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CLIMATE CHANGE AND CORPORATE AFRICA: ASSESSING RESPONSES TO CLIMATE CHANGE RISKS AND OPPORTUNITIES BY SMES AND MNCS IN SOME PARTS OF AFRICA.

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Abstract

Despite growing proliferation in awareness of climate change issues, there is little indication about whether companies operating across Africa are taking a strategic view of climate change risk, given the continent's vulnerability and exposure to the direct and indirect impacts of climate change. While utilizing the Carbon Disclosure Project dataset, the paper concludes with a summary of four findings; (1) Policy and appropriate legislation are critical drivers of climate change action by private companies in Africa; (2) Integrating relevant knowledge into local climate change policies with regards to size, geography and industry will likely increase the validity of implemented regulation and give consistency to sustainable practices; (3) Impacts that directly affect the bottom line for most businesses can be targeted for nudging businesses towards sustainable practices; (4) Although perceptions are not a replacement for overall environmental principles, they are useful in realizing behavioural intentions that can influence sustainable climate action.

Keywords: Climate change adaptation and mitigation; Corporate responses to climate risk; Sustainable climate action.

1. Introduction

1.1 Contextualization

Most of the African continent will be severely affected by the direct and indirect impacts of climate change as a result of global warming (IPCC, 2019). In line with the Paris Agreement on Climate Change, mitigation efforts to limit global warming by reducing global greenhouse gas emissions will require a global energy transition away from fossil fuels such as crude oil and coal to low-carbon sources. To comply, African economies will need to reconfigure their transport sectors, increase energy efficiency and decarbonize industrial production and commerce amongst other emissions reductions activities (Altieri et al., 2016). Transition costs that will be carried for the most part by government, companies and consumers (Tvinnereim et al., 2018). This is of particular concern for South Africa which has an energy-intensive economy, is the highest carbon emitting country in Africa and amongst the Top 15 carbon emitters in the world - accounting for an estimated 1% of global carbon dioxide emissions (WRI; Scenario Building Team, 2007; Baumert, Herzog, & Pershing, 2005). The entire continent is predominantly vulnerable to direct climate change impacts such as increasing weather variability and more frequent extreme weather events due to considerable limited adaptive capacity exacerbated by widespread poverty, inadequate infrastructure and public services, and limited financial resources (Nkomo, Nyong & Kulindwa, 2006, IPCC, 2019). One particular extreme weather event experienced in 2019 was Cyclone Idai, this disaster claimed hundreds of lives and left many homeless, displaced and in financial and emotional distress. Cyclone Idai devastated most of Southern Africa, with physical effects spilling over beyond the destruction of settlements, it immediately plunged South Africa into phase 4 load-shedding because Eskom imports electricity from Mozambique which was severely affected by this disaster. Energy analysts estimate "R1 billion, R2 billion and R4 billion per day for stage 1, 2, and 3 load shedding respectively" (Olasoji et al., 2018, p. 609). Thus up to 4 billion a day cost for 10 to 14 days was experienced during the unfolding of this crisis (Yelland, 2019), needless to say, that all businesses experienced massive operating costs during this period.

With increasing global awareness of climate change companies are under increasing pressure from shareholders, governments, financial institutions and customers to demonstrate how they are managing climate risk as it impacts long-term business sustainability (TCFD, 2017). Companies operating in Africa could be at considerable risk to the impacts of climate change. It is important to understand their awareness and responses to climate change risks and assess whether their response strategies are adequate and sustainable in the long term. Outside of a small, emerging body of work focused on South Africa, there is limited literature about this alluding to how companies operating in Africa are responding to climate change risk. This reference pool becomes even smaller when considering how Small-Medium sized Enterprises (SMEs), which constitute a greater proposition of businesses, respond to climate change risk (CDP, 2011; Crick et al., 2018b). much literature from developed economies that alludes to the conclusion that Multi-National Corporates (MNCs) and other big companies have reserves and policies in place to mitigate and recover from extreme climate change disturbances, while small businesses do not.

1.3 Research question

What is driving the responses by African businesses against climate change risk?

1.4 The gap

There is little indication or information about whether companies operating across the African continent are taking a strategic view of climate change in light of this risk., There is inadequate data regarding how African businesses are responding in the supply chain, as SMEs and as large companies across sectors (not limited to just agriculture, mining or tourism) (Nhamo & Swart, 2012; Niehaus, Feiboth & Goedhals-Gerber, 2018; Odeku, 2018; Elum, Modise & Marr; 2017). The CDP dataset is the only global survey in Africa that investigates how the supply chain (which also includes SMEs) responds to the growing risk of climate change as well as responses by top businesses in corporate South Africa. No such study investigates how risks and opportunities affect the perception of vulnerability and opportunities of climate change, and their significance in driving the behavior of these firms towards or away from sustainability. The present study is motivated by these apparent gaps in the extant literature.

1.5 Aim and Purpose Statement

More specifically, this paper set out to investigate the combination of factors that drive businesses to switch from one form of adaptation to another relative to its size, industry and country of location. Its results and conclusions will inform investors, regulators and policymakers on recommendations that can assist African businesses in becoming more sustainable against climate change.

1.6 Objectives

- **(i)** Examining the response of SMEs in the supply chain, MNC and other large companies in some parts of Africa to climate change risk using descriptive statistics.
- **(ii)** Identifying the combination of risk factors and opportunities that drive perception and sustainability using coded data and quantitative analysis.
- **(iii)** Unpacking significant factors that influence sustainable responses to climate change and drawing their policy and investment behavior implications spanning the considered contexts (such as industry, size and country of location).

Ultimately, the present study aims to amalgamate the gap found between conceptual research and evidence found through data analysis in the strategic choices made by the corporate community on mitigating and adapting to climate change risks. The rest of the paper is structured as: A literature review, this section exposes the case for this research. Followed by a Conceptual framework that outlines the scaffolding upon which the research paper is built and the Methodology section. This is followed by the Results section that discusses and factually present our findings, before the Discussion section that relates our findings to the literature review and theoretical framework developed. Finally, the Conclusion section summarizes what we did, what we found and what the implications are. Additionally, there is an Appendix section that contains tables and other additional material relevant to the paper that help clarify some material to the reader without distracting from the flow of ideas in the main paper.

2. Literature Review

"It is understood that many businesses are responding to climate risks by taking adaptive action, which might implicitly increase their resilience to climate change and influence the risks for others."– Surminisk, et al. (2018, p.6)

"Due to environmental sustainability problems, green marketing is not only applicable to large companies, but also for small and medium companies." – Mazirire (2018, while citing Yee 2016, p. 41)

There is a consensus in the business community that large companies (in comparison to smaller ones) have more adaptive capacity against climate change because of their size and financial capacity. However, this does not necessarily translate into sustainable responses. When the goal is to promote resilient climate change actions in the business community, it is important to expose and propose solutions to areas of negligence found in corporate responses. SMEs are seen as to be dismissive of climate change issues and there is a debate surrounding the intentions of the actions taken by Multi-National corporations that do not translate into sustainable responses against climate change.

2.1 Climate change responses by MNCs outside the African continent

2.1.1 The role of policy and legislation

(Jones & Levy, 2007) studied North American businesses and discovered that Multi-National Corporates are more reluctant to take proactive actions against transition risk in the face of weak and fragmented policy regimes. This study indicates how business responses to climate change are highly ambiguous, inconsistent, heterogeneous, and limited in scope when there are no stringent policies in place to direct sustainable practices. However, most companies that become aware of climate change as an opportunity rather than just a burden take it seriously regardless of the prevailing policy regimes because they anticipate some profitable opportunities. But on the other hand, these responses are rather ineffective relative to the scale of action needed in terms of emissions reductions and are a part of a phenomenon called "green-washing" where large companies use greening opportunities to address the climate change crisis without effectively reducing carbon emissions or making structural and sustainable changes to operations. This sentiment is was suggested earlier on by (Garrod and Chadwick, 1996) when they reveal that most businesses develop their environmental management strategy to increase their profits instead of actually thinking about the environmental issue that they would like to address. (Jones & Levy, 2007) conclude that although they are positive and energetic efforts, they are still yielding ambiguous and tentative results, thus, businesses are not on a sustainable path towards real solutions. But a more proactive approach to climate change would still provide companies with more capacity to defend themselves against litigation and reputational damage (Wellington and Sauer, 2005).

In addition, (Eberlein & Matten, 2009) evaluated how large MNCs in Germany and Canada, who have dynamically different regulatory approaches on the spectrum of strategic responses to the threat of climate change. However, in both cases, MNCs are critical actors in the development of regulation but are resistant to the issues. This ignorance demonstrates an

unsustainable course of action in the long term. While, a proactive, rather than a passive response to climate change was proven to be the long-term successful approach for MNCs.

2.1.2 Management practices

In 2017, de Abreu et al., using Brazilian energy firms propose a conceptual framework for corporate climate change strategy development. They aimed to show the vigorous influence investor pressures have on climate change risk assessment when it came down to carbon reduction practices and the manager's perception of performance. The conclusion was that the energy sector is well aware of the real effects of climate change and the potential of more natural disasters yet only big companies were more likely to carry out a dynamic range of sustainable actions in comparison to smaller companies. These results are consistent with the findings by (Weinhofer and Hoffmann, 2010) that favor MNCs' business strategies of being "pressure managers" and "emissions avoiders" when responding to climate change issues. This will once against limit the extent of sustainability when the larger companies only respond to pressure and because of societal responsibility to manage carbon emissions and fight against the acceleration of climate change. But instead, (Gasbarro et al., 2017) found that most MNCs responded to professional standards and practices rather than cultural expectations from society when adopting climate change responses.

2.1.3 Collective responses

(Finke et al., 2016) contributes to our understanding of corporate responses by showing how companies fail to collectively respond to climate change because of barriers to interaction. Barriers that are exacerbated by economic rationale around contradictory discernments of the rules of the game. Particularly when it comes to self-serving interests (Stroebe & Frey, 1982). Understandably, each key actor is different and is driven by differing perceptions which leads to the complicating of collective action. However, as stated by Finke et al. (2016, p. 5; p. 7) "Climate protection measures that involve multiple parties are disproportionally more difficult to achieve." Self-interests around "cost savings, image improvements and the protection of resources" impede the potential of collaborative action against climate change. Immediate costs incurred when responding to climate change lead them to focus more on cost reductions instead of confronting the climate change issue directly to influence positive and resilient impact to the environment for future purposes (Veal and Mouzas, 2010). Therefore, coming up with cross-company resolutions is not always feasible and at times impractical because the business community responses are varied across industries, countries and sizes. Subsequently, the corporate community is unsuccessful in producing collaborative responses to climate change that are sustainable because they are "rent-seeking" and engage in reactionary behaviors (Helm, 2010; Boiral, 2006; Markussen & Svendsen, 2005).

2.2 Climate change responses by MNCs in the African continent

The majority of the existing literature has predominantly focused on the classification of climate change strategies and identifying drivers and barriers to corporate strategies across the world, with little done for African businesses (e.g. Kolk & Pinkse, 2005; Jeswani et al., 2008; Böttcher & Müller, 2013; Linnenluecke et al., 2012; Winn et al., 2011).

(Reyers et al., 2010) is one of the first specific studies in South Africa that uncover corporate motivations for climate change responses using the CDP framework for carbon disclosure to investors and customers. Their study in line with other international scholars suggests that proactive companies likely emphasize demand (of existing or new products/services) and competitive advantages. While companies tend to be reactionary in response to reputational, regulatory and risk signals. The biggest limitation of their study is that they surveyed only six businesses in the three industries analyzed, thus their findings are not sufficient for predictions on a wider spectrum of South African corporations. Our paper will extend upon this research and provide further insight into growing solutions to the impending risks of climate change in the continent.

(Nhamo and Swart, 2012) investigated the possibility of measuring business responses to climate change in South Africa through a scholarly framework that could separate corporate 'green wash' from genuine concern on climate change as has been the problem with voluntary disclosure pertaining to climate change responses. They define 'Green wash' as the phenomenon where business portrays an image of going green, but in reality, the business is run as usual. Although the proposed scholarly framework by (Nhamo and Swart, 2012) was articulately presented and well researched, it appeared ambitious and potentially difficult for companies to meet the requirements of this measuring framework. Regardless, they point out that the existing disclosure framework such as the CDP makes use of bare minimum requirements that will probably not trigger real change in corporate behavior as they do not measure performance. This paper rather than focusing on the measures of disclosure aims to determine and predict the factors that drive a sustainable response and confront those that do not from the data that does exist.

