt to maintain competitiveness.

2.3.1 Cost comparison of countries with carbon tax law

According to a report by The World Bank (2020), the following table provides an overview of current national and sub-national countries that have implemented a direct carbon tax.

Table 1: Carbon tax by country

Country/Jurisdiction	Year	Overview / Coverage	Tax rate / tCO_2e
British Columbia	2008	The carbon tax applies to the purchase or use of fuels within the province. The carbon tax is revenue neutral; all funds generated by the tax are returned to citizens through reductions in other taxes.	USD23 (2012) CAD30 (2012)
Chile	2014	Chile's carbon tax is part of legislation enacted in 2014. The country is to start with measuring carbon dioxide emissions from thermal power plants in 2017 and begin the tax on CO_2 emissions from the power sector in 2018.	USD5 2018
Costa Rica	1997	In 1997, Costa Rica enacted a tax on carbon pollution, set at 3.5% of the market value of fossil fuels. The revenue generated by the tax goes toward the Payment for Environmental Services (PSA) programme, which offers incentives to property owners to practise sustainable development and forest conservation.	3.5% tax on hydrocarbon on fossil fuels

Denmark	1992	The Danish carbon tax covers all consumption of fossil fuels (natural gas, oil and coal), with partial exemption and refund provisions for sectors covered by the EU ETS, energy-intensive processes, exported goods, fuels in refineries and many transport-related activities. Fuels used for electricity production are also not taxed by the carbon tax, but instead, a tax on electricity production applies.	USD31 2014
Finland	1990	While initially based only on carbon content, Finland's carbon tax was subsequently changed to a combination of carbon/energy tax. It initially covered only heat and electricity production, but was later expanded to cover transportation and heating fuels.	USD39 2013 EUR35 2013
France	2014	In December 2013, the French parliament approved a domestic consumption tax on energy products based on the content of CO_2 on fossil fuel consumption not covered by the EU ETS. A carbon tax was introduced from 1 April 2014, on the use of gas, heavy fuel oil, and coal, increasing to €14.5/tCO_2 in 2015 and €22/tCO_2 in 2016. From 2015 onwards, the carbon tax will be extended to transport fuels and heating oil.	EUR7 (2014)
Iceland	2010	All importers and importers of liquid fossil fuels (gas and diesel oils, petrol, aircraft and jet fuels and fuel oils) are liable for the carbon tax regardless of whether it is for retail or personal use. A carbon tax for liquid fossil fuels is paid to the treasury, with (since 2011)	USD10 per tCO_2e (2014)

		the rates reflecting a carbon price equivalent to 75% of the current price in the EU ETS scheme.	
Ireland	2010	The carbon tax is limited to those sectors outside of the EU ETS, as well as excluding most emissions from farming. Instead, the tax applies to petrol, heavy oil, auto-diesel, kerosene, liquid petroleum gas (LPG), fuel oil, natural gas, coal and peat, as well as aviation gasoline.	EUR22 (2013) USD20 (2013)
Japan	2012	Japan's Tax for Climate Change Mitigation covers the use of all fossil fuels such as oil, natural gas, and coal, depending on their CO_2 emissions. In particular, by using a CO_2 emission factor for each sector, the tax rate per unit quantity is set so that each tax burden is equal to US$2/t$CO_2$ (as of April 2014).	USD2 (2014)
Mexico	2012	Mexico's carbon tax covers fossil fuel sales and imports by manufacturers, producers and importers. It is not a tax on the full carbon content of fuels, but instead on the additional amount of emissions that would be generated if the fossil fuel were used instead of natural gas. Natural gas, therefore, is not subject to the carbon tax, though it could be in the future. The tax rate is capped at 3% of the sales price of the fuel. Companies liable to pay the tax may choose to pay the carbon tax with credits from CDM projects developed in Mexico, equivalent to the value of the credits at the time of paying the tax.	Mex$ 10 (2014)*
Norway	1991	About 55% of Norway's CO_2 emissions are	USD4-69

		effectively taxed. Emissions not covered by a carbon tax are included in the country's ETS, which was linked to the European ETS in 2008.	(2014)*
Portugal	2014	Portugal's carbon tax of €5 per tCO_2e went into effect in 2015 as part of a more comprehensive package of green tax reforms. It applies to non-EU ETS sectors and covers approximately 26% of the country's greenhouse gas emissions.	USD6 (2015) €5 (2015)
South Africa	2016	In May 2013, the South African government published a policy paper for public comment on the introduction of a carbon tax. The paper proposes a fuel input tax based on the carbon content of the fuel. It was agreed that emissions factors and procedures are available to quantify CO_2-eq emissions with a relatively high level of accuracy for different processes and sectors. The carbon tax will cover all direct GHG emissions from both fuel combustion as well as non-energy industrial process emissions, and started in June 2019.	USD8.50/t CO_2 R120/tCO_2 *Tax is proposed to increase by 10% per year until the end of 2019
Sweden	1991	Sweden's carbon tax was predominantly introduced as part of energy sector reform, with the significant taxed sectors including natural gas, gasoline, coal, light and heavy fuel oil, liquefied petroleum gas (LPG), and home heating oil. Over the years, carbon tax exemptions have increased for installations under the EU ETS, with the most recent increase in exemption starting from 2014 for district heating plants participating in the EU	USD168 per tCO_2e (2014)

		ETS.	
Switzerland	2008	Switzerland’s carbon tax covers all fossil fuels unless they are used for energy.	USD68

It is observed from Table 1 that South Africa has one of the lowest carbon taxes among the countries that have implemented the tax worldwide. The set carbon tax rate is well below that stated in the Paris agreement target of US$40 to US$80/tCO_2 by 2020 and might not be deterrent enough to influence offenders to take steps in addressing the pollution problem. Different countries make use of the collected carbon tax differently, but it is mostly re-invested back into the system. South Africa, in its initial phase of implementation, is not charging tax for the generation of electricity, and a similar provision is notable in the case of Denmark and Switzerland.

2.3.2 **Mechanics of carbon tax**

A carbon tax in its simplified form would be enforced on the extraction of fossil carbon, through mining coal, pumping oil or extracting natural gas. The amount of carbon tax liable would therefore depend solely on the amount of carbon contained. Taxing of carbon will start from the point of extraction and will also be imposed on all the secondary forms of carbon extraction (Waggoner, 2009). The revenue obtained from a carbon tax can, in some instances, be used for general government expenditure. Along the distribution chain, the tax is also imposed, for example when refuelling vehicles, electricity consumption or industrial emissions. It may be deduced that the polluter pays principles impartially, and simplicity makes carbon taxing attractive as an emissions control instrument.

2.3.3 **Impact of carbon tax implementation**

Despite the carbon tax having desirable effects, it is worth remembering that any tax has undesirable effects, which are:

- There always will be systemic problems in the collection of taxes.
- Taxpayers lose income to budget and comply with taxes, avoid taxation, or even evade taxes.
- Enforcement of tax payment involves costs.

- Resolution of tax-associated disputes costs tribunal money.

Taxes can distort the behaviour of the populace, decelerate economic activities as it siphons money from the fiscus, and dampens people's incentive to work, innovate and willingness to take risks (Waggoner, 2009).

2.3.4 Application of carbon tax

The tax policy framework must ensure that there is neutrality, fairness and simplicity. The principles of a sound taxation system, as mentioned in the four canons of Adam Smith, who elaborated on its use and implementation, are as follows.

2.3.4.1 Canon of equality

The process of paying tax revolves around a corporation or an individual's ability to pay. According to Smith and Stewart (1963), "The subjects of every state ought to contribute towards the support of the government, as nearly as possible, in proportion to their respective abilities; that is, in proportion to the revenue which they respectively enjoy under the protection of the state". The tax burden must correspond to benefits from the government's expenditure of collected tax income.

2.3.4.2 Canon of certainty

Taxpayers need to be aware of their obligations to plan their budgets appropriately. Therefore, each person is obliged to pay an individual tax that should not be arbitrary (Smith & Stewart, 1963). The government must comprehensively define penalties charged, time of implementation and type of tax. The state must also be aware of the revenue it will gather from the taxpayer for its budgeting purposes.

2.3.4.3 Canon of convenience

The taxpayer must be alerted of the policy applied by the system as to whether it is progressive, regressive or proportional. Every tax should be such that it becomes most likely to be appropriate for the taxpayer to pay.

2.3.4.4 Canon of economy

Compliance costs must remain at a minimum possible value. In the words of Smith and Stewart (1963), "Every tax ought to be so contrived as both to take out and to keep out of the pockets of the people as little as possible over and above what it brings into the public treasury of the state". Exorbitant taxes may be due to the following four factors:

- The process of levying might require a great deal of human resources such that the salaries of the tax collectors end up eating into the collected taxes.
- Some taxing systems may obstruct the smooth flow of the production industry and result in some companies laying off people, thereby defeating the initial objective.
- Injudicious taxes increase the temptation for taxpayers to evade payment; therefore, the penalties of tax evasion must rise simultaneously with the temptation. The legislation, according to all the expected values of justice, first generates temptation and afterwards penalises any who give in to it.
- Subjecting individuals to frequent visits and hateful examination by tax-collectors may commit them to much-unwanted difficulty, despondency and harassment. Although despondency is not, strictly speaking, a cost, it is equal to the cost at which every person would be ready to redeem himself.

It is in some of these four distinct respects that taxes are often so much more cumbersome to the individuals than they are favourable to the government (Smith & Stewart, 1963).

The Davis Tax Committe (2015), in their report, proposed that in its application, the carbon tax should:

- Be comprehensive enough to make CO_2 mitigatory option incentives attractive
- Take advantage of the tax dividend with revenues channelled reduction of other distorting taxes or for economically beneficial purposes.
- Beset to the degree that is reliable, consistent and increasing with time signalling to the market that the only way forward is a clean technology
- Attain a reasonable compromise between environmental and economic needs.

A carbon tax can improve a country's competitiveness if it is trading with countries also affected by the tax. In the case of South Africa, most of the trade is currently with South East Asia, a section in which there are not many calls for carbon tax imposition; therefore, carbon taxes cause SA products to lose competitiveness. The copious amount of CO_2 in the atmosphere needs a concerted global effort to achieve a significant decrease, and unilateral imposition of the tax by SA will be utterly ineffective (Lloyd, 2011). South Africa is currently the only developing nation to impose the carbon tax.

2.3.5 **Advantages of carbon tax**

There are significant advantages of a carbon tax over the traditional option of controlling pollution by traditional cap-and-control policies. In their research, Pearce (1991) summarised the advantages of implementation of a carbon tax as follows:

1. Environmental taxes are unique in that they correct distortion, such as external costs resulting from increased use of environmental services. A carbon tax can consequently be calculated based on the carbon content of the fuel. Use of fossil fuel would therefore inevitably attract a tax translating to government revenue. The government can, on the other hand, cushion the effects of the tax through the injection of the collected tax to finance emission reduction incentives and also by distorting other taxes such as the income or corporate taxes. Acceptability of the carbon tax can be enhanced if the government introduced it as part of “a package of fiscally neutral measures”. Fiscal neutrality of a carbon tax is therefore instrumental to its success.

2. Carbon taxes can minimise the cost of compliance for industry and also consumers who partake part of the tax. This benefit is a result of the fact that if tax is common to all polluters, there will exist varying costs of abatement depending on the individual’s level of pollution. High polluters will prefer to pay the tax, while low emission polluters will concentrate on abatement processes, which overall result in a minimisation of the abatement costs.

3. Carbon taxes serve as a persistent incentive to embrace cleaner technologies and energy efficiency. Standards strive to be ‘technology-based’ and therefore promote technology transfers to the extent that the emissions regulator considers to be the ‘best available’. However, to incentivise polluters to go beyond the standard, there is a need to continuously revise the standards and set them slightly above what can be achieved by the best technology available.