In other parts of Africa such as Cameroon, there is little proactive engagement in the private sector in climate change-related activities. (Tieguhong et al., 2019) partially attributes this to the lack of institutional arrangements and also the lack of salience of these matters as observed in most parts of the sub-Saharan. Although the most vulnerable to the effects of climate change, the African continent lags in collective mitigation and adaptation actions (Collier et al., 2008; Hope et al., 2009; Descheemaeker et al., 2016; Nyiwul 2019). (Kapfudzaruwa, 2014) particularly showed how participation in climate change issues is low in Kenya in comparison to South Africa using the top100 companies listed on the JSE in South Africa and the entire list of companies on the Nairobi Stock Exchange in Kenya. Their research feeds into the previous studies that claim that South Africa has thus far taken more steps to promote the transition to a green economy and it could share these lessons with the rest of Africa that is lagging (Kaggwa, Mutanga & Nhamo, 2013)

2.3 Small and Medium-sized Enterprises (SMEs) and the green economy

However, there is still much debate over the behavior of SMEs that is aligned with the global movement towards an environmental conscious pathway as a consequence of rising [business, social, ecological] vulnerability to climate change. The literature around SMEs shows that they are ignorant and are not concerned with sustainability issues despite being rooted in most vulnerable local communities. There is a disconnect between their involvement in areas of recycling, energy efficacy, and the use of environmentally friendly products and actually

understanding the strategic prominence of environmentally sustainable policy and practice (Surminisk, et al., 2018). Much of these concerns as presented by big companies are derived from the Stern Review (2006) that concludes that there will be irreparable damage to the environment if there is no urgent intervention to reduce greenhouse gas emissions. Moreover, transitioning to a low carbon emission economy brings forth new business growth and investment opportunities (Revell et al., 2010), a movement that most SMEs are behind in. SMEs are of particular interest due to their high vulnerability to climate change, they are some of the most affected by harsh and unpredictable weather disasters and typically do not have enough adaptive capacity or resilient infrastructures (Runyan, 2006; AXA and UNEP, 2015; Wedawatta et al., 2010; Yoshida and Deyle, 2005). Not surprisingly, SMEs play a crucial role in influencing community development, fostering innovation and building community resilience. SMEs are significant drivers for communal responses to climate change risks and for seizing the opportunities that it brings about (Dougherty-Choux et al., 2015).

2.3.1 Why study SMEs?

Small and Medium-sized Enterprises (SMEs) have a key role to play in most developing economies, in South Africa, they take up an estimate of 34% of GDP while contributing approximately 60% of total employment (Fatoki, 2018; Banking Association of South Africa, 2018). SMMEs make up 91% of all formalized businesses in South Africa (Banking Association of South Africa, 2018). They encompass an estimate of 2.8 million businesses in corporate South Africa and will likely be responsible for the creation of no less than 90% of new jobs by 2030 as predicted by (Groepe, 2015). Needless to say, SMEs have a critical role to play in the sustainable development of South Africa.

The massive number of SMEs around the world means that it is essential to research the environmental and social consequences of their existence as they collectively emit more GHGs and release more wastes in their daily operation than perceived (Roxas & Chadee, 2012). There is a common misconception among SMEs owners/managers that their operations are insignificant towards the environment because of their small size (Rowe & Hollingsworth, 1996; Natarajan & Wyrick, 2011). (Roxas & Chadee, 2012) showed that this is not the case and went further to challenge the notion that SMMEs are unable to pursue a proactive environmental strategy plan solely because of financial constraints.

SMEs are often under-researched as they are increasingly costly and time-consuming to reach (Rutherford et al., 2000). Commonly, little information is present regarding their direction towards corporate sustainability (Luken & Stares, 2005; Perrini et al., 2007; Lee and Klassen, 2008; Dangelico and Pujari, 2010). Even so, they make up 91% of all formalized businesses, which when aggregated, has the power to significantly impact climate change issues (Revell, et al., 2010; Banking Association of South Africa, 2018). There is yet to be data-driven facts on the realized effect that local SMEs have on climate change issues, although it appears quite significant when considering the magnitude of all (formal and informal) small businesses across the globe (Kapelus, Hamman, Agbazue & Hein, 2004). In England, approximately 60% of the industry's greenhouse gas emissions are attributed to S(M)MEs, they have the same percentage for commercial waste contamination and are accountable for an estimate of 80% of all pollution accidents (Vivier, 2009). Vivier also found that SMEs' owners and managers are

cognizant of the consequences of their behaviour but most of them view environmental management as costly so participation in sustainable practices was in the minority.

(Cant et al., 2014) showed that most start-ups in South Africa close down within less than 5 years of existence. The Stats SA Integrated Business Register recorded a high yearly mean failure rate of businesses of about 75% in SMMEs according to (DTI, 2008). (GEM, 2005) reported that 45 of 100 South African business owners are "necessity-driven" (Von Broembsen et al., 2005), thus, their priority is to survive the financial year over other objectives. SMEs in most parts of Africa fail to prioritize adaptation to climate change because they face significant constraints to the development of their businesses and operations (Vivier, 2009; Fatoki 2011). Constraints that restrict their general progression and development, and subsequently limit the SMEs' adaptive capacity.

2.3.2 Constraints that SMEs face: To their development and growth

(BMI & GEP, 2013) approximated an average of 8 out of 10 failed SMMEs in Johannesburg and Pretoria combined were started and run by non-matric holders, a sentiment previous literature identified (Rogerson, 2008; Mutyenyoka & Madzivhandila, 2014). It is thereby not coincidental that uneducated or un-skilled owners and personnel not only lack the significant training and skills to keep the business afloat or conduct effective risk assessment, but 90 of a sample of 100 SME business owners saw little need for skills training and may not value the link between training and business improvement (Fatoki, 2012; World Bank 2012).

The most prominent firm-specific dynamics that hider continuation of SMEs operations include: "the lack of proper marketing strategies, incompetent human resources, insufficient financial knowledge, lack of business infrastructure and inadequate business management skills (Cant & Wiid, 2013; Grundling & Kaseke, 2010)" (Ngary et al., 2014, p. 912).. That being said, SMEs, justifiably, may not meet the expenses of skills training and consulting services owing to the surrounding financial constraints and other socio-economic issues faced (Mahadea & Pillay, 2008; Maas & Herrington, 2006).

Financial constraints or lack of access to adequate capital has been identified by over 90% of SMEs in various cities in South Africa making restrictions to access to credit a major constraint (Fatoki, 2011; World Bank, 2012d). (Mutezo, 2013) explained that their difficulties in getting access to finance from formal institutions result heavily from credit rationing. The resulting high-interest rates are keystones to why most SMEs do not use formal bank services for loans, aggravated by complex and rigorous application processes, they usually do not have secure collateral or have a history of successful loan repayment (thus low credit scores or zero credit history). The most feasible source of start-up capital for business ventures is from their own savings or loans from their immediate circle of friends and family. This leaves them with little to no financial resources.

Cassar (2004) identifies external factors such as current economic environments as the most probable constrain. Their burdens are not only limited to access to funds and lack of business skills and knowledge, in addition, they face "high interest rates, strict government legislation, taxation rates, high inflation rates, volatile market conditions and crime (Bbenkele, 2007;

Grundling & Kaseke, 2010; Fatoki & Garwe, 2010; Salie, Strauss, Davids, Smit, Boshoff & Bruwer, 2014)" (Ngary, Smit & Bruwer, 2014, p. 909). Factors that hinder their success.

Consequently, they are susceptible to unstable rates of return and higher failure rates. SMEs are not fully prepared in terms of human and financial resources to withstand economic turmoil. For example, crime and labour conflicts make for a volatile operating environment in South Africa. (Niemann et al., 2016) identified corruption as a barrier, but little if any existing research is available on this relative to SMEs. Rising crime level affects businesses directly in cases of theft of property and money, and indirectly in reduced business confidence (Mahadea & Pillay, 2008). (Vivier & Venter, 2008) pointed out the adverse significance of fraud on businesses in South Africa yet only 10% of their respondents took strategic actions in their budgets for combating fraud. Changing the perceptions of owners/managers may be key to becoming high-value adding entrepreneurs. (Crick et al., 2018a) also takes note of policies, regulatory and legal frameworks as critical external drivers that can motivate or impede private sector engagement when responding to climate change (Agrawala et al., 2011; Ackerman et al., 2012; OECD, 2015).

2.3.3 Constraints that SMEs face: To their ability to respond to climate change

SMEs are more vulnerable to the uncertainty and risk that is involved with climate change as they lack refined and robust frameworks to engage sustainably (Siwangaza, Bruwer, Smit & Ukpere, 2014). As aforementioned, SMEs often cannot afford to cover the large upfront capital costs of investing in both immediate and future climate change actions because of financial strains. As a result, they lack the capacity to respond proactively but some scholars show that even those that do are still at risk against climate variability (Trabacchi & Stadelmann, 2013).

(Agrawala et al., 2011; Trabacchi & Stadelmann, 2013 cited in Crick et al. (2018a, p. 7)) mentioned "low institutional capacity, insufficient business settings, and policies and incentive structures that distort price signals" as constraints to the private sector's ability to respond to climate change risks thus limiting the value of early warnings. Despite existing research suggesting that governments are drivers to green supply chain management implementation, in some cases, their actions can be found restrictive (Niemann et al., 2016). Nevertheless, (Hillary, 2000) found that SME managers were often unaware of the relevant laws, regulations and ordinances in their sectors with regards to going green. For which (Viviers, 2009, p. 46) showed the importance of SME owners/managers becoming "better informed about existing environmental legislation and incentives, in terms of the financial benefits of 'going green' and their role in terms of environmental conservation".

On the other hand, (Struwig & Lillah, 2017) observe that the commitment to implement an environmental management strategy is linked to SMEs owners' underlying ideologies, abilities and cognitive predispositions to behave in a certain manner (Boiral et al. 2014). Meaning that global events such as the Paris Agreement of 2015 and the United States' intentions of withdrawing from that agreement could harm their commitment to sustainable action. Using (Ajzen, 1991 cited in Struwig & Lillah, 2017) the theory of planned behaviour uncovers that the execution of environmental management strategies must be observed through the individual's personal and ethical obligations. Vivier (2009, p. 39) supports this using Revell's

(2002, p. 291) argument that "low levels of engagement often result from the perception that environmental and economic interests are at odds [unlikely]." This suggests that the more optimistic the SME owner's perception towards an environmental management strategy, the higher the chances of behavioural intentions to adopt it.

2.3.4 The economic costs associated with not responding to climate change

The following are some of the transitional costs of climate change according to Peattie (1995, p.40), "Primary product costs may increase. Capital expenditure, such as facility changes, may increase. Costs may be incurred by complying with new 'green' legislation. Green overheads may be incurred by changing the management of the firm. Costs associated with carbon taxes and fines may be incurred." However, it is imperative to point out that going green is only worth something if the adaptation measures are sustainable (Schaltegger & Figge, 1998).

Several papers have shown the opinion that initial costs associated with "going green" can be substantial, but there is supporting evidence that shows that in the long run, businesses can expect cost savings that can offset those initial costs (Lesourd & Schilizzi, 2001; Swallow and Furniss, 2011). This section will address the economic costs of not responding to climate change as a result of the risks it poses, as well as in terms of opportunity cost, that is, the loss in benefits of transitioning to low carbon emissions.

(ECLAC, 2003) defines loss and damage assessment as part of risk assessment to measure the monetary value of disasters on communities, economies and the environment in relation to the cost of a specific event, either actual (post-impact) or hypothetical. (UNFCCC, 2012) puts an important distinction between direct losses, which are in the form of visible damage and the assessment of indirect losses (tangible and intangible) which are more difficult to quantify and value. Losses such as loss of production due to the interruption of business or losses on the community (social impacts), such as access to networks, services and assets including recreation areas.

Surminski et al. (2018, p. 2) present the following argument: "It is widely accepted that climate change can influence the ability of business and industry to produce goods and services. These impacts can be immediate, for example, if flooding causes business to close temporarily, or they can occur over time in a more dynamic sense, for example by increasing the costs of operating in a specific location to the point where relocation or closure is the only viable option for the business. Furthermore, a business can experience direct impacts, such as business interruption and damage to physical assets in case of a windstorm, or indirect impacts through public policy or market changes such as rising demand for flood resilient materials or increased competition for certain resources."

According to the Stern's review, adaptation will cost tens of billions of dollars a year in developing countries alone and will put further strain on already scarce resources. The economist intelligence unit in 2015 found that up to 30% of the world's total stock of manageable assets may be at risk due to climate change impacts (Diaz, 2016). Thus, adaptation efforts, particularly in developing countries, should be accelerated. Understanding these climate change risks matters—to companies to prepare, reduce risks and take advantage of any opportunities that might arise; and to governments because risks to businesses impact the

economy as a whole and because company behaviour plays an important role in economic stability (OECD 2015).

The acknowledgement of these financial implications of climate change has catapult MNCs and other businesses into "going green" (Dahlmann et al., 2008). That being said, environmental sustainability has been shown to promote economic processes and lead to access to new environmentally conscious markets. Businesses can expect to reduce GHG emissions and contaminations, increased production capacity and lower costs of compliance, and being fully aware of the environment can be viewed as a competitive advantage (Fatoki, 2018). "Green" businesses, irrespective of size, will benefit from competitive advantage as they can hold their market share against competing firms (Vivier, 2009).

Kehbila et al. (2009) recognized improved client relations; competitiveness; compliance with policy and regulation; and employee acceptance as some of the benefits of implementing a sustainable environmental management strategy. (Vivier, 2009) also connects "Going green" to have a positive effect on staff morale. As shown by Millet (2000, p. 5) "people may feel a renewed sense of meaning in their work and have the sense that they are contributing to important work if businesses take on an environmental approach". Also, some of the identified benefits SMEs can expect from improved environmental management include enhanced public and brand/corporate image, operational savings (Viviers, 2009; Peattie, 2001; Lesourd & Schilizzi, 2001). Ultimately reducing costs and increasing profits. Additionally, individuals seeking environmentally friendly goods and services tend to have high reservation prices and so firms can benefit from higher mark-ups on those products (Grove et al., 1996). (Kronrod et al., 2012) reported that 45 % of American SME owners/managers believed that their consumers would be willing to pay a higher mark-up for environmentally friendly products and services however this may not translate to real action. (Barbarossa & Pastore, 2015); Dhari et al., 2018) explores the price sensitivity to green products expressing that some consumers are not always willing to prioritize environmental issues including climate change over personal income. Biswas (2016) suggests that inclination to pay the extra mark up on green products can be fostered through better environmental awareness agendas as a means to influence customer's intentions.

Responses to climate change as shown by the Stern Review (2006, p. viii) "create significant business opportunities, as new markets are created in low-carbon energy technologies and other low-carbon goods and services." However, failure of climate change mitigation and adaptation measures lead to significant opportunity costs for SMEs and ultimately, leave no room for businesses without the comparative advantage of responding to climate change. This becomes imperative in the era of the fourth industrial revolution where businesses that are not sustainable lose their value as the future aims to enhance productivity and efficiency of manufacturing, perhaps towards zero-carbon production processes with this idea of "smart factories" as put by (Schwab, 2017). Nonetheless, traditional means of operating that are not sustainable will no longer be relevant across all industries, and if big companies are already shifting their business to sustainable actions, SMEs in the African economy needs to catch up.

2.4 What is adaptation?

(Ford et al., 2015) defines adaptation actions as tangible changes made to deliberately reduce vulnerability and increase adaptive capacity to climate change. The IPCC in 2007 conceptualizes vulnerability as "an outcome of susceptibility, exposure and adaptive capacity for any given hazard", the extent to which a system is susceptible to, and fails to manage the negative effects of climate change. Bicknell & McManus (2006, p. 388) note that "adaptive capacity recognises that adaptation takes place within economic, social and institutional circumstances." Risk assessment of this magnitude has not successfully operated well in this regard for the majority of SMEs and some MNCs. Identifying the costs (and benefits) of responding to mitigation and adaptation within the context of multiple risks that SMEs are faced with is imperative. It is the high vulnerability of SMEs that drives this compelling argument for urgency in mitigation and adaptation.

(Crick et al., 2018b) bares a distinction in SME adaptation behaviour, in that there is adaptation to present climate change risks (that's either sustainable or reactive) and premeditative planning for future climate change risks, in support of (Pelling, 2011)'s forward-looking adaptation. Forward-looking adaptation has the potential to support the development of policy and practices that are sustainable through progressive risk reduction.

(Vincent et al., 2013) defines coping to typically refer to stopgap strategies that can only sustain survival in the short-run. The purpose of coping strategies is to enable continued existence when it is threatened by inescapable future climate variability. Hence coping strategies are usually interim, reactive responses. However, deducing whether the observed strategies are examples of reactive coping or sustainable practices is dependent on the specific scale of interest in which they were observed (Vincent et al., 2013), yet, finding this distinction is important as it can inform policy and practice (Crick et al., 2018a; 2018b).

However, coping measures leave the business still susceptible to exposure to the same hazard. Reactive coping and sustainable climate change strategies are therefore on the opposite spectrum of resilient efforts. The latter minimize vulnerability at the time of exposure and more likely to be as successful in the future when faced with the same hazard. (Averchenkova et al., 2016) cautions against any responses that are not sustainable, particularly maladaptation which is also subject to the scale of analysis (Juhola et al., 2016). Typically maladaptation is found where responses to one extreme weather hazard (e.g drought) leave them vulnerable to another climate hazard (such as flooding). (Pelling, 2011, p. 50) describes maladaptation as "acts that, through bad planning or inadvertent consequences, cause either local or distant consequences that outweigh gains". (Heltberg & Bonch-Osmolovskiy, 2011) make an important note that the origins of maladaptation can be seen as psychological just as much as they can be rooted in financial restrictions or defective engineering. However, much remains to be discovered about how these acumens translate into better climate change interventions.

To conclude, SMEs and much of the corporate community do not need to choose between averting climate change and promoting growth and development. Resilience is not a normative concept, thus, transitioning to low-carbon economies has created real opportunities that can discover advances in business structures from low GHG emissions and demand for new markets. "Market drivers therefore play a key role in private sector adaptation, as businesses may respond to changing demand, diversify their activities, develop new products and services,

upgrade their business, adopt new technologies, access new markets, and seize new business opportunities arising from climate change." (Crick et al., 2018, p. 6). Indeed, SMEs overlooking the threats of climate change will have irreparable repercussion to economic growth but it is also fascinating that although big companies appear to be responding more urgently and seizing the opportunities, their self-interests may be doing more damage than good in terms of building resilience against the risks of climate change and thus their views need to change towards behaviours that actually result in real changes.

3. Methodology

3.1 The data collected

The Carbon Disclosure Project (CDP) climate change questionnaire is a global disclosure framework that has responses to climate risk management strategies targeted at investors from 1,650 firms. We only have responses provided by SMEs in the supply chain in Africa, but we can observe what is happening in some of the fastest growing economies in different parts of Africa; specifically in West Africa (through Nigeria and Cameroon), East Africa (through Kenya and Ghana), North Africa (through Egypt) and Southern Africa (through South Africa and Zimbabwe). SMEs self-select by filling out the short otherwise known as the SMEs questionnaire with the criteria that they have gross profits below say US$250 million or so, a parenthesis, these criteria are subject to discretion and other conditions. Additionally, we use the description of SM(M)Es as defined by the South African gazette in Table 1 below. The dataset also contains the Top 100 JSE companies in South Africa, and given that no other big African businesses contributed to the full survey, we only use this across all industries in the form of panel data.

Table 1. Quantitative definition of SMMEs in South Africa

Enterprise Size	**Total number of workers**	**Annual revenue**	**Gross assets not including fixed property**
Medium	Few than 100 to 250 depending on industry	Less than R4m to R50m depending on industry	Less than R2m to R18m depending on industry
Small	Fewer than 50	Less than R2 to R25m depending on industry	Less than R2m to R4.5m depending on industry
Very Small	Fewer than 10 to 20 depending on industry	Less than R200,000 to R500,000 depending on industry	Less than R150,000 to R500,000 depending on industry

Source: Fatoki, O., 2018. Environmental Sustainability Practices of Immigrant-Owned Small and Medium Enterprises in South Africa. *European Review of Applied Sociology*, *11*(17), pp.27-43.

3.1.1 Sampling and survey instrument

Saunders et al. (2007, pp. 136-143) define a case study as "an empirical investigation of a particular contemporary phenomenon with multiple sources of evidence; boundaries between phenomenon and its context are not clearly evident; for research questions of: why, what, how; research purpose: exploratory and triangulation of data: qualitative and quantitative." In this section, we conduct a case study, firstly with formal SMEs in South Africa, Nigeria, Kenya, Cameroon and Egypt from the period of 2013 - 2017. And secondly, with data from Top JSE companies in South Africa from the period 2012 - 2018. The methodology in part follows a similar model used by (Crick et al., 2018b) in the Kenyan and Senegalese context.

3.1.1.1 The questionnaire

The CDP climate change questionnaire is for companies disclosing environmental information at the request of their investors and customers or value chain. The questionnaire provides a framework for companies to disclose on their governance and policy, risks and opportunity management, environmental targets and strategy, and scenario analysis (which is the only section our research doesn't cover). (See CDP website for full description)

3.1.1.2 Limitations of the questionnaire

The questionnaire is long so that often leads to incomplete responses, and consequently lead to missing data. It has also had regular changes to the questions over the period it has operated, often in negligible ways but there are cases it's significantly different and thus affected our choice of variables (Goldstein et al., 2018).

A much more common cause for missing data is that subjects themselves act in a way that makes it impossible to obtain measurements on certain variables. In our survey, the only responses we have are from the CDP framework. The CDP is an exclusive framework that is not readily available for all businesses. It poses a financial constraint as the firms need to pay the CDP to run their global environmental disclosure system at the request of their investors, purchasers and city stakeholders. As a result, the companies in the dataset are not an accurate representation of all corporations in Africa, in fact, those that are burdened with financial constraints because of size or any other factors which make them more likely to be vulnerable to the risks of climate change are unfortunately not captured. Thus restricting data analysis to the sample of companies in the CDP leaves us with a *self-selected* sample. If the interest is in the relationship between firm-specific characteristics and sustainable adaptation in the population as a whole, the sample of non-missing observations is likely to produce misleading conclusions (Dubin and Rivers, 1990). A Heckman two-stage estimator could be implemented to eradicate the effects of the selection bias in binary dependent variables that have endogenous covariates such as our case. The method used by (Schwiebert, 2015) can be summarized as using firstly, an estimation (in STATA) to implement our estimator. Second, the approach provides a measure to analyze the composition of the fully observed sample with respect to unobservables. The Heckman selection model can be used to study the shift in the unobserved quality of the SMEs and MNCs in the African region because the main equations of interest can be augmented by a control function, the inverse Mills ratio term, for the sample of SMEs and MNCs. The endogenous covariates such as perception of vulnerability and perception of

opportunities are allowed to enter the main equations only, the selection equation only, or both. Thus, the model is sufficiently general to accommodate all cases of endogeneity. (Schwiebert, 2015) extends Heckman's (1979) bivariate normality assumption and assume that the error terms of main equation, selection equation and the reduced form equations for the endogenous covariates, have a multivariate normal distribution.

3.1.2 Measurements

The combination of indicators at the empirical level representing our social science constructs were decoded from open-ended responses using content analysis. We develop indicators that measure certain unobservable socioeconomic indicators such as sustainable responses and quantify abstract theoretical constructs such as perception using different levels of measurements. The main rating scales used are; nominal scales that measure categorical data such as industry type and country of location, and specifically Likert scales to categorize climate change responses as the dependent variable. We used ordinal scales to measure likelihood which was further transformed into a ranking scale for perception, while an interval scale was used to measure timeframe we also rank-ordered this variable. And finally, we used binary scales to quantify yes or no responses. (see Tables below).