4. It is easy to modify carbon taxes to keep in line with newly acquired information or technology.

5. A tax on inexpensive fossil fuels raises its price per energy unit and makes cleaner energy sources more cost-competitive. These alternative energy sources are usually less polluting, and this results in reductions in emissions.

6. A carbon tax raises government income, which can be reinjected as incentivised schemes for emission reduction and also finance government agencies tasked with combating climate change.

2.3.6 **Disadvantages of carbon tax**

As with other mitigatory measures, there are problems and disadvantages associated with the introduction of a carbon tax, summarised below (Pearce, 1991):

1. Attainment of the target CO_2 reductions is difficult as relevant, unpredictable elasticities cannot be estimated accurately as elasticity for energy demand is widely variable. As the tax is dependent on fuel carbon content, the information on inter-fuel substitution elasticities and the elasticity of prices has to be known. As the tax adjustment is necessary for the efficient running of the instrument, this may trigger hostile reactions from industry and consumers.

2. Carbon taxes themselves would trigger a deadweight loss that must be offset against the benefit from the decreased externality of global warming.

3. The introduction of a carbon tax on its own is a shortcoming as a consumer will logically compare it to alternative non-tax instruments.

4. An inappropriate price of carbon can result in unintended negative consequences as some companies might opt to pay the price for emissions and not focus on emission reduction. The negative consequences can occur in instances where the tax is low, and the cost of improving the production process or use of alternative technologies is not economically sustainable (Kuo *et al.*, 2016).

5. A carbon tax can be regressive in that they make fossil fuels more expensive, which mainly affects low-income groups most as they will spend more of their meagre salaries on basics such as electricity, petrol and food.

2.3.7 **Global carbon tax initiatives**

Carbon tax had widespread global implementation in an attempt by countries to reduce emissions. From an economic perspective, it is possible that a domestic carbon tax may presumably promote the production of carbon-intensive products to move to low-carbon tax countries. The move compromises some local companies' competitiveness and encourages local consumers to purchase carbon-intensive goods from reduced-tax countries. In practice, a well-designed tax may combat climate change, decrease the cost of reducing emissions, promote innovation in low-carbon technology and create future public revenues (Marron & Toder, 2014).

In research on energy market outcomes in the US, Noah Kaufman (2018) observed that the commodity price increase is dependent on the tax rates, and also on the carbon content of the fuel in question. There is a general shift away from dependence on coal as a source of fuel towards renewable energy sources with negligible impact on oil and natural gases consumption. The effect of the carbon tax on products is largest where the energy source is coal, followed by petroleum and lastly natural gas. The introduction of carbon tax led to a simultaneous decline in coal production of 28% and a projected further decrease of 84% by 2030. As coal is substituted by natural gas as a source of energy, an increase in natural gas production was inevitable, which will drop by 5% in 2030 (Noah Kaufman, 2018).

In a summary of findings from a study about US carbon tax, Larsen *et al.* (2018) concluded that:

- A carbon tax can yield marked reductions in US GHG emission realising reductions of 39 to 47% below the 2005 levels by 2030,
- Reductions in emissions occur primarily in the electricity generation sector. This industry is the most sensitive to the carbon price, and this, in effect, is where most reductions in emissions occur across the economy
- The carbon tax causes significant increases in the usage of renewable energy and large reductions in coal consumption. A drop of 28 to 84% in coal production is estimated by 2030.
- An increase in federal revenue due to carbon tax is expected in the range $617 million to $2.5 trillion in the first ten years.

Norway is one of the pioneers in the implementation of carbon tax, having done so in 1991. The country is famed for having one of the highest carbon tax rates of US$44 per tonne of CO_2. Despite such a high rate, the policy has only achieved modest influence on GHG emissions with a recorded increase of 19% CO_2 emitted from 1990 to 1999. From observations, the overall carbon tax contributed to between 1.5 and 2.3 % decreases in carbon emissions. Despite the impression that the Norwegian carbon taxes have been both substantial and ground-breaking, these findings may seem surprising. The small improvements are due at least in part to the exemption from the carbon tax for a wide range of fossil fuel-intensive sectors. These exemptions are primarily a result of concerns regarding productivity and product competitiveness (Bruvoll & Larsen, 2003). The sectors that are exempt from carbon levies are the ones where the carbon tax is be most effective in terms of lowering production and emissions. It may be inferred from these observations that it is critical to inculcate some exemptions in the levying of the tax to protect both the consumer and the producer.

A model by Xie *et al.* (2018) showed that the introduction of the carbon tax in China could enable it to meet its NDC carbon intensity reduction target by 2030. Nevertheless, it will have slightly negative implications on economic development, with GDP falling by 1.54 to 2.5% in the Chongqing regions. A reduction in the negative impact of tax on the economy is realisable by ensuring that:

(a) Revenue from the carbon tax goes towards subsidising businesses to cut economic losses and help in the development of environmentally friendly energy-saving technologies,

(b) Companies and industries take energy-saving steps or developments should be compensated for by tax relief and preferred policies.

(c) This initiative will maintain the core profitability of these firms, boost the use of green technologies and improve production technology (Xie *et al*., 2018).

It is common practice in business that companies shift their financial burden to the consumers; in the case of the carbon tax, the imposed penalties will be on consumers' accounts. Correct execution of the taxation process will ensure companies modify their processes. Moreover, if companies feel that the tax levels are not deterring enough, they usually end up opting to pay the penalties rather than remedying their processes to reduce emissions. In such situations, it is up to the policymakers to provide incentives to offset the costs targeted at reducing emissions. Alternatively, hefty penalties may force companies to comply (Kuo *et al.,* 2016).

2.3.8 Carbon Disclosure Project

The Carbon Disclosure Project (CDP) is an independent non-profit agency that provides businesses and communities with the only comprehensive framework for tracking, reporting, monitoring and exchanging critical environmental knowledge (Worldwide, 2020). CDP harnesses market forces to gather information from companies about their greenhouse gas emissions and climate change assessment and water risk and opportunity. The CDP currently owns the most extensive set of fundamental climate change and water data worldwide and positions these observations at the centre of the strategic industry, procurement and policy decisions. CDP distributes annual questionnaires that require companies to disclose their carbon emissions. These disclosures stimulate the sharing of information relating to climate changes between business stakeholders. “The CDP’s ambition to drive sustainable economies has a basis on the assumption that disclosure of information will motivate and facilitate a meaningful dialogue between business actors, investors and the general public, and ultimately trigger significant corporate responses to climate change” (Pattberg, 2017). The CDP is therefore a transparent and voluntary way of emissions reporting that can help in reporting a country’s emissions levels. However, there is a need to educate the corporate world on the benefits of such a reporting platform as it will go a long way in curtailing emissions and also attracting investment.

2.3.9 South African carbon tax

The Republic of South Africa is in the top 20 of the world’s carbon dioxide emissions with an annual per capita of 10 tonnes emissions a figure comparable to that of developed countries (RSA, 2004). On the backdrop of these observations, the government through the Tax Policy Unit affiliated to the National Treasury embarked on research to determine the possibility of environmental reforms by using a taxation system. The research resulted in the 2006 draft Environmental Fiscal Reform Policy Paper, which presented a structure and set of criteria for assessing and reviewing environmental tax plans. The reasoning behind the carbon tax strategy introduced by the National Treasury is to internalise some of the external costs of global warming via a pricing mechanism and to incentivise behavioural change by producers and consumers towards a lower carbon, sustainable technology expenditure and purchases (The Davis Tax Committe, 2015).

In 2017, the government publicly released the Draft Carbon Tax Bill that gives effect to the ‘polluter pays’ approach, whose aim is to price carbon by internalising the external costs of carbon emissions. The carbon price set at R120 per tonne of CO_2 equivalent emitted. In order to allow companies flexibility for adjustment, a simple percentage limit of 60% under which tax is not payable should apply. A myriad of allowances factored in the tax enable up to 95% allowances, which is a function of which sector an industry falls in (Department of Environmental Affairs, 2018). The staggered method to the implementation of an initial low-cost carbon tax with substantial tax-free exemptions seeks to give the business sector time and adaptability to make the required modifications necessary for the transition to a low-carbon economy (National Treasury Republic of South Africa, 2018). The South African carbon tax came into law in June 2019. Given this development, it can be interpreted and predicted that this tax will impact on economic social and environmental aspects of the metals and mining industry and other stakeholders involved. This research will investigate the degree to which this sector of the economy is affected.

Using a computable general equilibrium (CGE) model on the South African economy, Devarajan *et al.* (2011) reported that a tax in the range of R22 to 214/tCO_2 could result in emission reductions of up to 25% accompanied by a welfare loss. However, the welfare losses in the investigated range are reasonably small, with losses of up to 1.15%. One way of getting around the welfare losses is to recycle the collected tax and use them in reducing pre-existing tax distortions, thereby reducing welfare losses to almost zero. The carbon tax is regressive in low-income households and has high consumption shares on goods whose prices rise with a carbon tax and are therefore influenced by the carbon price (Devarajan *et al*., 2011). This therefore means that the effects of carbon tax can be both beneficial and also regressive depending on what perspective one is looking at.

2.3.9.1 Tax policy

The South African carbon tax is a levy targeted at businesses and companies that emit a high amount of pollution and pollute the environment. Industries that rely on fuel consumption and electricity generation are the most prolific perpetrators (IEA/IRENA Renewables Policies Database, 2019). The architecture of the carbon tax also allows for substantial tax-free pollution allowances ranging from 60 to 95% in this first step.

This provides a general tax-free allowance of 60% on all operations, a 10% process and a fugitive pollution allowance, a cap of 10% allowance for businesses who use carbon credits to minimise their tax obligation, an output allowance of up to 5% for companies that reduce the emission intensity of their activities, and a 5% carbon expenditure allowance for compliance (IEA/IRENA Renewables Policies Database, 2019).

The key features of the South African carbon tax bill are:

- The tax applies to all direct stationary and mobile greenhouse gas (GHG) emissions from industrial and non-industrial sources.
- The taxes covered six GHGs (CO_2, CH_4, N_2O, PFCs, SF_6 and HFCs)
- Organisations will remain answerable for emissions emanating from fuel combustion, production processes and any fugitive emissions.
- There is a performance allowance for companies that implement measures to curtail greenhouse gas emissions (Government Gazette, 2019)

The implementation of a carbon tax would also have little effect on the price of electricity in the first process. This will result in a relatively moderate carbon tax rate varying from R6 to R48 per ton of CO_2 equivalent produced, which is a relatively low tax rate to give existing big emitters time to convert their activities to sustainable technology by engaging in energy conservation, renewables and other low-carbon initiatives (IEA/IRENA Renewables Policies Database, 2019). Given the moderate effective tax rate (R6-R48), the major question is whether the applied tax will induce a change in behaviour or will companies find it easier to rather pay the penalties.

2.3.9.2 Practical compromises

Carbon tax policy implementation would face a myriad of barriers since it may stunt economic growth. For South African industries to remain competitive, the government, as stated in National Treasury (2018), had to make the following compromises:

- A phased approach to tax introduction
- Ensure a significantly high tax-free allowance
- Revenue recycling to minimise the impact in phase 1 of implementation

- The first phase cushions the impact on the price of electricity so that it lessens the effects on energy-intensive sectors such as metals and miningand mining.
- Measures to protect vulnerable households
- Tax relief measures temporarily put in place.

It should be noted that these measures are a good intervention, which ensures that the tax is not drastic and therefore reduces the overall effects on the bottom line and shareholders' dividends.