Table 2.1. Definition and Measurements of the Dependent Variable

Dependent Variable	Distinction of Identifying Responses	Characteristics of Responses to Transition and Physical Risk	Measure
SUSTAINABLE	Planned/Proactive	Deliberate and anticipatory decisions to prepare for potential effects. Engineered infrastructure, including built structures. Goldstein (2018). "Environmental management policies. Gadenne et al. (2009) note that environmental management policies such as ISO 14000 help businesses to have clear environmental procedures leading to more engagement with sustainability. Yu & Bell (2007)" (Salimzadeh., 2015. pp. 54-56); Odeku, K.O., (2018)	1
	Continuous/ Concurrent	Environmentally friendly practices that (Goldstein et al., 2018) label as soft adaptation "such as recycling (Keijzers, 2002; Gadenne et al., 2009; Evans & Sawyer, 2010)" Waste reduction.(Keijzers, 2002). Energy efficiency. (Evans & Sawyer, 2010; Potts, 2010; Altieri et al., 2016). Use of environmentally friendly products. "A business should invest in using green products (Zsidisin & Siferd, 2001).Yu & Bell (2007); Revell et al. (2010). Work to reduce carbon emissions." (Salimzadeh, 2015); CDP (2011)	
	Resilient	Ecosystem-based adaptation builds ecological resilience and robust system designs while considering mitigation. Conservation and restoration of ecosystems have been labelled as a general resilient climate change strategy. Goldstein (2018).	
UNSUSTAINABLE	Reactive Coping	Measures that are not premeditative, but are taken after and in response to an extreme climate change phenomena. Crick et al. (2018b)	0
	Do Nothing/ Deferred	This implies that there is no action taken against the specific risk.	

Table 2.2. Description and Measurements of the main Explanatory Variables (Covariances)

Independent Variables	Description		Responses of Sample firms	
Incentives	Incentives for management of climate change issues		Yes	1
			No	0
Governance	Highest Level of direct responsibility			
	No individual/board			0
	Individual/board or other subcommittees of the board e.g., Social, Ethics and Transformation Committee, Risk and Environmental Sustainability Division, or Health, Safety, Environment and Risk committee, SDAC,			1
	Senior Manager/Chief Executive Officer (CEO)/ Chief Financial Officer (CFO)/ Chief Risk Officer/Business Executive Consumer Brands/Chief Supply Chain Officer/ Group Sustainability Manager (as well as the board)			2
Climate Change Integration	Is climate change integrated into your business strategy?		Yes	1
			No	0
Frequency	Frequency of monitoring			
	Unknown			0
	Sporadically, not defined			1
	Annually			2
	Six-monthly or more frequently			3
Perception	Perception/likelihood of risk and opportunities			
	Unknown			0
	Exceptionally Unlikely			1
	Very Unlikely			
	Unlikely			
	About As Likely As Not			2
	More Likely Than Not			3
	Likely			
	Very Likely			4
	Virtually Certain			
Future	(2012-2013) Timeframe of risk assessment.	(2014-2018) Timeframe of risk assessment and How far into the future are risks considered?		
	Up to 1 year/Current	Up to 1 year/Current		1
	1 to 5 years/Short-term	1 to 3 years/Short-term		2
	6 to 10 years/ Medium-term	3 to 6 years/ Medium-term		3
	>10 years/ Long-term	>6 years/ Long-term		4

(see Appendix A. for full list of variables)

3.2 Descriptive statistics

Table 3. Summary description of Population

MNCs	***SMEs***	***MNCs***	***SMEs***	***MNCs***	***SMEs***	***MNCs***	***SMEs***	***MNCs***	***SMEs***
Sample Composition		Sample Size		Share of business that adopt Sustainable Practices in at least one area		Share of business that only adopt Unsustainable Practices		Key Explanatory Variables	
Multinational Corporations in the Top 100 JSE operating in South Africa.	Small and Medium sized Enterprises in the Supply chain from Nigeria, Cameroon, Egypt, Kenya, South Africa and Zimbabwe.	437	62	67,92 %	53,23 %	32,08 %	46,77 %	*Perception of Vulnerability. *Perception of Opportunities *Firm specific characteristics such Capacity, i.e., relevant knowledge, sufficient internal resources. *External Characteristics such Investment opportunities and capital availability.	

Top Companies in South Africa

This dataset contains 61 companies in the Johannesburg Stock Exchange Top 100 over 6 years in over 15 industries provide us with 437 data points. Appendix 11 shows that the Finance industry carries the biggest proposition of the overall population at 19,6% and the Mining industry coming in second claiming 18% of the total population.

Supply Chain SMEs in Parts of Africa

The data contains 62 observations for 27 SMEs in the supply chain across Africa in the following proportions; Kenya holds 37,10% of the population, Nigeria with 35,48%, South Africa holds17,74%, Ghana and Egypt have 3,23%, while Cameroon and Zimbabwe account for only 1,61% of the population. The firms are proportioned in the following industries; where the majority are found in Containers & Packaging at 37,10%, Trading companies and those in Food & Beverages contribute to 14,52%, the Ground Transportation industry with a proportion of 9,68%, while those in Air transportation and Food production (Agriculture) contribute 8,06%. Consumer durables contribute 3,23% while Telecommunications, Chemicals and Media each contribute 1,61%. Considering this study is of supply chain SMEs, these proportions make sense.

The definition for SMEs that was used in this paper is an amalgamation of each country's regulation and/or industry-related information across the borders regarding the number of total employees. Small firms have employees fewer than 50 and medium-sized firms have employees fewer than 300 (see Table 1). But in cases where this information is not provided, they will self-select which questionnaire to fill out that is specific to SMEs by the CDPs standards. Of course, this may pose challenges if firms (large) simply prefer to fill out the SME version or SMEs have been permitted by the CDP to fill out the full questionnaire regardless of their size, more desktop research was required. Nonetheless, 93,55% of the population are medium-sized firms and the rest are small; 19,35% of the population are subsidiaries of multinational companies. (see Appendix B on more of these statistics)

3.2.2 Responses against Physical and Transitional Risk

The Task Force on Climate-related Financial Disclosures (TCFD) has identified several categories of climate-related risks and opportunities and "develop recommendations for voluntary climate-related financial disclosures that are consistent, comparable, reliable, clear, and efficient, and provide decision-useful information to lenders, insurers and investors." see TCFD, 2017 and 2019 on the two fundamental dimensions of climate risk and resilience to boost corporates' resiliency that we use to make a case for Sustainable responses to Transition risk and Physical risk as shown in figure 1.



Figure 1. Task Force on Climate-related Financial Disclosure (TCFD) alignment

Source: GRESB, 2020 Resilience Reference Guide

The firms can choose to respond in one or more ways at the same time to each risk. The responses are not mutually exclusive, however, Do Nothing/Deferred response is always mutually exclusive as firms cannot "do nothing" and another form of response at the same time.

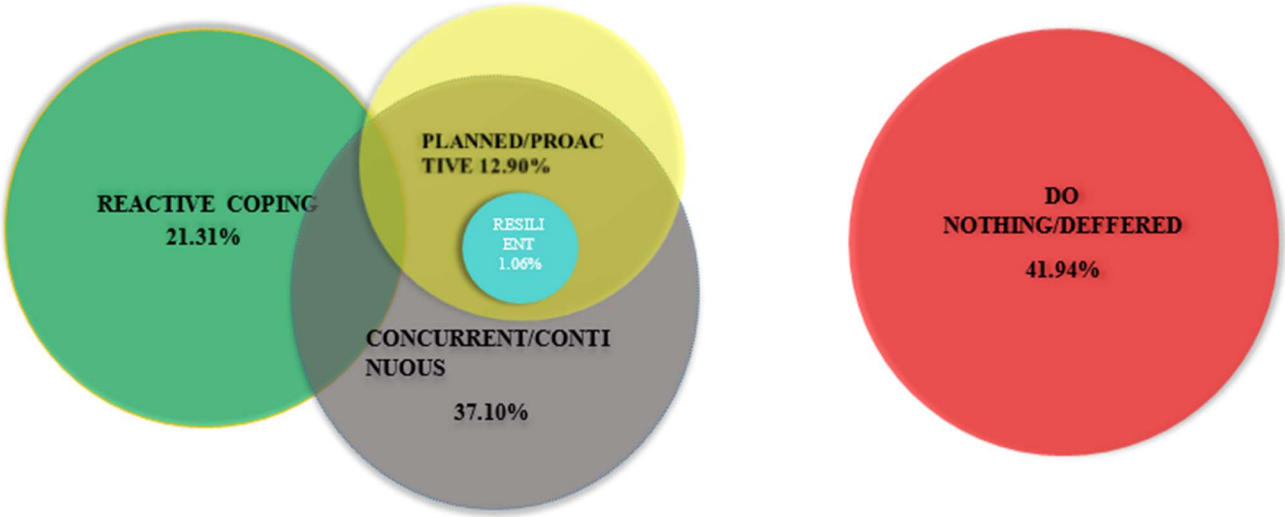
3.2.2.1 Transition Risk

Top Companies in South Africa

Most of the firms are engaging in continuous responses with 42,62% while that are proactive in this regard are at 25,53%. While 32,32% of the total population is reactively responding to the risk. We also observe that less than 9% are doing nothing/defer action but less than 1% of the population is actually resilient in their responses even though 100% of them use continuous responses at the same time. While 52% of the proactive responses are also continuous responses, 31,31% are vice versa.

Supply Chain SMEs in Parts of Africa

The majority of the population under transition risk do nothing with almost 42% of then deferring any action, only 12,90% of the population are proactive and just about 1% is resilient. The second-largest portion of the population (37,10%) is continuously implementing some measures to transition to lower carbon emissions. Although there is a relatively small proportion of firms that engaged in proactive behaviour, 87,50% of those also engage in continuous behaviour, and 25% implement reactive actions. Once again, 100% of those that are resilient are both proactive and continuously adapting.



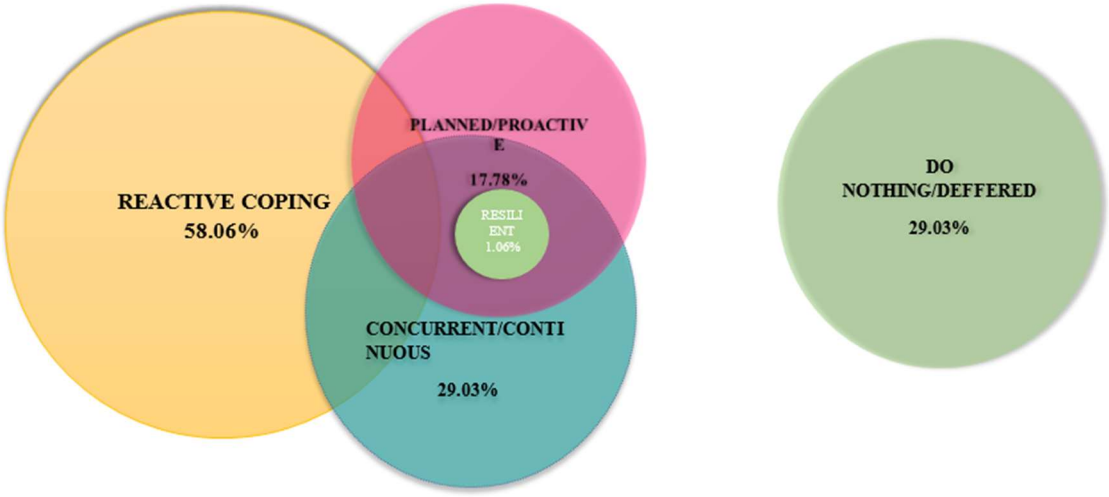
3.2.2.2 Physical Risk

Top Companies in South Africa

The widely implemented course of action is reactive coping measures at 45,4% of the population. Planned/proactive responses are about 36,3% while concurrent/continuous responses are 23,42%, and only 5,39% of these firms do nothing/defer action. Additionally, 29% of proactive responses are also accompanied by continuous responses. And 45% of those who engage in continuous responses also implement proactive responses but only about 4% and 7,7% of reactive behaviour are accompanied by proactive and continuous actions, respectively. And 100% of those that are resilient (only about 1,17% of the total population) also implement proactive and continuous measures against physical risk.

Supply Chain SMEs in Parts of Africa

The majority of the population engages in reactive adaptation (58,06%) after that is a tie between firms who do nothing and those that engage in continuous adaptation behaviour at 29,03%. Only about 1% of the population has resilient responses to physical risk. Furthermore, of the 17,74% of those who engaged in proactive behaviour, 72,73% of them also engage in continuous adaptation responses and 54,55% still engage in reactive coping as well. Whilst 100% of those who are resilient are also implementing proactive and continuous adaptation measures.