2.3.9.3 Economic challenges

A model presented by Van Heerden *et al.* (2016) showed that carbon tax would negatively affect the gross domestic product of South Africa (SA) because of all the exemptions and revenue recycling options presented. The researchers report that the implementation of a carbon tax decreases the real GDP by 6.4% by 2035, despite 60 to 100% exemptions. However, in the case without exemptions (from 2022), a decrease of 13.7% is expected over the forecast period. However, the reduction in CO_2 far outstrips the effect on GDP by several orders of magnitude. Total exports will dwindle as the competitiveness of South African products becomes compromised, assuming trading partners have not also adopted a carbon tax policy. In line with the objective of the carbon tax to promote systemic change, there are several significant industry winners and losers from the imposed tax. Businesses that will experience a significant drop in output compared to the baseline include oil refining, metals and mining making, coke production and the electrical power generation market (World Bank Group, 2016). The metals and mining industry was the most severely affected with a projected 50% reduction in its exports. The study recommends that recycling through the imposition of subsidies on green energy technologies is a mitigatory measure to the steel industry and other export-oriented industries (Van Heerden *et al.*, 2016). In their predictions, the model, however, did not take into account the exemptions that were included in the carbon tax law, thereby making their predictions not very realistic.

It is worth mentioning that the timing of imposition of the carbon tax is not convenient for the metals and mining industry. South Africa's metals and mining industry is a leading employer with over 10 000 permanent staff. In their report for 2016, Arcelormittal South Africa Limited (AMSA), South Africa's most prominent metals and mining producer, incurred losses in their first half of 2016 amounting to R450 million. The losses put the company in a situation where it is not financially stable enough to afford the proposed tax. For the first phase of carbon tax implementation, the financial impact on AMSA is approximately R250m per annum – a cost passed on to consumers, reducing competitiveness (Cronje, 2016).

According to the World Bank Group (2016), the introduction of the carbon tax in SA affects the price of inputs and, subsequently, products from the metals and mining industry. The industry is an energy-intensive industry relying on electricity produced from the burning of fossil fuels. These factors will hike production costs, which are passed on to the buyer and later to the exporter. The situation leads to an increase in steel prices, thereby affecting its competitiveness in both the local and international market, inadvertently threatening the survival of the local steelmaking concerns. In a study by World Bank Group (2016) on the impact of the carbon tax on the economy, they concluded that, by 2025, there would be a reduction in the annual growth by 0.05 to 0.15 percentage points, which implies that the GDP of South Africa will grow at an average of 3.3 to 3.4 % annually, instead of 3.5% growth rate without the tax. A decrease in growth by up to 3% for 2035 is imminent. The argument above paints a bleak picture about the carbon tax introduction; however, the exemption of tax for electricity production makes the points invalid.

2.3.9.4 Competitiveness

In their paper against imposing a carbon tax in SA, Lloyd (2011) raised some interesting and valid points. They argue that the primary emitters are the USA and China, accounting for nearly 50% of the total annual GHG load on the atmosphere. On the other end, SA contributes about one-fiftieth of this load. In this regard, if the objective of the tax is to reduce SA's emissions, then they will fail in the overall global objective as SA is not the prime source of the damage. Reduction of SA emissions to zero will have no significant impact on the global stage. Fossil fuels meet a whopping 97% of SA energy requirements; therefore, a carbon tax can be a *de facto* tax on energy, which translates to a tax on development. The EU, which is SA's trading partner, is already reeling from the effects of a carbon tax; similarly, SA will be equally uncompetitive due to the government imposing carbon tax (Lloyd, 2011).

According to the World Steel Association, the production figures for SA steel show a decline of 20% for the period 2007 to 2016 with its global contribution falling from 0.7 to 0.44%. The situation is different when compared to the Chinese production levels, which, for the same period, have risen by 68% (Ryan, 2016). The ongoing trade wars between the USA and China come on the backdrop of firming of metals and mining products prices due to mine accidents in Brazil. This situation gives SA an opportunity to be a free rider and benefit from these trade wars by pushing their ferrous products into the international market. It must be noted that the locally produced steel has been traditionally more expensive than imported options. Carbon tax introduction might be the final nail in the coffin for SA steel producers' local markets.

We can argue that although the current research focuses mainly on the effects of the carbon tax on companies' profitably, which is also related to competitiveness, competitiveness and profitability have overall similarities, and they are near related; however, they have different implications. Competitiveness is related to the ability of a company to sell products in a given market as compared to other companies in the same market. Carbon tax pricing differs among different countries; therefore, the effect of a carbon tax on competitiveness will differ from region to region. With all things remaining constant, an industry may face an added expense due to a carbon tax that is not incurred by rivals in another country. The business with increased costs may risk a loss in market share or a decrease in its profit margin, or both. In such situations, emissions leakage is more likely to occur as companies relocate to countries with lower taxes. However, even though carbon taxation does add to the expense of firms, it does not inherently impact competition considerations, since businesses do not compete purely based on prices.

2.3.9.5 Key areas of uncertainty

As the carbon tax in SA kicks off, the key stakeholders must have clarification on some concepts of the tax to remove any uncertainties. In their study, Gous *et al.* (2017) outlined some areas that need to be clarified, and they are as follows:

2.3.9.5.1 Legislative uncertainty

The knowledge of the regulatory framework is an essential part of the tax cycle. Understanding what is required by law will reduce business risks and facilitate leadership in decision-making. The decision-making process is, however, facilitated by having relevant information sourced by knowing which regulatory body to consult.

2.3.9.5.2 Quantification uncertainty

Emissions quantification can be complicated and could theoretically involve many errors due to the related quantities of data and estimation procedures. Giving incorrect information creates confusion for stakeholders to make decisions about the published carbon tax and represents a significant risk to the reporting organisation. Therefore, correct and accurate information is critical across the whole carbon tax process.

2.3.9.5.3 Reporting uncertainty

Carbon tax, which is part of the environmental levy, is submitted to the South African Revenue Service (SARS). The process involves filling some SARS forms showing the amount payable and the required methodology is vital to ensure accuracy and validity.

2.3.9.5.4 Liability mitigation uncertainty

The carbon tax bill allows companies to decrease their financial liability by making use of relevant deductions. This system can be taken advantage of entirely only if the organisation applying knows and understands the available opportunities.

2.3.9.5.5 Assurance uncertainty

Uploading a self-assessed tax value, including a multi-faceted procedure, could be of concern to stakeholders using the information. It is essential to gain the trust of stakeholders by ensuring proper and accurate handling of aspects of the carbon tax. Certainty offers a form of assurance that means that the findings are accurate. It is essential that the reporting parties provide certainty of the tax value decided as well as that they follow procedures accordingly.

Managing each area of uncertainty will increase stakeholder trust in the tax decided. Guidance is necessary for each area of uncertainty to help ensure high stakeholder trust. Nonetheless, there is minimal guidance in the bill, and the links to further assistance are vague (Gous *et al.*, 2017).

2.4 Cost and profitability analysis

In addition to growth, long-term profitability is one of the primary goals and prerequisite of any business venture. Whether they report on profitability for the given period or project profitability for the coming future, calculating profitability is the most critical indicator of the company's performance. The survival of a business lies in its profitability, and a highly profitable company has the potential to provide its investors with a large return on their investment (Hofstrand, 2009).

Triple bottom line (TBL) initiatives, in the most straightforward terms, focus not only on the financial value they contribute, but also on the social and environmental values or ruin they contribute (Elkington, 2013). This TBL initiative is contrary to the postulate by prominent economist, Milton Friedman that "the social responsibility of a business is to increase profits."

Ethical, social and environmental reporting has gained momentum in the new millennium. There has been an emergence of initiatives such as the King Reports, which encourage companies to annually report on ethical, social, safety and environmental policies. In this extraordinary setting, clients and financial markets are already increasingly challenging companies to be transparent and show their TBL obligations and results. It is quite apparent now that there is a transparency revolution that advocates for voluntary disclosure of company activities (Elkington, 2013).

In their study, Gimenez *et al.* (2012) observed that environmental programmes and policies positively impacted the three aspects (social, environmental and economic) of TBL by a reduction in waste, process efficiency and cost savings. Environmental programmes led to an improvement in social performance as less pollution generally results in an improvement in plant working conditions, nearby communities' improved standards of living, overall making a good social reputation for the company (Gimenez *et al.*, 2012).

A carbon tax, as the name implies, taxes businesses for carbon released into the atmosphere, where increased emissions simultaneously increase tax liability. Businesses will consequently reduce tax payable by emission reduction, implying that carbon tax acts as an instrument for enforcing environmental corporate social responsibility (CSR) on businesses (Medarevic, 2012). As an add-on to this effect, tax collected can fund carbon reduction initiatives as more environmentally sound technologies are adopted and implemented. In Australia, mining concerns termed carbon tax 'doomsday' as they projected that it would result in mine closures, increased power bills and affect international product competitiveness. The solutions suggested for these industries were to change existing practices so that emissions were reduced and also migrate from fossil fuel dependence to no renewable energy sources (Medarevic, 2012). The carbon tax is a legal matter with repercussions for non-compliance – a parameter that was lacking in the Kyoto Protocol. The direct and indirect carbon costs need to outbalance profits obtained from pollution to win the war against carbon and other pollution.

2.4.1 Profitability ratios

Profitability ratios reflect the company's performance in obtaining a net revenue profit or investment gain. Such figures are typically looked at by creditors, as their primary interest is the potential of a business to make money (Eliot, 2015). The purpose of financial ratios is to assess the operating, investment and financing strategies of a company that has effects within both historical and prospective contexts. The function of the ratios is to extract meaningful information that would not be more evident on examination of financial statements (Brigham & Ehrhardt, 2016).

2.4.1.1 Net profit margin

Net profit margin (also referred to as 'profit margin' or 'net profit margin ratio') is a financial ratio used to calculate a business' percentage of profit from its total income. The ratio estimates the amount of net income a company receives per dollar of generated sales.

$$\text{Net profit margin ratio} = \frac{\text{Net income to shareholders}}{\text{Revenue}}$$

2.4.1.2 Return on assets (ROA)

The return on assets ratio is a measure of management ability to accrue a return on the utilisation of the assets of the firm. The formula for return on assets is as follows:

$$\text{Return on Assets} = \frac{\text{Net income to shareholders}}{\text{Total assets}}$$

2.4.1.3 Return on equity (ROE)

The return on equity, which indicates the profitability of the capital provided by the shareholders, is calculated as follows:

$$\text{Return on equity} = \frac{\text{Net income to shareholders}}{\text{Total Equity}}$$

2.5 Summary

The literature review covered four broad areas, which include global warming, the Kyoto protocol, carbon tax law and the profitability aspects. The first two concepts discussed cover the general framework leading to the introduction of the South African carbon tax law. This study discusses general aspects of the carbon tax, and the impact of the tax on South Africa as presented by other researchers. The carbon tax of South Africa is new, and no case studies have been done to determine its effects. This study is among the first to supply insight into the effects of the carbon tax on metals and mining industry.

3 CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

The main focus of this chapter is to clarify the empirical research methods and logic used in this study. This section will give supporting reasoning about the research philosophy, methodology and design as applied in the current research work in answering the presented research questions given in earlier chapters. The statistical approach used to analyse the data and obtain the necessary relationships is explained.

3.2 Research philosophy

Research philosophy is a system of beliefs and assumptions about the procedure for acquisition, analysis and interpretation of data concerning a particular phenomenon. The whole concept of research involves the development of knowledge and the form of knowledge in a specific field of study. According to Saunders *et al.* (2015), in the course of the research, there exist three assumptions, namely:

(a) epistemological assumptions – these deal with human knowledge;

(b) ontological assumptions – about realities faced during the research; and

(c) axiological assumptions – the ways a researcher's values shape the research process.

The assumptions will ultimately influence how one understands the research questions, the research procedure and data interpretation. A well-thought-out and coherent set of assumptions will represent a reliable philosophy of research that will underpin methodological decisions, a strategy of research, and methods of information collection and analysis. The strategy will enable the design of a consistent study project that fits all research elements together (Johnson & Clark, 2006). Within the context of this research, the term research philosophy is the overall approach to the subject matter under investigation.

3.2.1 Positivism

This study adopted a positivist approach in determining the effect of the South African metals and mining organisations' carbon footprint on profitability. Positivism has been explained as a rejection of metaphysics while using or imitating natural sciences methods. It maintains that the objective of understanding is merely to portray the experienced phenomena. The philosophy holds that the purpose of scientific research is to stick to what can be observed and measured, with anything to the contrary being impossible. The positivists believe in empiricism – the concept that the essence of the science effort was observation and measurement. The scientific method's primary strategy is experimentation – the effort to discern natural laws by direct manipulation and observation (Trochim *et al.*, 2015). If a study represents the positivism philosophy, then the researcher is likely to embrace the natural scientist's philosophical position. They will prefer to work with observable social reality, and the end product of such research may be generalisations similar to those produced by physical and natural scientists. It is a common argument that an extremely organised methodology is likely to be used by the positivist scientist to promote reproduction; besides, the emphasis is on quantifiable findings that are eligible for statistical analysis (Saunders *et al.*, 2015).

This philosophy points to the use of quantitative methodology, which analyses secondary data collected from company reports. The relationships of various financial performance ratios to the emissions will be determined so as to predict the effect of emissions on financial performance.

3.3 Research methodology

Research methodology is the systematic approach used to solve a research problem and can be interpreted as the science of learning how scientific research is conducted. It is a study of the various steps taken by a researcher in tackling a research problem and details the logic behind the steps (Kothari, 2004). Research methodology refers to the theory of how thorough the execution of research is; it encompasses the science and philosophy behind all research (Adams *et al.*, 2014)

The current research applies quantitative and statistical techniques to the numeric analysis of financial and emission data in order to assess the relationship between organisational profitability and emissions.

3.4 Research design

Research design is the binding force that couples the various elements involved in research together. The design organises the study and demonstrates how all the critical aspects of the project, namely samples, measures, procedures or programmes and assignment methods, work together to resolve the core hypothesis of interest (Trochim *et al*., 2015). In the quantitative design continuum, there exist two extremes. On one end, the design has variables that are not controlled, but only observed. In contrast, at the other end of the spectrum, there is close control of variables with relationships between variables established. In the middle is a blend of the two extremes. The four main types of quantitative research are descriptive, correlational, causal-comparative/quasi-experimental, and experimental research. The current study adopts the correlational research design.

3.4.1 Data analysis

This section provides an introduction to the econometric or panel data analysis used in this report, its advantages and also the numerous econometric model specification tests conducted to evaluate the relationship between the emissions and corporate performance.

Econometrics is the application of statistical techniques to economic data in order to provide analytical substance to economic relationships. More specifically, “the quantitative study of real economic processes, based on the parallel evolution of hypothesis and observation, is connected by acceptable methods of inference.” As shown in Table 2, the dependant variables in this study are the ratios that measure the financial performance. Independent and dependant variables used in the study are also listed in the table.

Table 2: Information on the financials and emissions for the selected companies

Parameter	Description
Independent variables	
Scope 1 & 2 emissions	Total of scope 1 & 2 emissions in metric tons
Carbon emissions intensity	Company’s scope 1 & 2 emissions per million rand sales
Net income	Income after deductions
Total assets	Amount of assets owned by the company
Equity	Value of the shares issued by a company

Annual sales	Total revenue
Dependent variables	
Net profit margin (NPM)	Ratio of net incomes to revenue
Return on assets (ROA)	Ratio of revenue to total assets
Return on equity (ROE)	Ratio of revenue to equity
Control variables	
Leverage	The ratio of debt to equity
Growth	Calculated as year-on-year % change in sales
Capital Intensity	Ratio of assets to sales
Carbon intensity	Amount of carbon emitted per unit sales
Firm size	Natural logarithm of sales

3.4.1.1 Correlation analysis

Correlation analysis is a mathematical (statistical) tool used to determine the strength of the association between two quantitative variables. High correlation means that two or more variables have a good relationship with each other, while a weak correlation means that the variables are not so closely related.

3.4.1.2 Panel data regression analysis

The data that is analysed in this current study is two dimensional; that is, time series and cross-dimensional (TSCD) in that it has a time series and contains observations on multiple phenomena. One of the advantages of TSCD is that it can increase the number of observations and can model time and space and also to generalise across them. The data is analysed using the fixed-effects and random-effects approaches. The fixed-effects analysis allows for the capture of unobserved time-invariant attributes and the correlation to the observed independent variable.

Linear regression analysis estimates the dependent variable based on one or more independent variables. Fixed-effect methods are considered for data with the dependant variable calculated on an interval scale and are linearly proportional to a series of predictor variables. We have a set of companies (I = 1, ……, n) each of which is measured at over two points in time (t = 1, …., T). The basic regression model, in this case, is given as:

$$y_{it} = \mu_t + \beta_{it}x_{it} + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where: y_{it} - is the dependant variable, μ_t - intercept and β_{it} is the coefficient x_{it} is the independent variable and ε is the error term.

Applying equation 1, the following expression holds as derived from the ordinary least squares regression model used in the study:

$$\begin{aligned} Financial\ Performance_{it} &= \mu_t + \beta_1(Effective\ carbon\ tax) \\ &+ \beta_2(Effective\ carbon\ tax \times Growth) + \beta_3(Carbon\ intensity) \\ &+ \beta_4(Dummy\ size) + \beta_5(Capital\ intensity) + \beta_6(Leverage) \\ &+ \beta_7(Growth) + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2) \end{aligned}$$

This model will be tested on the three dependant variables using coefficients obtained from the regression analysis. Previous studies have found that poor carbon efficiency ultimately enhances environmental deterioration and accompanies poor corporate financial practice (King & Lenox, 2001). In this case, the ordinary least square approach was crucial to the establishment of a linear relationship involving carbon performance and financial performance measures

3.4.1.3 Fixed effects model

Fixed effects models disregard the inter-company variation and rely instead on intra-person variation. Unfortunately, discarding the inter-company variation will lead to standard errors that are considerably higher than those created by approaches that use both intra-person and inter-company variations. It is necessary to use this model as inter-company variations have a high chance of being contaminated by unmeasured company characteristics and their correlations with revenue.

3.4.1.4 Random effects model

Random effects models are mathematical models in which some of the variables (effects) that describe the functional components of the model display some degree of random variation.

3.4.2 Promethium Carbon Basic GHG calculation tool

The introduction of a carbon tax in South Africa meant that companies have to go through the daunting task of not only quantifying relevant emissions, but also estimating the monetary liability. To address this need, Promethium Carbon introduced a tool for quantifying carbon tax, and it is known as the v7.0 Promethium Carbon Basic GHG calculation tool, which is available online free of charge. This tool can give companies an indication of the tax liability due to them. Promethium Carbon is a South African company that is involved in consultation and acts as an advisor to companies on issues of climate change and carbon emissions. Promethium Carbon enjoys the status of trustworthy adviser to large multinational companies based in of South Africa (Promethium, 2019).

3.5 Descriptive statistics

Descriptive statistics were used to describe the basic characteristics of the basics providing basic summary about the sample and measures. Along with basic graphical analysis, they form the basis of nearly all quantitative analyses of the results by presenting quantitative descriptions in a manageable manner.

3.5.1 Establishing relationships

Statistical techniques will be applied to the data to investigate trends and relationships between the gathered data. Statistics will be applied to the data to obtain information such as maxima, minima, mean, mode and standard deviation per question with linear regression giving the relations between the variable and profitability. Excel histograms and line plots are also applied to investigate and determine the relationships visually.

3.5.2 Mean

The mean is calculated for all the variables applied in this study. The calculated mean will give us the average for all the sampled companies over five years.

3.5.3 Standard deviation

On the other had standard deviation is an indication of the variance of individual data points from mean. A small standard deviation is indicative of a lack of diversity and leads to the conclusion that the data point is near to the mean.

The formula for standard deviation is shown in equation (4) below:

$$S = \sqrt{\frac{\sum(x-\mu)^2}{N-1}} \quad \text{...(4)}$$

Where:

x – Each score in the analysis

μ – Sample mean

N – Sample size

Emission figures from integrated reports will be used in a spreadsheet to calculate carbon cost for the selected companies.

3.6 Delimitation of study

This research would concentrate on the price of carbon pollution and the impact of rising tax prices on business profitability. Data from companies' integrated statements is available from the public domain. The sampled companies are listed on the Johannesburg Stock Exchange and domiciled in the Republic of South Africa. The primary focus from these companies would be on the energy-intensive entities that we regarded to be significantly impacted by carbon pricing.

3.7 Study population

A study population is a group of individuals to which a survey or questionnaire can be applied. The researcher has to identify groups or individual who are capable of answering questions about the study. In its ideal form, the target population constitutes a countable list of all of its representatives (Pfleeger & Kitchenham, 2002).

The populations for the current study will be the 46 metals and mining companies domiciled in South Africa, listed on the JSE and disclosed their financial and emissions information as required by the integrated reporting system.

3.8 Study sample

Purposive sampling: Sampling is done with a purpose in mind usually seeking specific predefined groups. The most important thing is to verify whether the respondent meets the criteria for being in the sample. As described by Leedy and Ormrod (2015), purposive sampling involves the selection of people of a specific unit for a particular purpose. In our case, it will be companies with considerable emissions as shown by their emission report. This study employs purposive sampling techniques through a purposeful selection of companies.

For this study, all ***JSE-listed*** companies ***domiciled in South Africa,*** which ***fall under the metals and mining sectors*** with required emissions and financial data will constitute the sample. These target companies are a subset of those that disclosed data on their carbon emissions in the country, in line with JSE integrated reporting system. The study used financial and emissions data for 2014 to 2019. The samples were selected from a population of 46 companies, and comprised 12 companies that met all the research requirements. Of the 46 companies in the population, 34 companies were excluded as they did not have complete emissions data. A total of 58 data points are collected and analysed. The decision to utilise JSE-listed companies rather than unlisted companies became one of the selection criteria, to obtain the necessary financial information as well as emissions levels. It is a prerequisite of the JSE that companies avail their integrated statements in the public domain.

3.9 Data collection

Data relating to company emissions and financials is obtained from the companies' integrated annual reports that are downloadable from the company websites found on the public internet domain. All the reports contain scope 1 and 2 emissions as required for companies listed on the JSE and also the requisite financial information. The research is unobtrusive as secondary data already exists and can respect ethical issues of privacy, confidentiality, anonymity, non-traceability and not involve people as primary data may be on sensitive topics and from individuals 'hard to meet'. The design of integrated reporting and carbon disclosure projects is such that they provide a full summary of the impact of the company – both positively and negatively – that would enable stakeholders to make an informed evaluation of the company's ultimate financial value. The data obtained from these reports is considered reliable and robust.

3.9.1 Data manipulation

Emissions data manipulation using the v7.0 Promethium Carbon Basic GHG calculation tool gives the tax liability of different companies. The Promethium Corporate Carbon Footprint Tool executes a basic calculation of South African companies' carbon footprint based on scope 1 and 2 emissions and the energy consumption data. The tool analyses the carbon footprint against the legislative system currently defined concerning the following matters:

- Mandatory reporting requirements
- Requirements for submitting a plan for GHG mitigation
- Impact of a carbon tax with regard to scope 1 and 2 emissions relief measures and offsets, scope 2

The study calculates the initial profitability of the companies in the sample for this study from sales, net profit, equity and asset values. Equity ratios are a comparison of the company's revenue to its earnings. Profitability ratios are recalculated after factoring in carbon costs (as calculated) to determine the profitability change. The researcher calculates profitability ratios before and after the deduction of a carbon tax to determine the change in profitability.

The process will be repeated with increases in carbon tax to assess the effect on profitability, forming a scenario analysis with three scenarios listed below from the current rate of R120/tCO_2:

- A slight increase in carbon tax (R150/tCO_2)
- A notable increase in carbon tax (R300/tCO_2)
- A dramatic increase in carbon tax (R1000/tCO_2)

This hypothetical scenario model is most likely the most appropriate method to tackle this problem as it is unclear what the price of CO_2 pollution would be in the future.