3.2.3 Sustainable Responses

To make the econometric model more parsimonious, we create a dichotomous variable for sustainability (as shown in Table 2.1). 1 is attached when the firm engages in one of the following sustainable behaviours (resilient, planned/proactive and/or continuous actions) and 0 is attached when the firms engage in unsustainable behaviours either do nothing/deferred action or reactive coping.

Top Companies in South Africa

For Transition risk; 55,50% of the total population engages in at least one of the 3 sustainable behaviours and 45,50% is either reactively coping or deferring action. For Physical risk;

49,18% are implementing at least one of the sustainable actions and 50,82% are either reactively coping or deferring action.

Supply Chain SMEs in Parts of Africa

Only 38,7% of the population implemented sustainable practices against transitional risk while 61,3% implement unsustainable actions such as reactive coping or deferring their responses altogether. For physical risk, 33,87% of the population engaged in sustainable practices and 66,13% did not do so.

Defining complete sustainability for a firm is definitely more nuisance than this paper may show, but based on the data collected, we can infer that if a company is responding sustainably in both areas of major climate change risk as defined by the TCFD then we could call it "sustainable", and "partially sustainable" if it responds sustainably in only one of the two risks. To conclude, almost 36,77% of top companies are sustainable, 32,08% of them are unsustainable and 31,15% are partially sustainable. For SMEs, we find that only 19,35% of them are sustainable while 46,77% of the entire population is unsustainable while only 33,87% of the total population is partially sustainable. For the rest of the paper, we use the term sustainable without distinguishing whether it is partial or not.

3.3 Conceptual framework

The goal of this section is to study the proposed relationships in the conceptual model in depth to fulfil our second objective. A conceptual framework outlines the link between variables investigated in the study (Sekaran and Bougie 2011; Gunzler and Morris, 2015) and we want to observe the factors that act as predictors for the decision to develop sustainable or unsustainable measures in the face of climate change risks.

3.3.1 Hypothesis development

The relationship between vulnerability, awareness of climate change and the subsequent adoption of sustainable strategies has been studied extensively by (Gasbarro and Pinkse, 2016; Fleming et al., 2015; Dubey et al., 2017). Our dependent variable (Sustainable climate change action) is decoded from the following question: "*Please describe the methods you are using to manage this risk"* (while referring to transition and physical risk separately). Based on our literature review, we have hypothesized the following "cause-effect" relationships stemming from firm-specific characteristics to external characteristics.

3.3.1.1 Firm-specific characteristics (Internal decision-making processes)

Management Structure: (Crick et al., 2018b) showed that there is a positive link between management structures such as seniority of climate champions or length of the planning horizon and business success; and sustainable adaptation action. Thus, we hypothesis that there is a positive relationship between the presence of climate change leaders (top governance) and sustainable responses to climate change risks. Answers to the question "*Where is the highest*

level of direct responsibility for climate change within your organization?" may have a positive correlation with sustainable adaptation behaviour.

The length of the planning horizon is also hypothesized to have a positive link with sustainable climate change behaviour and negatively with unsustainable adaptation behaviour. Responses to "*How far into the future are risks considered?"* and *"Please provide further details on your risk management procedures with regard to climate change risks and opportunities: Frequency of monitoring"* are considered.

(Damert et al., 2018) empirically examine how the perception of climate change-related risks and opportunities affect the likelihood that a supplier's decision to adopt low-carbon supply chain management (LCSCM) practices can be influenced. They found that in most cases, a company's perception of both risks and opportunities is directly and positively related to LCSCM. Thus we are expectant of the same results given our context. Responses to *"Please describe your risks [and opportunities] that are driven by change in [particular] climate parameters: Likelihood*" will be used to fulfil this relationship.

Moreover, the theory of bounded rationality as coined by Hebert Simon in 1957 is a theory that "designates rational choice that takes into account the cognitive limitations of the decision-maker" (Simon, 1990, p.15). Using this theory (Kahan et al., 2011) predicts that as people become more proficient and competent they also become more concerned with climate change and form a perception of climate change risk that is less biased towards underestimation. Hence we hypothesis that capacity, which relates to relevant knowledge and sufficient internal resources, contribute to the lack of 'salience' (perceived importance of climate factors to business success) and that cognitive biases limit behavioural intentions that can reduce the impacts of climate change (Zaval & Cornwell, 2016). (Crick et., 2018b) found that a lack of salience makes it more likely for firms to not engage in sustainable responses. Thus we there is likely a negative link between lack of relevance (and lack of knowledge of climate change issues) and sustainable adaptation.

3.3.1.2 External Characteristics

(Crick et al., 2018b) found a positive relationship between unsustainable adaptation and financial barriers; and a negative relationship between sustainable adaptation and financial barriers. Thus, we hypothesize a negative link between the lack of sufficient financial resources and support for sustainable adaptation. Observe response to *"Main reason for not having a process in place for assessing and managing risks and opportunities from climate change….*" for which factors such as lack of regulation are mentioned and likely have a similar outcome.

As shown by the literature, we hypothesis that impacts from tangible business risks and opportunities and their drivers are positively related to sustainable adaptation. Responses to *"Have you identified any inherent climate change opportunities that have the potential to generate a substantive change in your business operations, revenue or expenditure?"* may give further insights to the constraints.

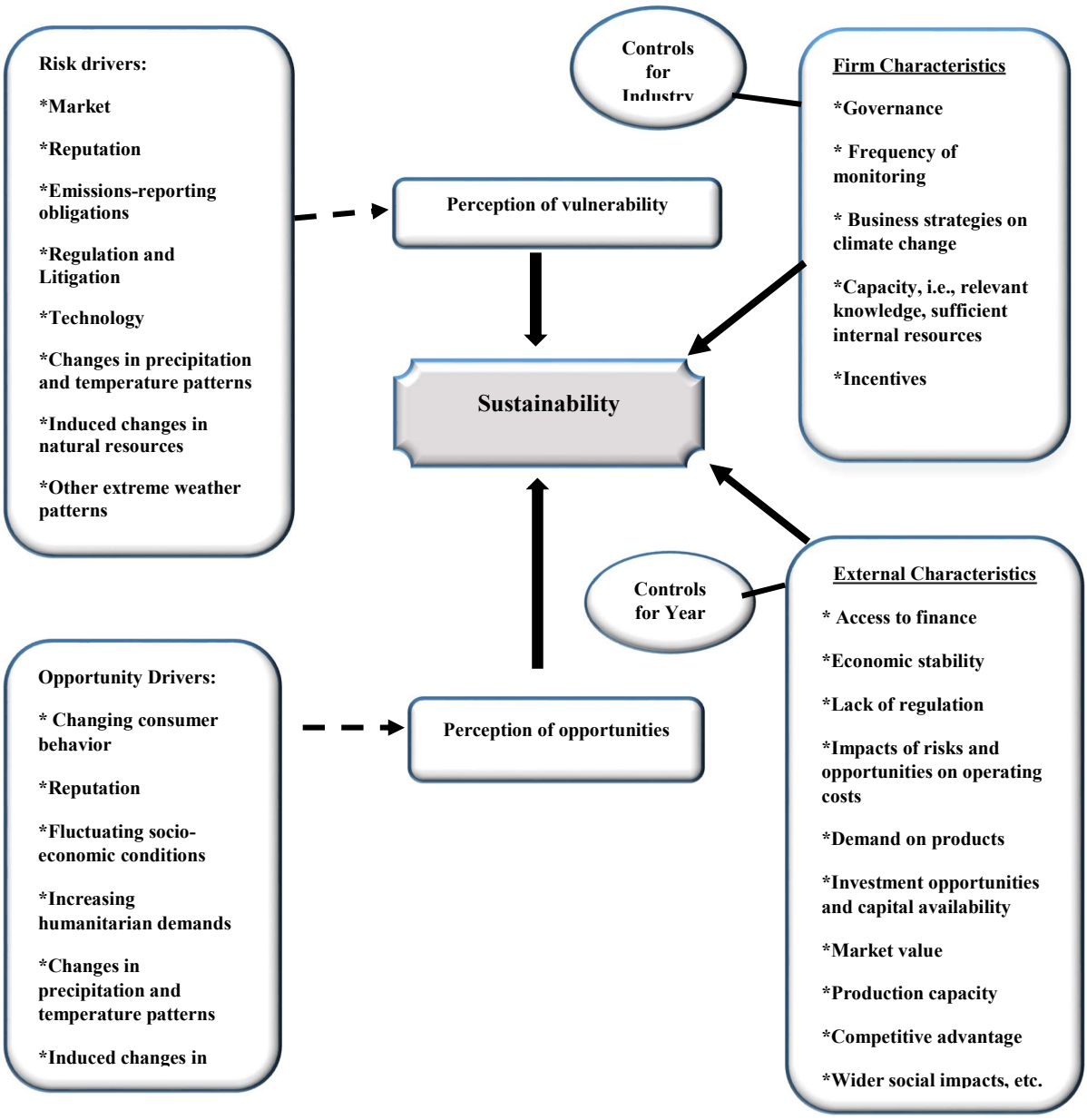


Figure 2. Summary of Proposed Conceptual Framework.

3.4 Econometric specification

We use STATA as the statistical package for the analysis to fulfil our third and final objective using part of the model developed by Crick et al., 2018b.

3.4.1 Justification of Methodology

As explained previously, the paper follows the methodology constructed by (Crick et al, 2018b) because it was one of the first detailed investigation on how the perception of climate change risks and opportunities affect the likelihood of sustainable and unsustainable adaptation practices in the African context on SMEs. The paper employed a bivariate probit model to explore the objectives of the paper. The survey results show that many companies adopt both sustainable and unsustainable adaptation measures at the same time. Therefore, we need a model that consists of a system of equations.

The binary dependent variables S_i^* (defined as 1 if SME i adopts at least one sustainable adaptation measure and 0 if not) and M_i^* (defined as 1 if MNC i adopts at least one sustainable adaptation measure and 0 if not) are determined by two unobserved latent variables in Eq. (1) and Eq. (2);

$$S_i^* = \alpha_S + x_i\beta_S + z_i\gamma_S + \epsilon_{Si} \,. \quad (1)$$

And

$$M_{it}^* = \alpha_M + x_{it}\beta_M + z_{it}\gamma_M + \epsilon_{Mit} \,. \quad (2)$$

Where observations are indexed by *i* for firm and *t* for time. The vectors *x* and *z* represent a set of firm-specific characteristics (which includes the different perceptions) and external environment variables, respectively. The error terms ϵ_{Si} and ϵ_{Mit} are jointly normally distributed with means of 0 and variances of 1.

We had to employ an ordered probit model as it was the most appropriate model to identify the characteristics that contribute to the development of perceptions of vulnerability and opportunities to climate change, because perception, as a dependent variable, is ordered in nature (a likert scale from 1 - 4). The model consists of a system of equations described in Eq. (3) and Eq.(4). The dependent variables S_i^{P*} and M_i^{P*} defines Perception of Vulnerability and Opportunity responses on a 1 - 4 Likert scale for SMEs and MNCs, it assigns a 0 when the perception is unknown (see Table 3). These are determined by two unobserved latent variables shown in Eq. (3) and Eq. (4). The vectors *y* and *v* represent a set of climate change risks/opportunity drivers and impacts of climate change-related risks/opportunities, respectively. The variables μ_i are the cut-off values used for finding the probability that a firm falls into a certain response category used to measure the perception of risks and opportunities, i.e., dividing the range of possible values for the latent variables S_i^{P*} and M_i^{P*}. ε_{Si} and ε_{Mit} are the residual/error terms.

$$S_i^{P*} = \sum \varphi_{S_i{}^P}\, y_i + \sum \tau_{S^P}\, v_i + \varepsilon_{Si}$$

$$S_i^P = 0 \;\; if \;\; S_i^{P*} < \mu_1$$

$$S_i^P = 1 \;\; if \;\; \mu_1 \leq S_i^{P*} < \mu_2$$

$$S_i^P = 2 \;\; if \;\; \mu_2 \leq S_i^{P*} < \mu_3$$

$$S_i^P = 3 \;\; if \;\; \mu_3 \leq S_i^{P*} < \mu_4$$

$$S_i^P = 4 \;\; if \;\; S_i^{P*} \geq \mu_4 \qquad (3)$$

And

$$M_i^{P*} = \sum \varphi_{M_{it}{}^P}\, y_{it} + \sum \tau_{M^P}\, v_{it} + \varepsilon_{Mit}$$

$$M_{it}^P = 0 \;\; if \;\; M_{it}^{P*} < \mu_1$$

$$M_{it}^P = 1 \;\; if \;\; \mu_1 \leq M_{it}^{P*} < \mu_2$$

$$M_{it}^P = 2 \;\; if \;\; \mu_2 \leq M_{it}^{P*} < \mu_3$$

$$M_{it}^P = 3 \;\; if \;\; \mu_3 \leq M_{it}^{P*} < \mu_4$$

$$M_{it}^P = 4 \;\; if \;\; M_{it}^{P*} \geq \mu_4 \qquad (4)$$

4. Results and Discussion

This section presents, the estimation coefficients, their associated marginal effects and the results of the robustness checks. Firstly, we predict the likelihood that Top 100 South African companies (using panel data from 2011-2018) are sustainable under internal and external environments and secondly, do the same thing for SMEs in the supply chain in some African countries (using pooled data from 2013-2017). Then, we discuss the results and give recommendations to regulators, investors and stakeholders and some policy implications.