Exploratory data analysis helps to understand the trends in the data through the use of diagrams with critical aspects while being guided by research questions and objectives. The study makes use of data analysis and correlations using Stata statistical software and Excel spreadsheets through the use of graphs and histograms and other excel analytical tools deemed necessary.

The collected data will be used for research purposes only and is destroyed after analysis and interpretation to protect information. Table 3 summarises the data management stages of the research.

Table 3: Data management system

Data collection	
Type of data	Quantitative
Instrument of collection	Company reports
Documentation	
What documents will accompany data?	Company reports
Data storage & backup	
Data storage techniques	Data will be stored on a laptop and backed on the cloud and also on password-protected USB.
Access	Laptop, cloud storage and USB will all be accessed using user ID and passwords.
Data preservation period	
The fate of data after analysis	After the research is completed, data on all forms of storage will be permanently deleted.

3.10 Research ethics

There is an ethical responsibility in conducting studies to execute the research honestly and with honesty (Adams *et al.,* 2014). The active research landscape warrants that any research or study follows set research ethics regulations and governance. This current study ensures the following stipulations were met by adhering to the abovementioned regulations as follows.

- Data usage: The findings shall be used solely for educational purposes and possible publication in scholarly journals
- Appropriate citation of all secondary data used in the study
- The study ensures complete anonymity
- Avoid use of offensive, discriminatory or unacceptable language in the preparation of data collection instruments

3.11 Summary

The objective of this section was to outline the research methodology and design, as followed in the study. The chapter described the philosophies of the mini-dissertation in which this investigation is centred, with a positivist research approach driving the research procedure as dictated by the computable nature of the research questions, which primarily aim to test hypotheses among variables. An econometric approach was designed to address the stated research questions presented in Chapter 1. The statistical software STATA was used in the analysis of the data.

4 CHAPTER 4: RESULTS AND DISCUSSION

4.1 Introduction

The analytical findings are discussed in this chapter. The first segment of the chapter presents statistically manipulated data, and the second part graphically represents the effects of increment in carbon tax on profitability. Panel regression analysis results on NPM, ROA and ROE are presented and profitability expressions are derived from the results. Excel data analyses on the relationship between firm size and carbon intensity and the effects of increasing carbon tax rate are presented. All the observations and findings are interpreted and discussed.

4.2 Research variables

The knowledge gap that motivated this study is the lack of data relating to the impact of the recently introduced carbon tax on profitability in the metals and mining industry. Quantitative analysis of the secondary data gathered is done to test the correlation between the carbon tax and three profitability ratios. The independent variable was the carbon tax that was investigated at four different rates of R120, R150, R300 and R1000/tCO_2. The rates were determined based on the government-approved one of R120/tCO_2 and ramped up to R1000/tCO_2.

The dependent variables are the accounting ratios used to measure profitability, and these are net profit margin (NPM), return on equity (ROE) and return on assets (ROA). Control variables used are firm size, carbon intensity, leverage and growth.

4.3 Gathering of data and analysis

Data was extracted from integrated financial statements of 12 metals and mining industry companies over a five-year period, from 2015 to 2019, and used in this study. The data collected included total sales, net profit, assets, equity, total of scope 1 & 2 emissions, and leverage. The carbon tax liability was calculated using the Promethium v7.0 carbon tax calculator. Statistical analysis was done using the software Stata, and graphical illustrations were done in Excel.

4.4 Results and discussion

The collected secondary data was statistically and also graphically analysed and is reported in this section. The analysed data is then interpreted and presented, as shown in the following sections.

4.4.1 Descriptive statistics

Table 4 below gives a summary of all the descriptive of all the variables used in this study for a carbon rate of R120/tCO_2. For the observed 12 (n) companies over the five-year (T) period, we notice that there are 58 (N) data points recorded instead of 60, which is due to one of the companies not availing adequate data for two years. The standard deviation values for assets, sales, equity, net profit, carbon tax and carbon intensity are substantial (in the orders of tens of thousands). Statistically, it implies that the data points are far from the average value and within the context of this study it means we have a variation in size of companies with regard to operational output and levels of investments. This observation is also supported by the significant differences or spread in the minima, maxima and also the means of the above-stated variables.

The overall averages for the control variables, namely firm size, growth, leverage and capital intensity are 1.017, 1.217, 1.066 and 8.552, respectively. A maximum value of leverage of 7.84 indicates that some of the sampled companies are asset intensive, which implies that they are more reliant on borrowing for asset acquisitions as it may be less costly to acquire debt for such entities.

Table 4: Descriptive statistics for the sample (Source Appendix D)

Variable	Mean	Std. dev.	Min	Max	Observations
Assets	24998	22058	2287	101072	N=58, n=12, T=5
Equity	13785	12295	1267	47524	N=58, n=12, T=5
Sales	14620	18296	-593	72295	N=58, n=12, T=5
Net profit	1516	4295	-4433	21316	N=58, n=12, T=5
NPM120	0.122	0.310	-1.050	0.940	N=58, n=12, T=5

ROE120	0.032	0.193	-0.525	0.448	N=58, n=12, T=5
ROA120	0.0292	0.111	-0.389	0.318	N=58, n=12, T=5
effe~120	1.713	2.451	-0.166	9.735	N=58, n=12, T=5
car ~120	2.391e+06	3.737e+6	5016	1.430e+07	N=58, n=12, T=5
car~t120	406.8	583.6	-35	2318	N=58, n=12, T=5
Firm Size	1.017	0.748	0	2	N=58, n=12, T=5
Capital intensity	8.552	18.37	0.398	111.9	N=58, n=12, T=5
Leverage	1.066	1.199	0.0947	7.840	N=58, n=12, T=5
Growth	1.217	0.739	0	2	N=58, n=12, T=5

4.4.2 **Correlational analysis**

From the data in Table 5, the carbon emissions and intensity have a negative relationship with NPM, ROE and ROA. The dummy variable method was applied so as to view the data of companies with different sizes. With the dummy variable being size, all companies below 25 percentiles were classified as small sized, and assigned value 0; companies in the 25 to 75 percentile were classified medium sized, and assigned value 1; and the companies above 75 percentiles were classified large sized, and assigned a value of 2. These values were replicated across the multiple values for each company.

Table 5 shows that the carbon emissions and intensity develop a negative relationship with profitability ratios (NPM, ROE and ROA). This means that an increase in emissions and the cost of carbon reduce corporate profitability. Growth, firm size, capital intensity and leverage show negative relationships with profitability ratios, which is an indication that if a greater part of the company's capital is debt, then it is less likely to achieve gains.

Table 5: Correlation coefficients among variables at different carbon tax rate (Source Appendix D)

	Assets	Equity	Sales	Net profit	NPM120	ROE120	ROA120
Assets	1						
Equity	0.822	1					
Sales	0.814	0.548	1				
Net profit	0.380	0.681	0.435	1			
NPM120	0.067	0.295	-0.066	0.379	1		
ROE120	0.198	0.418	0.189	0.691	0.474	1	
ROA120	0.284	0.513	0.240	0.743	0.508	0.938	1
effect c~120	-0.273	-0.150	-0.340	-0.177	-0.171	-0.153	-0.225
Carbon emissions	-0.172	-0.213	0.099	-0.097	-0.180	-0.123	-0.171
Carbon intensity	-0.272	-0.148	-0.339	-0.176	-0.165	-0.152	-0.224
Dummy size	0.596	0.383	0.832	0.332	-0.065	0.146	0.190
Capital intensity	-0.058	0.011	-0.304	-0.122	-0.286	-0.056	-0.080
Leverage	0.166	-0.241	0.360	-0.255	-0.236	-0.306	-0.216
Growth	0.162	0.082	0.121	-0.007	0.190	0.039	0.059

	effe~120	car ~120	car~t120	size dum	capita~y	leverage	grow dum
effect c~120	1						
Carbon emissions	0.611	1					
Carbon intensity	1.000	0.612	1				
Dummy size	-0.266	0.293	-0.263	1			
Capital intensity	0.229	-0.203	0.220	-0.490	1		
Leverage	-0.220	0.058	-0.221	0.265	0.094	1	

Growth	-0.178	-0.136	-0.175	0.208	-0.150	-0.050	1

4.4.3 Panel regression: Net profit margin

The data in this study covers five years; the statistical approach used was a panel data regression, which involved the integration of cross-sectional and time-series data. The results of the panel regression variable estimation using Stata software showing random effects and fixed effects estimations for aggregated variables of carbon tax, capital intensity, leverage and growth are shown in Table 6. The data was analysed initially without and then with the interactive variable (Growth*Carbon tax) to circumvent the effects of collinearity. The effective carbon tax has a marginally significant negative effect on NPM under both random effects and fixed effects conditions. As is expected from theory, the more the company emits, the higher the tax liability, and ultimately this lowers the NPM. We present the data under random effects and fixed effects where we capture the totality of all company-specific attributes that do not change over time. From the computed coefficients, it can be concluded that the magnitude of the effects of the analysed variables on net profit margin is as follows:

Effective carbon tax > Size > leverage > Carbon Intensity > Growth

The effective carbon tax (%carbon tax / sales) is a parameter that gives a true reflection of the burden of a carbon tax on each of the various companies relative to their sales. Usage of absolute carbon tax values may not be able to pick up the intensity of the tax.

Both the REM and FEM confirm that an increase in emissions will negatively affect NPM as shown by the negative coefficients. For the effective carbon tax, we note that the calculated value of p is less than 0.01; we can therefore deduce that the coefficients for this variable (for both REM and FEM) are statistically significant. We can conclude that we are 99% confident that the variables' effective carbon tax and carbon intensity have a negative effect on the Net Profit Margin. This means that increasing the emissions or increasing carbon tax will effectively lower the profit margin a logical conclusion, as tax is an expense that reduces profit.

Table 6: Results of regression of carbon tax, firm size, leverage and growth on NPM (Source Appendix D)

	Without the interactive variable		With interactive variable	
	(1)	(2)	(3)	(4)
VARIABLES	**NPM2 REM**	**NPM2 FEM**	**NPM3 REM**	**NPM3 FEM**
effect_carb_tax120	-7.800***	-9.381***	-7.964***	-11.267***
	(1.804)	(2.534)	(1.790)	(2.536)
Growth*effect carb_tax120			0.020	0.034**
			(0.014)	(0.014)
Carbon intensity	0.033***	0.039***	0.033***	0.046***
	(0.008)	(0.010)	(0.007)	(0.010)
Dummy size	-0.057	0.028	-0.051	-0.002
	(0.087)	(0.226)	(0.087)	(0.215)
Capital intensity	0.004	0.008	0.004	0.013*
	(0.004)	(0.007)	(0.004)	(0.007)
Leverage	-0.050	-0.055	-0.058*	-0.074**
	(0.031)	(0.034)	(0.031)	(0.034)
Growth	0.007	0.014	-0.036	-0.048
	(0.039)	(0.042)	(0.048)	(0.048)
Constant	0.319***	0.333	0.382***	0.544**
	(0.123)	(0.245)	(0.130)	(0.249)
Observations	58	58	58	58
R-squared		0.623		0.669
Number of companies	12	12	12	12
	Standard errors in parentheses			
	*** p<0.01, ** p<0.05, * p<0.1			

The computed coefficients in Table 6 can be substituted in equation (2) to get the approximation of the net profit shown in Table 7.

Table 7: Net profit margin relationship

Net Profit margin : Without interactive variable	
1.REM	= 0.319 - 9.381Eff Carbon Tax + 0.039Carbon Intensity – 0.057Size + 0.04Capital intensity – 0.05Leverage + 0.007Growth
2. FEM	= 0.333 -7.80Eff Carbon Tax + 0.033 Carbon Intensity – 0.028Size + 0.08Capital intensity – 0.055Leverage + 0.014Growth
Net Profit margin : With interactive variable	
3.REM	= 0.382 – 7.964Eff Carbon Tax + 0.02Growth*Eff carb tax + 0.033Carbon Intensity – 0.051Size + 0.004Capital intensity – 0.058Leverage - 0.036Growth
4. FEM	= 0.544 – 11.267Eff Carbon Tax + 0.034Growth*Eff carb tax + 0.046Carbon Intensity – 0.002Size + 0.013Capital intensity – 0.074Leverage - 0.048Growth

Using the REM model (3) in the table above, with the interactive variable in the analysis, and applying partial derivatives, the following expression is obtained:

$$\frac{\delta(\text{NPM})}{\delta(\text{carbon tax})} = -7.964 + 0.02 \times \text{Growth} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (3)$$

If equation (3) is equated to zero, growth rate will be equal to 398.2, which implies that increasing the effective carbon tax improves the firm ROA when the growth rate was greater than 398.2 for the metals and mining industry. For the five-year period, there is no company that is above this threshold; this outcome shows that increasing the tax rate will not be beneficial to the NPM. The increase is only beneficial to companies with an almost unrealistically high growth rate (398.2). This means that the tax will always erode profits and shareholder dividends; a similar observation was made by Luo and Tang (2014), who found that carbon tax has an overall negative effect on shareholder wealth.

4.4.4 Panel regression: Return on assets

From the regression analysis shown in Table 8, both the REM and FEM confirm that emissions, leverage and growth negatively affect ROA as shown by the negative coefficients.

Table 8: Results of regression of carbon tax, firm size, leverage and growth on ROA (Source Appendix D)

	Without the interactive variable		With interactive variable	
	(1)	(2)	(3)	(4)
VARIABLES	**ROA1 RE**	**ROA1 FE**	**ROA2 RE**	**ROA2 FE**
effect_carb_tax120	-0.477	-0.255	-0.537	-1.261
	(0.809)	(1.332)	(0.778)	(1.330)
growth_effect_carb_tax120			0.016**	0.018**
			(0.006)	(0.008)
Carbon intensity	0.002	0.001	0.002	0.005
	(0.003)	(0.005)	(0.003)	(0.005)
size	0.047	0.080	0.052	0.064
	(0.033)	(0.119)	(0.032)	(0.113)
Capital intensity	0.002	0.001	0.002	0.004
	(0.002)	(0.004)	(0.002)	(0.004)
Leverage	-0.029**	-0.019	-0.033**	-0.029
	(0.014)	(0.018)	(0.014)	(0.018)
Growth	-0.003	-0.000	-0.037	-0.033
	(0.019)	(0.022)	(0.023)	(0.025)
Constant	0.028	-0.022	0.073	0.091
	(0.048)	(0.129)	(0.051)	(0.131)
Observations	58	58	58	58
R-squared		0.040		0.161
Number of companies	12	12	12	12

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The computed coefficients in Table 8 can be substituted in equation (2) to get the approximation of the net profit shown in Table 9.

Table 9: Return on assets relationships

Return on assets : Without interactive variable	
1.REM	= 0.028 – 0.477Eff Carbon Tax + 0.002Carbon Intensity + 0.047Size + 0.002Capital intensity – 0.029Leverage - 0.003Growth
2. FEM	= -0.022 -0.255Eff Carbon Tax + 0.001 Carbon Intensity + 0.08Size + 0.001Capital intensity – 0.019Leverage + 0.00Growth
Return on assets : With interactive variable	
3.REM	= 0.073 – 0.537Eff Carbon Tax + 0.016Growth*Eff carb tax + 0.002Carbon Intensity – 0.052Size + 0.002Capital intensity – 0.033Leverage - 0.037Growth
4. FEM	= 0.091 – 1.261Eff Carbon Tax + 0.018Growth*Eff carb tax + 0.005Carbon Intensity – 0.064Size + 0.004Capital intensity – 0.029Leverage - 0.033Growth

Using the REM model (3) with the interactive variable in the analysis, and applying partial derivatives, the following expression is obtained:

$$\frac{\delta(\mathrm{ROA})}{\delta(\mathrm{carbon\ tax})} = -0.537 + 0.16 \times \mathrm{Growth} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (4)$$

If equation (4) is equated to zero, growth rate will be equal to 3.356, which implies that increasing the effective carbon tax improves the firm ROA when the growth rate was greater than 3.356 for the metals and mining industry. For the five-year period, there is no company that is above this threshold; this outcome shows that increasing the tax rate is not good for the ROA. The increase is only beneficial to companies with a high growth rate (3.356). The ROA will consequently always have a negative relationship with carbon tax and can only be improved if there is a reduction in emissions, a process known as greening. In research on the benefits of greening, Hart *et al.* (1996) observed that emission mitigation over time period **t** would increase ROA over time through the more effective utilisation of assets.

4.4.5 Panel regression: Return on equity

From the regression analysis shown in Table 7, both the REM and FEM confirm that emissions, leverage and growth negatively affect ROE as shown by the negative coefficients. Of the three profitability ratios (NPM, ROA, and ROE), the ROA is least affected by carbon. Other parameters similarly affected are leverage and growth.

Table 10: Results of regression of carbon tax, firm size, leverage and growth in ROE (Source Appendix D)

	Without the interactive variable		With interactive variable	
	(1)	(2)	(3)	(4)
VARIABLES	**ROE1 RE**	**ROE1 FE**	**ROE2 RE**	**ROE2 FE**
effect_carb_tax120	-0.884	-1.019	-0.959	-2.637
	(1.333)	(2.461)	(1.306)	(2.501)
growth_effect_carb_tax120			0.026**	0.029**
			(0.012)	(0.014)
Carbon intensity	0.004	0.004	0.004	0.011
	(0.006)	(0.010)	(0.005)	(0.010)
Size	0.087*	0.110	0.096**	0.084
	(0.047)	(0.220)	(0.047)	(0.212)
Capital intensity	0.003	0.003	0.003	0.008
	(0.003)	(0.007)	(0.003)	(0.007)
Leverage	-0.074***	-0.076**	-0.081***	-0.092***
	(0.023)	(0.033)	(0.023)	(0.033)
Growth	-0.016	-0.010	-0.069*	-0.064
	(0.034)	(0.040)	(0.041)	(0.047)
Constant	0.055	0.021	0.121	0.203
	(0.075)	(0.238)	(0.080)	(0.246)
Observations	58	58	58	58
R-squared		0.120		0.204
Number of companies	12	12	12	12

	Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

The computed coefficients in Table 10 can be substituted in equation (2) to get the approximation of the net profit shown in Table 11.

Table 11: Return on equity relationship

Return on equity: Without interactive variable	
1.REM	= 0.055 – 0.884Eff Carbon Tax + 0.004Carbon Intensity + 0.087Size + 0.003Capital intensity – 0.074Leverage - 0.055Growth
2. FEM	= -0.021 -1.019Eff Carbon Tax + 0.003Carbon Intensity + 0.11Size + 0.003Capital intensity – 0.076Leverage - 0.01Growth
Return on equity: With interactive variable	
3.REM	= 0.121 – 0.959Eff Carbon Tax + 0.026Growth*Eff carb tax + 0.004Carbon Intensity – 0.096Size + 0.003Capital intensity – 0.081Leverage - 0.069Growth
4. FEM	= 0.203 – 2.637Eff Carbon Tax + 0.029Growth*Eff carb tax + 0.011Carbon Intensity – 0.084Size + 0.008Capital intensity – 0.092Leverage - 0.064Growth

Using the REM model (3) with the interactive variable in the analysis, and applying partial derivatives, the following expression is obtained:

$$\frac{\delta(\mathrm{ROE})}{\delta(\mathrm{carbon\ tax})} = -0.959 + 0.026 \times \mathrm{Growth} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(5)$$

If equation (5) is equated to zero, growth rate will be equal to 36.88, which implies that increasing the effective carbon tax improves the firm ROE when the growth rate was greater than 36.88 for the metals and mining industry. For the five-year period, there is no company that is above this threshold; this outcome shows that increasing the tax rate is not good for the ROE. The increase is only beneficial to companies with an almost unrealistically high growth rate (36.88), tenfold higher than for ROA. According to Hart *et al.* (1996), ROE impacts the company's capital costs, which represent not just the operational performance, but also the capital impact. They observed that the relationship between emission reduction and ROE is less immediate than with ROA.

4.4.6 **Carbon Intensities vs firm size**

Figure 1 illustrates the average carbon intensity of the companies for the years under review. From the graph, it is apparent that the data used in this study consists of a range from the severe carbon-intensive companies to the moderate and then low carbon intensity companies. The differences arise from the scope of activities and technologies used by the companies in their various undertakings. Figure 1 also shows the sizes of the different firms, which are measured as the natural logarithm of net sales. The plot shows that there is no direct correlation between firm size and carbon intensity. It is logical to theoretically propose that the larger the company, the more carbon-intensive it is. However, this relation does not hold, because:

- different companies use different technologies with some technologies being more efficient than others leading to more energy-efficient companies releasing fewer emissions;
- some companies may be under-reporting their emissions as the onus of measuring and documenting the emissions is the responsibility the individual companies; and
- different products sell at different prices, and therefore some companies may report higher sales than others, which will, in this analysis, appear as bigger firm size. The sales parameter used to calculate firm size can therefore be misleading.

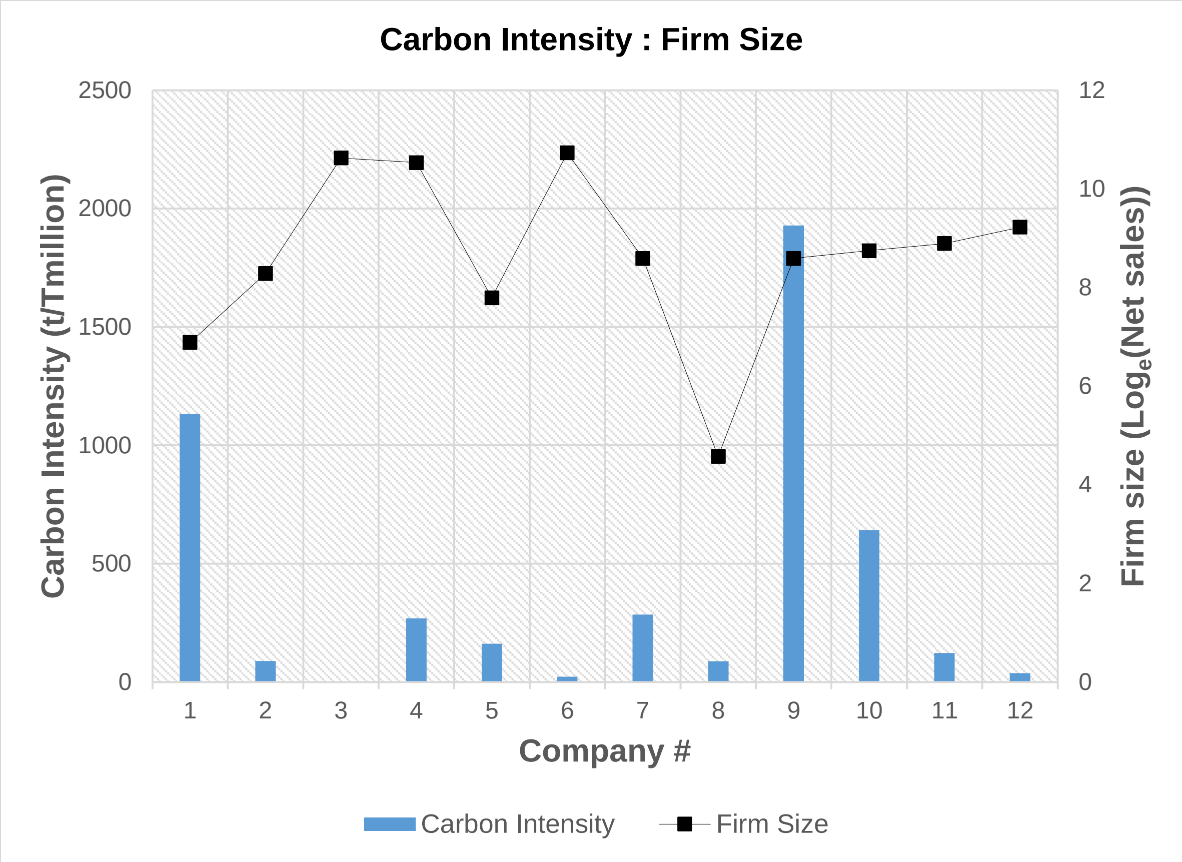

Figure 1: Average carbon intensity and Size of the companies over five years' period (Source: Appendix B)

- Different metals processing methods emit different volumes of CO_2 gas with some processes being high-intensity carbon processes, while others are low-intensity carbon processes.