4.1 Estimation results

The estimated coefficients from the model are reported in the tables below and the appendix section. It is important to note that we have two different datasets, the dataset for the supply chain is flawed with missing information, attrition, and omitted variables, as is common with African data for SMEs. So we use the cmp model with the probit analysis as it provides results that are unbiased in the presence of omitted variables. We use a panel dataset for Top JSE companies in SA which is richer and provides a well-rounded analysis in discovering how the combination of the aforementioned factors (as shown in Figure 2) drive sustainability.

4.1.1 Transition Risk:

Top Companies in South Africa

Presented in Table 4 are the results of three models that determine significant variables that can predict the likelihood that a big firm has a sustainable response to the risk of transitioning to low carbon emissions. Model 2 and Model 3 build from Model 1, but Model 2 includes

impacts of transition risk, while Model 3 additionally includes opportunities from transitioning to low carbon usage. None of the impacts of the opportunities significantly affect the likelihood that a firm would choose sustainable actions. Thus, Model 2 is selected as the main equation of interest. While controlling for industry and year; we find that the Chemicals, Construction, Trading, Retailing, Logistics, Food & Beverages and Healthcare industries are statistically significant and less likely to engage in sustainable behavior to curb transition risk. However, "Frequency" at six-monthly intervals or more, is a positive and significant predictor for sustainable action in response to transition risk. Likewise, "Governance", "Incentives" and "Business strategy" are positive predictors of sustainable actions but they are not statistically significant at any level.

Impacts of transitioning risks such as "Wider Social Disadvantages" significantly reduce the likelihood of sustainable behavior, while a "Decrease in Investment and Capital Availability" and "Demand/Revenue Loss" significantly stimulate the chances of sustainable behavior when responding to transition risks. In this model, we do not have the impacts of low carbon emissions opportunities because they were insignificant predictors of sustainable action. However, they are in the model for predicting "Perception of Opportunities" because it is an affirmative and significant predictor of the likelihood of sustainable action, when the perception is viewed as "more likely than not" and "virtually certain". Lastly, "Perception of vulnerability" is also statistically significant in improving the likelihood of a sustainable response, when it is viewed as "more likely than not" and "virtually certain" as well.

Table 4: TRANSITION RISK SUSTAINABILITY

	TR_SUS1	TR_SUS2+	TR_SUS3
	b/se	b/se	b/se
TR_sustainable			
CHEMICALS	-3.152****	-3.050****	-3.444****
	(0.59)	(0.50)	(0.78)
TELECOM	-0.395	-0.313	-0.543
	(1.03)	(1.01)	(1.09)
PHARMACEUTICALS	0.228	0.294	0.062
	(0.46)	(0.41)	(0.61)
CONSTRUCTION	-1.922***	-1.853***	-2.076***
	(0.67)	(0.63)	(0.78)
MINING	-0.739	-0.675	-0.968

	(0.60)	(0.58)	(0.77)
FINANCE	-0.702	-0.636	-0.954
	(0.55)	(0.51)	(0.65)
TRADING	-0.825*	-0.772	-0.917
	(0.44)	(0.41)	(0.69)
RETAILING	-1.581*	-1.502*	-1.609*
	(0.83)	(0.80)	(0.83)
FOOD AND BEVERAGE	-1.520***	-1.442***	-1.615**
	(0.55)	(0.52)	(0.70)
REALESTATE	-0.079	-0.033	0.053
	(0.66)	(0.62)	(0.79)
LOGISTICS	-2.721**	-2.643**	-2.890**
	(1.29)	(1.27)	(1.40)
HEALTH CARE	-1.170*	-1.098*	-1.301*
	(0.63)	(0.60)	(0.72)
CONTAINERS & PACKAGING	-0.562	-0.495	-0.578
	(0.43)	(0.39)	(0.51)
YEAR	0.096	0.095	0.094
	(0.09)	(0.09)	(0.10)
LEVEL OF GOVERNANCE~1	0.480	0.480	0.345
	(0.66)	(0.66)	(0.65)
LEVEL OF GOVERNANCE~2	0.160	0.159	0.054
	(0.79)	(0.79)	(0.78)
INCENTIVES	0.507	0.501	0.546
	(0.41)	(0.42)	(0.43)
CLIMATE CHANGE INTEGRATION	0.351	0.350	0.353
	(0.70)	(0.70)	(0.63)
FREQUENCY OF MONITORING	0.341***	0.341***	0.356***
	(0.12)	(0.12)	(0.12)
TRANS_RISK_LIKELIH~2	0.995	1.258	1.415
	(0.90)	(0.94)	(0.95)
TRANS_RISK_LIKELIH~3	1.243	1.529*	1.601*
	(0.81)	(0.87)	(0.88)

TRANS_RISK_LIKELIH~4	1.377	1.673*	1.777*
	(0.88)	(0.91)	(0.91)
TRANS_OPP_LIKELIHO~0	0.000	0.000	0.000
	(.)	(.)	(.)
TRANS_OPP_LIKELIHO~1	0.074	0.161	0.187
	(0.54)	(0.49)	(0.53)
TRANS_OPP_LIKELIHO~2	1.018	1.049*	1.196*
	(0.63)	(0.63)	(0.65)
TRANS_OPP_LIKELIHO~3	1.182***	1.204***	1.413***
	(0.42)	(0.42)	(0.50)
TRANS_OPP_LIKELIHO~4	0.670*	0.683*	0.893*
	(0.39)	(0.39)	(0.47)
TR_WIDER SOCIALDISADV	-0.629**	-0.631**	-0.756**
	(0.30)	(0.30)	(0.33)
TR_INCREASED OPERATCOSTS	0.314		
	(0.65)		
TR_INCREASED CAPITALCOSTS	-0.391	-0.398	-0.424
	(0.29)	(0.29)	(0.30)
TR_REPUTATION DAMAGE	0.222	0.225	0.404
	(0.60)	(0.60)	(0.71)
TR_DISRUPT PRODUCTION	-0.155	-0.145	-0.106
	(0.31)	(0.31)	(0.33)
TR_REVENUE LOSS	0.697**	0.684**	0.692**
	(0.32)	(0.32)	(0.31)
TR_DECREASED STOCKPRICE	0.099	0.097	0.220
	(0.26)	(0.26)	(0.28)
TR_DECREASED INVESTMENTOPP	1.739***	1.707***	1.721***
	(0.53)	(0.52)	(0.51)
TR_OTHER IMPACTS	-0.867**	-0.856**	-0.867**
	(0.38)	(0.38)	(0.38)
TO_WIDER SOCIAL BENEFIT			0.126
			(0.36)
TO_REDUCED OPERATING COSTS			-0.138

			(0.37)
TO_REDUCED CAPITAL COSTS			-0.126
			(1.03)
TO_PREMIUM PRICE OPP			-0.527
			(0.57)
TO_NEW PRODUCTS			0.147
			(0.34)
TO_INVESTMENT OPP			0.031
			(0.48)
TO_INCREASED PRODUCTION CAPACITY			-0.286
			(1.30)
TO_INCREASED STOCK PRICE			0.033
			(0.39)
TO_COMPETITE ADVANTAGE			-0.519
			(0.68)
TO_INCREASED EXISTING DEMAND			-0.342
			(0.29)
TO_OTHER IMPACTS			-0.085
			(0.46)
CONSTANT	-196.224	-193.855	-191.795
	(179.66)	(179.10)	(192.17)
R-sqr			
dfres			
BIC	526.7	520.9	583.3

* p<0.1, ** p<0.05, *** p<0.01, **** p<0.001

Table 5 shows three models that have been developed to characterize the link between transition risk drivers and the perception of vulnerability, these results indirectly implicate the model for sustainable responses in the same direction. Model 3 has been chosen and has risk drivers and increased operating costs as the only covariances that explain the different levels of perception of vulnerability.

Emissions reporting obligations (ERO) is a significant driver for positively affecting the perception of vulnerability. Likewise, Regulation and Litigation are also statistically significant at a 1% level. While costs to transition to lower emissions technology reduce the perception of vulnerability at a 0.1% level thus consequently reducing the likelihood of sustainable responses. However, market risk and reputational risk do not have a significant impact on the perception of vulnerability. Although reputational risk loses significance when included in the model with other covariances, it is quite significant when modelled against the perception of vulnerability alone.

Table 5: PERCEPTION OF VULNERABILITY TO TRANSITION RISK

	TR_PERCEP1	TR_PERCEP2	TR_PERCEP3
	b/se	b/se	b/se
Likelihood_of_Trans_Risk			
Trans_Risk_Market	-0.136	-0.193	-0.180
	(0.17)	(0.18)	(0.16)
TR_Emissions Reporting	0.329*	0.260	0.323*
	(0.18)	(0.19)	(0.18)
TR_Reputation	0.112	0.194	-0.068
	(0.25)	(0.25)	(0.21)
TR_Regulation & Law	2.280***		2.243***
	(0.76)		(0.81)
TR_Technology & Other	-0.722****	-0.812****	-0.667****
	(0.24)	(0.26)	(0.20)
Trans_Risk_WIDER S~N	-0.274	-0.249	
	(0.26)	(0.24)	
TR_INCREASED OPERATCOSTS	1.550**	2.991****	1.572**
	(0.61)	(0.50)	(0.67)
Trans_Risk_INCREAS~S	0.230	0.416	
	(0.23)	(0.27)	
Trans_Risk_NEGATIV~	-0.131	-0.298	

	(0.37)	(0.34)	
Trans_Risk_DISRUPT~T	0.177	0.112	
	(0.25)	(0.24)	
Trans_Risk_DECREAS~E	-0.107	0.126	
	(0.24)	(0.25)	
Trans_Risk_DECREAS~U	-0.320	-0.235	
	(0.21)	(0.19)	
Trans_Risk_DECREAS~	-0.141	0.078	
	(0.32)	(0.32)	
Trans_Risk_OTHER I~S	-0.306	-0.244	
R-sqr			
dfres			
BIC	788.2	807.9	747.0

* p<0.1, ** p<0.05, *** p<0.01, **** p<0.001

In Table 6, Model 3 is the chosen specification and it shows that market sub-drivers for low carbon emissions opportunities such as changing consumer behavior; Fluctuating socio-economic conditions and increasing humanitarian demands positively affect the perception of opportunities. The same way that Reputation Gains, Increased Demand for Existing Products, Competitive Advantage and Increased Production Capacity positively and significantly affect the perception of opportunities. However, we also find that Wider Social Benefits and Increased Market Valuation are statistically significant predictors that reduce the perception of opportunities and indirectly reduce the chances of sustainable responses as well.

Table 6: PERCEPTION OF TRANSITION OPPORTUNITIES

	TO_PERCEP1	TO_PERCEP2	TO_PERCEP3+
	b/se	b/se	b/se
Likelihood_of_Opp_			
Trans_Opp_Changing~a	0.939****	0.942****	0.911***

	(0.28)	(0.28)	(0.33)
Trans_Opp_REPUTATION	0.919***	0.922***	1.284****
	(0.28)	(0.28)	(0.31)
Trans_Opp_Induced ~m	0.154		
	(0.35)		
Trans_Opp_Fluctuat~n	1.600****	1.649****	1.628****
	(0.39)	(0.38)	(0.44)
Trans_Opp_Increasi~a	1.370**	1.408***	1.518***
	(0.54)	(0.54)	(0.58)
Trans_Opp_Other Dr~s	0.639**	0.647**	0.731**
	(0.29)	(0.29)	(0.33)
Trans_Opp_Wider So~t			-0.568*
			(0.30)
Trans_Opp_Reduced ~o			0.151
			(0.32)
Trans_Opp_Reduced ~s			-0.240
			(0.35)
Trans_Opp_Premium ~n			0.774
			(0.65)
Trans_Opp_New prod~			0.557*
			(0.30)
Trans_Opp_Investme~i			0.326
			(0.52)
Trans_Opp_Increase~c			1.390****
			(0.39)
Trans_Opp_Increase~			-0.552**
			(0.28)
Trans_Opp_Competit~e			1.171*
			(0.70)
Trans_Opp_Increase~e			-0.055
			(0.33)
Trans_Opp_Other Im~s			-0.599
			(0.53)

R-sqr			
dfres			
BIC	825.1	819.3	848.1

* p<0.1, ** p<0.05, *** p<0.01, **** p<0.001

Supply Chain SMEs in Parts of Africa

Deriving from Table 7, the chosen model is the simultaneous equation for sustainable action and the perception of climate change opportunities under transition risk in Model 1. Firms that are Nigerian and Kenyan based are shown to be statistically and significantly more likely to engage in sustainable behavior in regards to transition risk. Being located in the other countries studied in this paper is statistically insignificant in determining the likelihood of sustainable responses by the firms (except for South Africa which was omitted due to collinearity but remains as part of the study). The only industry that is statistically significant in explaining the likelihood of sustainable responses is the Logistics industry (for Air). But this industry makes it less likely for those firms to behave sustainably in response to transition risk.

"Perception of vulnerability" is a statistically significant predictor of sustainable responses when perception is viewed as "more likely than not". In an alternative model specification (Model 3) we find qualitatively similar results for Perception of Vulnerability which proves robustness. But, the Perception of Opportunities from transitioning to low carbon emissions is not a statistically significant predictor of sustainable responses by SMEs in the supply chain. In fact, Model 3 suggests that the Perception of Opportunities from 'going green' reduces the chances that an SME would undertake sustainable actions in response to transition risk. Nonetheless, the impacts of "greening" opportunities such as Increasing Demand for Existing Products (but not new products) and Reduced Operating Costs are significant drivers for Perception of Opportunities, but these impacts do not affect the likelihood of sustainable actions neither directly (as shown in Model 2), nor indirectly via the perception of climate change opportunities as shown in Model 1.

Moreover, as hypothesized in the conceptual framework, "Lack of relevance" of the risk of transitioning to low carbon emissions (which was correlated to the now omitted variables "Lack of knowledge" and "Lack of salience") would have had a negative impact on the likelihood of sustainable actions. But the variable is not statistically significant, just as "Lack of regulation" is not a significant predictor of sustainable responses to transition risk.

Table 7: Transition Risk Models

	Model 1	Model 2	Model 3+
	b/se[1]	b/se	b/se
EQUATION 1:TR_sustainable			
South Africa	0.000	0.000	0.000
	(.)	(.)	(.)
Nigeria	1.869	1.625	2.727***
	(1.57)	(1.21)	(0.74)
Kenya	2.057	1.459	2.801*
	(1.56)	(1.45)	(1.10)
Egypt	1.218	0.902	0.467
	(1.74)	(1.13)	(2.16)
Ghana	1.672	-0.125	2.512
	(1.61)	(1.23)	(1.36)
Zimbabwe	0.000	0.000	0.000
	(.)	(.)	(.)
Cameroon	0.000	0.000	0.000
	(.)	(.)	(.)
Containers&Packaging	0.000	0.000	0.000
	(.)	(.)	(.)
Air	0.000	-0.898	0.000
	(.)	(1.23)	(.)
Trading	0.000	-1.452	0.000
	(.)	(1.08)	(.)
Agriculture	0.000	0.000	0.000
	(.)	(.)	(.)
Ground	0.523	0.682	1.320
	(1.15)	(1.20)	(1.26)
Food	0.218	0.021	0.283
	(0.90)	(0.97)	(0.88)
Media	0.000	0.000	0.000
	(.)	(.)	(.)

[1] All Standard Errors Are Robust

Durables	0.000	0.000	0.000
	(.)	(.)	(.)
TeleComms	0.000	0.000	0.000
	(1.26)	(1.16)	(1.12)
TR_PERCEPTION OF V~0	0.000		0.000
	(.)		(.)
TR_PERCEPTION OF V~1	-0.857		-1.292
	(0.95)		(1.55)
TR_PERCEPTION OF V~2	2.395		4.804***
	(1.46)		(1.43)
TR_PERCEPTION OF V~3	3.456*		6.055***
	(1.53)		(1.11)
TR_PERCEPTION OF V~4	0.463		3.177
	(1.35)		(.)
PERCEPTION ON CC O~0	0.000		0.000
	(.)		(.)
PERCEPTION ON CC O~2	-2.479		-3.833
	(1.83)		(.)
PERCEPTION ON CC O~3	-1.927		-3.702***
	(1.25)		(1.11)
PERCEPTION ON CC O~4	-0.304		-1.278
	(.)		(0.95)
LACK OF RELEVANCE	-0.041	-0.689	0.088
	(0.90)	(0.77)	(1.10)
LACK OF REGULATION	0.373	-1.338	1.231
	(0.82)	(1.01)	(0.86)
INCREASED DEMAND F~R		-0.133	
		(0.81)	
COMPETITIVE ADVANT~E		0.000	
		(.)	
REDUCED OPERATIONA~S		-1.667	
		(1.19)	
REDUCED DEMAND		0.454	

		(0.84)	
INCREASED OPERATIO~S		0.641	
		(0.86)	
DISRUPTION IN PRDU~Y		-0.347	
		(0.87)	
constant	-2.687	-0.764	-4.678***
	(1.57)	(0.88)	(1.17)
EQUATION 2: PERCEPTION ON CC OPPOTUNITIES			
TR_sustainable	0.456	0.412	
	(0.77)	(1.25)	
INCREASED DEMAND F~R	1.142*	1.072*	
	(0.47)	(0.54)	
COMPETITIVE ADVANT~E	1.430	1.283	
	(0.95)	(1.01)	
REDUCED OPERATIONA~S	1.495**	1.414*	
	(0.57)	(0.62)	
EQUATION 2:TR_PERCEPTION OF V~Y			
REDUCED DEMAND			0.847
			(0.47)
SOCIAL DISADVANTAGE			0.812
			(0.58)
INCREASED OPERATIO~S			0.577
			(0.46)
R-sqr			
dfres			
BIC	259.4	283.3	304.5

* p<0.05, ** p<0.01, *** p<0.001

Lastly, Table 8 indicates that impacts such as Reduced Demand for Existing Products are a positive and statistically significant driver for "Perception of vulnerability" thus, indirectly affecting the likelihood of sustainable responses positively as well. All the other hypothesized risk drivers do not bear any statistical significance in predicting the perception of vulnerability.

Table 8: MODELS ON PERCEPTION OF VULNERABILITY

	PHYSICAL R~K	TRANSITION~K+
	b/se	b/se
REDUCED DEMAND	1.012	0.949**
	(0.80)	(0.35)
SOCIAL DISADVANTAGE	0.269	0.543
	(1.07)	(0.46)
INCREASED OPERATIO~S	0.618	0.525
	(0.77)	(0.36)
DISRUPTION IN PRDU~Y	0.475	0.492
	(0.89)	(0.41)
R-sqr		
dfres		
BIC	208.3	195.7

4.1.1.1 Marginal Effects:

Computing margins show the magnitude and direction of the changes in probability to the dependent variable caused by a unit change in the predictor, this enables us to observe the average partial effects of the predictors when all other variables are held constant. Table 9 displays results for top companies and SMEs in predicting sustainability.

Firstly, all the statistically significant industries (chemicals, food & beverages, logistics, retailing, trading, construction and healthcare) are less likely to have sustainable responses (actions that are either proactive and/or continuous). The highest probability to adopt unsustainable behavior is 59,7% by "Chemicals" and 53% by "Logistics" (Air and Ground).

Meaning that more than half of the time, top companies in Chemicals and Logistics are either reactively coping or deferring any action towards mitigating transition risk. Top companies show that higher frequency in monitoring climate change from annually to six-monthly increases the likelihood of sustainable action by 6,89%. The impacts of transitioning to low carbon such as; wider social disadvantages reduce the likelihood that a firm is sustainable in the future by 12% while "Other Impacts" such as write-offs, asset impairment and early retirement of existing assets due to technology changes decrease the likelihood for sustainable action by 17%. However, a decrease in investments and capital availability increases the likelihood of a sustainable response by double this probability (35%) while revenue losses increase by only 13,8%. Moreover, when "Perception of vulnerability" to transition risk is "more likely than not", the likelihood of sustainable behavior is up by 30%-33,8%. While the probability of sustainable responses by top companies increases by 25% when "Perception of opportunities" is "more likely than not".

Secondly, we also observe from Table 9 that Nigerian and Kenyan SMEs are 33% and 59% more likely to perform sustainable actions when responding to transition risk, respectively. While the Logistics industry (Air travel) makes it 41,1% less likely for the SMEs to engage in sustainable action towards low carbon emissions. Further, when "Perception of vulnerability" to transition risk is "more likely than not", this improves the likelihood of sustainable actions by SMEs in the supply chain to 63,4%.

Table 9. Estimation Results for Marginal Effects of Predictors against Transition Risk

Top Companies in SA	SMEs in Parts of Africa	
CHEMICALS	-0.597****	_
(-7.86)		
TELECOM	-0.0527	_
(-0.29)		
PHARMACEUTICALS	0.0432	_
(0.72)		
CONSTRUCTION	-0.375***	_
(-3.16)		
MINING	-0.121	_
(-1.15)		
FINANCE	-0.113	_

(-1.24)		
TRADING	-0.141**	-0.353
(-2.13)	(-1.38)	
RETAILING	-0.298*	_
(-1.92)		
FOOD AND BEVERAGE	-0.285***	-0.165
(-2.81)	(-0.60)	
REALESTATE	-0.00517	_
(-0.05)		
LOGISTICS (A&G)	-0.532**	_
(-2.50)		
LOGISTICS: AIR	_	-0.411*
(-1.75)		
LOGISTICS: GROUND	_	0.263
(1.09)		
HEALTH CARE	-0.209*	_
(-1.83)		
CONTAINERS & PACKAGING	-0.0861	_
(-1.40)		
NIGERIA	_	0.335**
(2.26)		
KENYA	_	0.537****
(3.51)		
EGYPT	_	0.185
(1.01)		
GHANA	_	0.059
(0.39)		
Year	0.0191	_
(1.09)		

1.GOVERNANCE	0.0988	_
(0.72)		
2.GOVERNANCE	0.0329	_
(0.20)		
INCENTIVES	0.101	_
(1.21)		
BUSINESS STRATEGY	0.0707	_
(0.50)		
1.FREQUENCY	0.0689***	_
(2.99)		
2.FREQUENCY	0.0689***	_
(2.99)		
1.Perception of Vulnerability	0	-0.0536
(.)	(-0.32)	
2.Perception of Vulnerability	0.251	0.390
(1.47)	(1.67)	
3.Perception of Vulnerability	0.308**	0.635****
(2.06)	(5.68)	
4.Perception of Vulnerability	0.338**	0.175
(2.10)	(0.51)	
1.Perception of Opportunities	0.0326	_
(0.33)		
2.Perception of Opportunities	0.216*	_
(1.76)		
3.Perception of Opportunities	0.247***	_
(3.02)		
4.Perception of Opportunities	0.141*	_
(1.79)		
Wider Social Disadvantage	-0.127**	_

(-2.13)		
Increased Capital Costs	-0.0802	_
(-1.38)		
Negative Brand Image	0.0455	_
(0.37)		
Disruption of Production	-0.0293	-0.141
(-0.46)	(-0.64)	
Decreased Demand/Revenue	0.138**	0.0129
(2.27)	(0.06)	
Decreased Market Value	0.0196	_
(0.37)		
Decreased Investment	0.345***	_
(3.24)		
Other Risk Impacts	-0.173**	_
(-2.31)		
Increased demand for existing-products	_	-0.135
		(-0.56)
Lack of Relevance	_	0.0915
(0.37)		
Lack of Regulation	_	-0.414
(-1.32)		
N	404	62
t statistics in parentheses		
*p<0.1, ** p<0.05, *** p<0.01, **** p<0.001		

Table 10 shows the results for latent variables “Perception of vulnerability” and “Perception of opportunities” for top companies only. To begin with, when the perception of vulnerability is “more likely than not” (at outcome 3), Emissions Reporting Obligations to improve the perception of vulnerability by 9,5%, while Increased Operating Costs improve this likelihood by 46,5%. Compared to Increasing Operating Costs, Regulation and Litigation has an even

larger average partial effect, increasing this likelihood by over 66%. Next, when the perception of low carbon opportunities is "virtually certain" (at outcome 4); Changing Consumer Behavior positively shifts the perception of opportunities by 16,6%; Reputational Gains do so by 23%; Fluctuating Socio-Economic Conditions by 30%, and Increasing Humanitarian Demands by 27%. Increased Production Capacity and Competitive Advantages also improve this perception by 25% and 21% respectively, whereas, Wider Social Benefits and Increased Market Valuation reduce the perception of opportunities by 10% in both cases.