These observations are in agreement with what was observed by Mukhibad (2018), who observed that company size had no effect on profitability. As carbon intensity is directly proportional to profitability, we can in this study observe no relationship between company size and profitability.

Effect of tax on profitability

Figure 2 below shows the effect of different tax rate scenarios, namely 1) R120/tCO_2; 2) R150/tCO_2; 3) R300/tCO_2 and 4) R1000/tCO_2. The study calculates the aggregate average of profitability ratios for all companies for the chosen five-year period. The three ratios were then measured as a percentage of the ratios before any carbon tax was deducted and expressed as a percentage change in profitability.

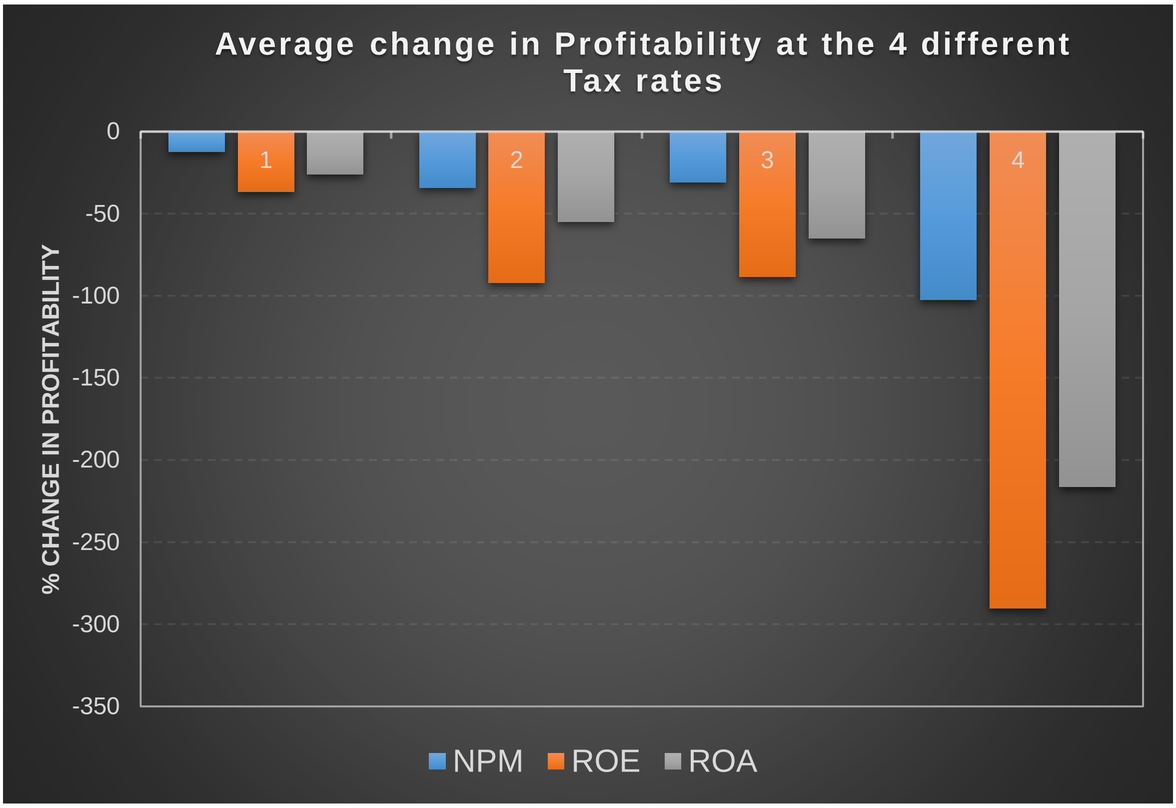

Figure 2: Changes in averages profitability as a function of a tax rate (Source Appendix B)

The general trend shown is that the tax negatively impacts profitability and increases with an increase in the tax rate. All the tax rates show a significant effect (> 10%) on the companies' profitability margins. However, the ratio that is affected most is the return on equity, which is an indicator that returns on investments by shareholders are severely curtailed.

Overall, the results show that the implementation of the carbon tax has put an additional cost on mining and processing activities, which led to a general decrease in the profit margin. The effects of the carbon tax on the industry can be therefore summarised as follows:

- It acts as a barrier for new entrants in the industry as they are aware of the reduced profit margins. The barrier will pose considerable disadvantages, especially to small players in the industry who do not have other alternatives such as moving to tax havens.

- As the tax cuts the profits derived from the industry, more and more mining houses are bound to close doors or relocate to other countries with less stringent and strict emissions control.
- As profit margins decline, no new investments will materialise, but companies will resort to retrenchments.
- On a positive note, companies will start investing in clean technology and capitalise on tax incentives derived from investment in such.
- Intrinsic company-specific attributes such as geographical factors (the company operating in a cold climate or windy areas) or human resources (talent between different companies) can adversely affect the emissions.

These findings are in agreement with Brännlund *et al.* (2010), who observed negative effects on increasing carbon tax. They concluded that a negative tax impact may be viewed as an overcrowding effect; that is, a higher tax that can or may not lead to an increase in energy production overcrowds all future productivity gains.

4.5 Summary findings

The financial and emissions data analysis show that the carbon tax has an overall negative impact on the profitability of the companies.

- ❖ The profitability of all the investigated companies will be negatively affected by the carbon tax.
- ❖ There will be loss of competitiveness in South African exporting companies if other exporting countries have no carbon tax.
- ❖ The study reveals that the new tax has an overall negative effect on shareholder capital as shown by its negative effects on return on equity.
- ❖ The reduction in profitability will act as a hindrance to companies and multinationals that have an interest in investing in South Africa.
- ❖ Ripple effects that this study expects include shrinkage in the sector due to company closure, migration of some companies to tax havens and a general increase in the country’s unemployment rate.

- Increasing the tax rate has negative effects on NPM, ROA and ROE for all the range of growth rates calculated
- Carbon tax negatively impacts profitability and the effects increase with an increase in the tax rate.
- There is no direct correlation between firm size and carbon intensity.

5 CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter gives highlights of the study's conclusions and recommendations as obtained from the prior chapters. The mini-dissertation indicates that the results and conclusions in this chapter respond appropriately to the key research questions. The contributions made by this study to the current body of knowledge on the impact of emissions on profitability in the metals and mining industry are given. Areas and avenues for future research pertaining to improving on the efficiency of the carbon taxing policy are given.

5.2 Conclusions

This study examined the influence of carbon emissions on company financial results using secondary data from 12 South African companies' integrated financial reports and consisted of 58 data points. The study documents evidence that the carbon tax has an overall negative impact on profitability as shown in Table 9 which is a list of the findings that address the research questions.

Table 12: The research questions and results

Research Question	**Findings**
What is the effect of a carbon tax on net profit margin (NPM)?	The carbon affects NPM negatively.
What is the effect of a carbon tax on return on assets (ROA)?	The carbon tax affects ROA negatively.
What is the effect of a carbon tax on return on equity (ROE)?	The carbon tax affects ROE negatively.
What are the effects of increasing the carbon tax?	All the profitability ratios are further negatively affected, a high carbon tax rate results in sustainability problems.

The research question for this study was to determine the impact of the carbon tax on profitability in the metal and mining sector of South Africa. This study has confirmed that the tax will have negative impacts on profitability, which means that there is a reduction in profits in the investigated industrial sector. Our findings give an early glimpse into its effect and indicate that investors will penalise companies with high direct operating emissions.

5.2.1 **Contributions to literature**

The current study is the first report in South Africa to focus on the metals and mining industry and make an in-depth analysis of the effects of the carbon tax on profitability. To the best of the authors' knowledge, no previous report has focused on the effect of an increase in the price of carbon, making the current study the maiden research in this area.

In a nutshell, this study contributes to the academic community by providing more up-to-date knowledge on carbon pricing and also how it might have an effect on the sustainability of the business if the carbon price rises. The study acts as a stepping stone for further research into the correlation of profitability, carbon price and competitiveness in the metals and mining industry of South Africa. The research findings and recommendations are also applicable to other sectors of the industry.

5.2.2 **Policy implications**

The goal of the study was to examine how price changes in CO_2 emissions will impact the viability of businesses with no emissions mitigation measures. Emissions negatively affect profitability significantly, and the effect increases with an increase in the price of carbon. Understanding how carbon tax impacts shareholder capital and wellbeing would motivate management to take constructive measures to minimise compliance costs under carbon regulations. The findings of this study highlighted the need to reduce emissions.

1. If a company's level of emission rises unabatedly, this will pose a threat to the survival of the entity as the carbon tax eats into the bottom line. The practical aspects of this study were to show the business stakeholders how the implementation and rise of the carbon price effects profitability.
2. In particular, carbon-intensive businesses that experience a significant effect, benefit from the findings, which may help them recognise their financial carbon risk. Carbon intensive companies can explore ways of investing in cleaner technologies

to take advantages of the tax rebate system, which is a provision in the carbon tax law. Managers seeking a numerical opportunity to minimise pollution can utilise some of the recommendations and findings of this study. Hypothetically, if the current price of carbon is not deterrent enough, the government will inevitably increase the tax rate, which, as shown, will further erode the profitability.

3. Understanding how carbon tax impacts shareholder capital and wellbeing would motivate management to take constructive measures to minimise enforcement costs under carbon regulations.
4. Policymakers can also find the findings helpful when assessing potential measures in the field of environmental protection and pricing of emissions. Policymakers must keep in mind that the carbon price works well as it allows businesses to adapt and invest in emerging technology.

This study will also be informative for prospective investors who need to assess financial threats to carbon-intensive businesses. Multinational companies wishing to invest in South Africa can therefore use the findings as a yardstick in their decision making.

5.3 Recommendations

- The government and policymakers need to seriously consider lower and upper limits at which the carbon tax has positive effects
- The government must put in place measures to insulate companies that are prone to international competition and those that are energy intensive to ensure that they do not lose their competitiveness.
- Companies must invest in environmentally friendly technologies not only to positively impact their bottom line, but to also alleviate environmental degradation.
- Investors must do an in-depth analysis of the environmental friendliness of any company before they undertake to make financial commitments.
- SARS needs to carry process audits to verify whether reported emissions are corresponding to outputs and also technology capabilities; this will reduce leakages of emissions due to under-reporting.

- Companies must investigate the advantages of investing in cleaner technologies as this is one solution for reducing the effects of the carbon tax on profitability.

5.4 Areas for further studies

- Analysis into the response to carbon tax by South African companies
- An evaluation into the effect of carbon tax on competitiveness of South African companies
- All the reported and analysed data was collected and reported by each individual company. It would also be worth exploring whether the emissions published by the organization would vary in any way from emissions when they were measured by a third party.

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7 Appendix A: Proof of language Editing

To whom it may concern

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7 December 2020

Dear Mr / Ms

Re: Language editing of dissertation: Effect of carbon footprint on profitability in the metals & mining industry of South Africa

I hereby declare that I language edited the above-mentioned mini-dissertation by Dr Innocent Shuro (student number: 31551084).

Please feel free to contact me should you have any enquiries.

Kind regards

Cecile van Zyl

Language practitioner

BA (PU for CHE); BA honours (NWU); MA (NWU)
SATI number: 1002391

8 Appendix B: Average carbon intensity and Size of the companies over five years' period

Company	Carbon Intensity	Firm Size
1	1132.985265	6.884223
2	88.38346975	8.282713
3	0.148366421	10.62723
4	268.4428645	10.53296
5	162.0474544	7.790189
6	22.87523983	10.73136
7	284.7695689	8.591532
8	87.38312302	4.572425
9	1928.794918	8.589404
10	641.8267558	8.745118
11	123.159792	8.891612
12	36.70762099	9.222727

9 Appendix C: Changes in averages profitability as a function of a tax

NPM	ROE	ROA
-12.3139	-36.6083	-25.9602
-34.2245	-91.9449	-54.7775
-30.7848	-88.4772	-64.9002
-102.616	-290.19	-216.334

10 Appendix D: 5 year aggregated companies' data

num_company	Period	Assets	Equity	Sales	NetProfit	NPM00	ROE00	ROA00	NPM120	ROE120	ROA120	Carb_Tax120	Car_Emm120	Carb_Int120
1	2015	35283	26905	1025	93	0.0907317	0.0034566	0.00263583	0.03967073	0.001511336	0.001152467	52.337502	1246131	1215.737561
1	2016	35127	24581	797	-87	-0.1091593	-0.003539	-0.00247673	-0.16595399	-0.0053808	-0.00376535	45.265332	1077746	1352.25345
1	2017	32246	24040	911	-99	-0.1086718	-0.004118	-0.00307015	-0.15696109	-0.00594807	-0.0044344	43.991556	1047418	1149.745335
1	2018	34305	27378	1028	852	0.8287938	0.0311199	0.02483603	0.786865313	0.029545531	0.023579581	43.102458	1026249	998.2966926
1	2019	37216	29703	1162	136	0.1170396	0.0045787	0.003654342	0.077186069	0.003019567	0.002409991	46.309788	1102614	948.8932874
2	2015	19759.3	14484.3	3045	619	0.2032841	0.0427359	0.031327021	0.199081672	0.041852467	0.030679411	12.796308	304674	100.0571429
2	2016	20317.9	14813.9	3342	585	0.1750449	0.0394899	0.028792346	0.171045709	0.038587729	0.028134539	13.36524	318220	95.21843208
2	2017	22145.4	14423.9	3499	618	0.1766219	0.0428456	0.027906473	0.172617596	0.041874179	0.027273789	14.011032	333596	95.34038297
2	2018	25510.6	15158.3	3627	666	0.1836228	0.0439363	0.026106795	0.179665472	0.042989429	0.025544153	14.353332	341746	94.22277364
2	2019	26950.7	16186.6	7492	1028	0.137213	0.0635093	0.038143722	0.134815728	0.062399728	0.037477299	17.960568	427633	57.07861719
3	2015	28266	14985	22717	538	0.0236827	0.0359026	0.019033468	0.023672106	0.035886502	0.01902495	0.240768	5016	0.220803803
3	2016	41721	16469	31241	3043	0.0974041	0.1847714	0.07293689	0.097395706	0.184755557	0.072930641	0.260736	5432	0.173874076
3	2017	76072	23998.2	45912	-4433	-0.0965543	-0.184722	-0.05827374	-0.09656095	-0.18473495	-0.05827777	0.306336	6382	0.139005053
3	2018	84923	24724.4	50656	-2521	-0.0497671	-0.101964	-0.02968572	-0.04977229	-0.10197478	-0.02968884	0.2652	5525	0.109069015
3	2019	101072	31138.3	72295	433	0.0059893	0.0139057	0.004284075	0.005984593	0.013894663	0.004280673	0.343824	7163	0.099080158
4	2015	30962	13472	31141	-809	-0.0259786	-0.06005	-0.0261288	-0.04425248	-0.10229115	-0.04450831	569.0664	13549200	435.0920009
4	2016	30646	13543	32737	190	0.0058038	0.0140294	0.00619983	-0.01255906	-0.03035856	-0.01341598	601.146	14313000	437.2117176
4	2017	31196	8058	39022	-315	-0.0080724	-0.039092	-0.01009745	-0.01565329	-0.07580328	-0.01958016	295.8228	7043400	180.4981805
4	2018	28560	7961	45274	3608	0.0796925	0.4532094	0.126330532	0.073011121	0.415212348	0.115738988	302.4945	7202250	159.0813712
4	2019	30100	3405	41353	-632	-0.0152831	-0.185609	-0.02099668	-0.02075695	-0.2520888	-0.02851702	226.36236	5389580	130.3310522
5	2015	2503	1529.9	2105.3	96.8	0.0459792	0.0632721	0.038673592	0.038061538	0.052376597	0.032013966	16.669044	396882	188.515651
5	2016	2419.1	1339.6	2433.1	108.8	0.0447166	0.0812183	0.044975404	0.038131001	0.069256897	0.038351676	16.023461	381511	156.8003781
5	2017	2287.4	1302.4	2339.9	-36.7	-0.0156844	-0.028179	-0.01604442	-0.02259545	-0.04059513	-0.02311406	16.171092	385026	164.5480576
5	2018	2360.4	1267.3	2490.4	32.4	0.01301	0.0255662	0.013726487	0.006724833	0.013215122	0.007095206	15.652476	372678	149.64584
5	2019	4060	2688.6	2762.1	105.1	0.0380508	0.039091	0.0258867	0.03172021	0.032587366	0.0215799	17.485608	416324	150.7273451
6	2015	48511	25167	36138	627	0.0173502	0.0249136	0.012924904	0.015955504	0.022910955	0.011885964	50.4	1200000	33.2060435
6	2016	57212	36536	40767	11144	0.2733584	0.3050142	0.194784311	0.272389923	0.303933654	0.194094246	39.48	940000	23.05786543
6	2017	62466	45546	46379	16133	0.3478514	0.3542133	0.258268498	0.346945816	0.353291178	0.257596132	42	1000000	21.56148257
6	2018	63051	46187	45725	12595	0.2754511	0.2726958	0.199758925	0.274567086	0.271820642	0.199117857	40.42	960000	20.99507928
6	2019	66941	47524	64285	21316	0.3315859	0.4485313	0.318429662	0.330932566	0.447647504	0.317802244	42	1000000	15.5557284
7	2015	19513.07	17824.72	3357.297	1290.44	0.3843687	0.0723961	0.066132092	0.363658161	0.068495235	0.062568759	69.531546	1655513	493.1088909
7	2016	20828.54	18911.61	2941.047	1497.641	0.5092204	0.0791916	0.071903325	0.491387692	0.076418368	0.069385304	52.446702	1248731	424.5872303
7	2017	25321.53	22624.95	7223.959	5138.33	0.71129	0.227109	0.202923354	0.703619955	0.22466	0.200735165	55.40829	1319245	182.6207762
7	2018	29373.33	26050.36	7804.737	5175.002	0.6630591	0.1986537	0.176180315	0.656312014	0.196632303	0.174387554	52.6593384	1253652	160.6270653
7	2019	34106.27	29802.38	8140.469	5963.932	0.7326276	0.200116	0.174863209	0.725785604	0.19824708	0.173230173	55.696788	1326114	162.9038818
8	2015	7626.543	2804.441	-593	-557	0.9387962	0.0290592	-0.07300818	0.940457178	-0.19889352	-0.07313735	0.985152	20524	-35
8	2016	7579.213	3107.125	594	302.7	0.5100253	-0.198542	0.039938184	0.508488869	0.097127777	0.039817873	0.911856	18997	32
8	2017	7979.577	3012.923	494	94	0.1908041	0.0974212	0.011805137	0.188532955	0.030893163	0.011664618	1.12128	23360	47
8	2018	9619.897	2925.096	86	-89	-1.0313953	0.0312653	-0.00922047	-1.05022369	-0.03087736	-0.00938879	1.619237	33734.114	392
8	2019	12473.2	3028.131	212	97	0.4566038	0.0319669	0.00776064	0.415071047	0.029059199	0.007054731	8.804938	209641.3788	989
9	2015	5357.605	3414.689	4428.075	343.457	0.0775635	0.1005822	0.064106443	-0.01978484	-0.02565643	-0.01635222	431.06574	10263470	2317.817562
9	2016	5962.403	3897.156	5701.567	532.43	0.0933831	0.1366201	0.089297889	0.016317913	0.023873223	0.015604057	439.392324	10461722	1834.885392
9	2017	6355.447	4635.525	5888.945	914.118	0.1552261	0.1971984	0.143832212	0.081244915	0.103213085	0.075281382	435.671166	10373123	1761.456933
9	2018	6628.552	4892.978	5606.324	683.416	0.1219009	0.1396728	0.103101854	0.04193455	0.048048178	0.035467577	448.317324	10674222	1903.960956
9	2019	4559.293	3380.517	5379.329	-1361.819	-0.2531578	-0.402843	-0.29869083	-0.32984364	-0.52487163	-0.38916943	412.518456	9821868	1825.853745
10	2015													
10	2016													
10	2017	6617.184	4675.751	6009.68	1164.44	0.1937607	0.2490381	0.175972136	0.159411729	0.204889746	0.144776612	206.426522	4914917.2	817.8334287
10	2018	7841.893	5131.345	6987.81	876.7184	0.125464	0.1708555	0.111799335	0.108364922	0.147570173	0.096562585	119.48496	2844880	407.120423
10	2019	7797.637	4967.171	5897.622	144.0672	0.024428	0.0290039	0.018475751	-0.00499409	-0.00592959	-0.00377721	173.52048	4131440	700.5264156
11	2015	19151.34	9036.935	6035.535	2768.189	0.4586485	0.3063195	0.144542866	0.453054215	0.302583184	0.142779834	33.76443	803915	133.1969743
11	2016	18977.86	8727.984	6097.07	2685.793	0.4405055	0.307722	0.141522415	0.43473367	0.303690018	0.139668076	35.19138	837890	137.4250255
11	2017	19636.11	8092.041	6865.185	1365.784	0.1989435	0.1687812	0.069554706	0.19354935	0.164204815	0.067668798	37.031904	881712	128.4323729
11	2018	23824.03	7386.679	7552.181	-2611.056	-0.3457354	-0.353482	-0.10959756	-0.35087274	-0.35873421	-0.1112261	38.798466	923773	122.318705
11	2019	26944.66	7456.8	10649.51	-3001.762	-0.2818687	-0.402554	-0.1114047	-0.28583455	-0.40821756	-0.11297216	42.234738	1005589	94.42588229
12	2015	6656.54	3854.517	8395	163.714	0.0195014	0.0424733	0.024594459	0.017579876	0.038288341	0.022171137	16.13094	384070	45.7498511
12	2016	6956.438	4346.688	10099	384.933	0.038116	0.0885578	0.055334785	0.036549571	0.084918476	0.053060793	15.81888	376640	37.29478166
12	2017	7230.066	4648.677	10160	332.232	0.0327	0.0714681	0.045951448	0.03120685	0.068204696	0.04385321	15.1704	361200	35.5511811
12	2018	6511.459	3802.621	11533.82	-773.411	-0.0670559	-0.203389	-0.11877691	-0.0683616	-0.20734915	-0.12108964	15.059248	358553.52	31.08714911
12	2019	4260.028	2570.308	10708.58	-1204.541	-0.1124837	-0.468637	-0.28275424	-0.11390563	-0.47456091	-0.28632856	15.226702	362540.53	33.85514197