Table 10. Average Partial effects of Perception of vulnerability (TR) and Perception of opportunities (TO) pertaining to Transition Risk as derived from the chosen regression models for Top companies in SA.

Variable {dy/dx}	(Outcome 1)	(Outcome 2)	(Outcome 3)	(Outcome 4)
TR_Market	0.000794	0.00798	0.0380	-0.0533
	(0.92)	(1.04)	(1.14)	(-1.14)
TR_ERO	-0.00142	-0.0143	-0.0681*	0.0954*
	(-1.04)	(-1.34)	(-1.82)	(1.79)
TR_Reputation	0.000300	0.00301	0.0144	-0.0201
	(0.32)	(0.35)	(0.33)	(-0.33)
TR_Policy&Law	-0.00989	-0.0993**	-0.474**	0.663***
	(-1.29)	(-2.16)	(-2.52)	(2.80)
TR_OtherDrivers	0.00294	0.0295**	0.141****	-0.197****
	(1.20)	(1.99)	(3.55)	(-3.50)
TR_IOC	-0.00693	-0.0696*	-0.332**	0.465**
	(-1.16)	(-1.81)	(-2.41)	(2.40)
TO_CCB	-0.00398	-0.0246**	-0.0420**	0.166***
	(-0.92)	(-2.29)	(-2.01)	(2.83)
TO_Reputation	-0.00561	-0.0347***	-0.0592**	0.234****
	(-0.98)	(-2.88)	(-2.30)	(4.24)
TO_FSEC	-0.00711	-0.0440**	-0.0750***	0.297****
	(-0.96)	(-2.45)	(-2.80)	(4.16)

TO_IHD	-0.00663	-0.0410**	-0.0699*	0.277***
	(-1.00)	(-2.54)	(-1.79)	(2.64)
TO_OtherDrivers	-0.00320	-0.0198**	-0.0337*	0.133**
	(-0.93)	(-2.09)	(-1.75)	(2.24)
TO_WSB	0.00248	0.0154	0.0262*	-0.104**
	(0.97)	(1.63)	(1.71)	(-1.97)
TO_ROC	-0.000661	-0.00409	-0.00697	0.0276
	(-0.49)	(-0.48)	(-0.46)	(0.47)
TO_RCC	0.00105	0.00647	0.0110	-0.0437
	(0.55)	(0.69)	(0.65)	(-0.68)
TO_PPO	-0.00338	-0.0209	-0.0356	0.141
	(-0.77)	(-1.11)	(-1.03)	(1.16)
TO_IDNP	-0.00243	-0.0151*	-0.0257	0.102
	(-0.77)	(-1.79)	(-1.51)	(1.91)
TO_IINV	-0.00143	-0.00882	-0.0150	0.0595
	(-0.49)	(-0.62)	(-0.63)	(0.63)
TO_PIC	-0.00607	-0.0376**	-0.0640**	0.253****
	(-0.96)	(-2.46)	(-2.29)	(3.60)
TO_IMV	0.00241	0.0149*	0.0254	-0.101**
	(0.96)	(1.82)	(1.62)	(-1.99)
TO_CA	-0.00512	-0.0316	-0.0540	0.214*
	(-1.30)	(-1.45)	(-1.34)	(1.68)
TO_IDEP	0.000239	0.00148	0.00252	-0.00996
	(0.16)	(0.17)	(0.16)	(-0.17)
TO_OtherIm~s	0.00262	0.0162	0.0276	-0.
	(0.71)	(1.09)	(1.02)	(-1.11)
N	427	427	427	427

* p<0.1, ** p<0.05, *** p<0.01, **** p<0.001

Lastly, Table 11 shows us the results of the average partial effects of "Perception of vulnerability" only since the latent variable "Perception of opportunities" pertaining to transition risk is statistically insignificant in predicting sustainable responses from SMEs. We do find that when SMEs experience decreased demand/revenue, the perception for vulnerability increases by 10,9% thus positively affecting sustainable responses by some small margin.

Table 11. Average Partial effects of Perception of vulnerability pertaining to Transition Risk as derived from the chosen regression model for SMEs in some parts of Africa.

{dy/dx}	Outcome (1)	Outcome (2)	Outcome (3)	Outcome (4)
TR_DRL	-0.00770	0.0315	0.148**	0.109*
	(-0.50)	(1.68)	(2.64)	(2.29)
TR_WSD	-0.00441	0.0180	0.0848	0.0621
	(-0.45)	(1.06)	(1.18)	(1.13)
TR_IOC	-0.00426	0.0174	0.0819	0.0600
	(-0.48)	(1.31)	(1.45)	(1.37)
TR_DOP	-0.00399	0.0164	0.0768	0.0563
	(-0.47)	(1.01)	(1.19)	(1.18)
N	62	62	62	62

t statistics in parentheses

* p<0.05, ** p<0.01, *** p<0.001

4.1.2 Physical Risk:

Top Companies in South Africa

Table 12 shows the three models for physical risk, once again for robustness. Model 1 and Model 2 demonstrate that none of the impacts of risks and the perception of climate change opportunities bear any significance. Model 3 replaces the variable for the perception of

opportunities with its mediating variables such as opportunity drivers and impacts. We can directly observe the variable's effectiveness in driving sustainable action without being concerned with multi-collinearity, so Model 3 is chosen.

After controlling for firm industry and year, we observe that firms in industries such as Mining, Oil & Gas, Real Estate and Trading are statistically and significantly more likely to behave in a sustainable manner rather than some industries such as Retailing and Logistics who are more likely to respond in an unsustainable manner. The following are some of the other findings; Frequency of monitoring both annually and six-monthly is a significant and affirmative predictor for sustainable action. Opportunity drivers from "Changes in Precipitation" is statistically significant in making it less likely for the firms that benefit from changes in precipitation patterns to response in a sustainable manner to combat this physical risk. Similarly, other drivers such as "Changes in Temperature" and "Induced Natural Resources" also reduce the likelihood of shifting to more responses against the physical risk, but not significantly so. Whereas impacts from these benefits such as reduced operating costs, wider social benefits and increased demand in new products/business services significantly improve the chances that the firms perform sustainably in response to physical risk. "Perception of vulnerability" has a positive and statistically significant partial effect on sustainable action at all levels of perception i.e., "unlikely" (outcome=1), "about as likely as not" (outcome=2), "more likely than not" (outcome=3) and "virtually certain" (outcome=4).

Table 12: PHYSICAL RISK SUSTAINABILITY

	Model 1	Model 2	Model 3+
	b/se	b/se	b/se
PR_sustainable			
CHEMICALS	-1.378***	-1.341	-1.298
	(0.40)	(0.92)	(1.65)
TELECOM	0.997	1.357	1.552
	(1.49)	(1.64)	(1.70)
PHARMACEUTICALS	0.000	0.000	0.000
	(.)	(.)	(.)
CONSTRUCTION	-1.382	-1.000	-1.027
	(0.91)	(1.05)	(1.39)
MINING	2.882*	3.134*	4.463**
	(1.33)	(1.42)	(1.73)

FINANCE	-0.806	-0.725	-1.632
	(0.73)	(0.82)	(1.34)
TRADING	1.747**	1.567	5.601**
	(0.67)	(0.99)	(1.96)
RETAILING	-0.857	-0.903	-2.529
	(0.85)	(1.08)	(1.71)
FOOD & BEVERAGES	-0.384	-0.151	0.137
	(0.86)	(0.91)	(0.95)
REALESTATE	1.460*	1.496*	2.416*
	(0.58)	(0.63)	(0.94)
LOGISTICS	-2.620**	-2.640**	-4.559*
	(0.98)	(0.88)	(1.94)
HEALTH CARE	0.027	0.167	0.526
	(0.90)	(0.95)	(0.85)
CONTAINERS & PACKAGING	0.852	1.237	0.832
	(0.72)	(0.99)	(1.02)
ELECTRICITY	0.184	0.299	0.646
	(0.61)	(0.69)	(1.59)
FOREST	0.000	0.000	0.000
	(.)	(.)	(.)
OIL & GAS	0.850	1.142	1.696*
	(0.46)	(0.64)	(0.84)
HOTELS & LEISURE	0.000	0.000	0.000
	(.)	(.)	(.)
Level of Govern~0	0.000	0.000	0.000
	(.)	(.)	(.)
Level of Govern~1	-2.408	-2.245	-2.506
	(1.28)	(1.31)	(2.62)
Level of Govern~2	-2.421	-2.265	-3.628
	(1.33)	(1.36)	(2.77)
Incentives	1.012*	1.031*	0.776
	(0.48)	(0.52)	(0.54)
Climate change integration	0.577	0.540	0.980

	(0.51)	(0.54)	(0.61)
How far into the f~k	-0.011	-0.012	0.227
	(0.19)	(0.19)	(0.23)
Frequency of monit~g	0.937***	0.982***	
	(0.17)	(0.16)	
Phys_risk_Likeliho~0	0.000	0.000	0.000
	(.)	(.)	(.)
Phys_risk_Likeliho~1	5.070***	5.573***	8.668**
	(1.44)	(1.67)	(3.21)
Phys_risk_Likeliho~2	2.602*	2.568	5.237*
	(1.24)	(1.43)	(2.62)
Phys_risk_Likeliho~3	2.653*	2.743*	5.518*
	(1.14)	(1.30)	(2.59)
Phys_risk_Likeliho~4	2.725*	2.707*	5.138*
	(1.22)	(1.36)	(2.48)
Phys_Opp_Likelihoo~0	0.000	0.000	
	(.)	(.)	
Phys_Opp_Likelihoo~1	0.000	0.000	
	(.)	(.)	
Phys_Opp_Likelihoo~2	0.532	0.387	
	(0.75)	(0.76)	
Phys_Opp_Likelihoo~3	0.784	0.851	
	(0.64)	(0.66)	
Phys_Opp_Likelihoo~4	0.264	0.201	
	(0.73)	(0.74)	
Phys_risk_WIDER SO~T		0.521	
		(0.88)	
Phys_risk_INCREASE~		0.106	
		(0.41)	
Phys_risk_INCREASE~T		0.231	
		(0.49)	
Phys_risk_DISRUPTI~I		-0.409	
		(0.41)	

Phys_risk_REDUCED ~U	0.542	
	(0.61)	
Phys_risk_OTHER IM~S	-0.493	
	(0.86)	
Frequency of monit~0		0.000
		(.)
Frequency of monit~1		0.000
		(.)
Frequency of monit~2		3.850***
		(0.89)
Frequency of monit~3		3.595***
		(0.75)
PO_Change precipitation		-2.100**
		(0.69)
PO_ Change Temperature		-0.204
		(0.72)
PO_Induced Natural Resources		0.019
		(0.66)
PO_other drivers		-0.246
		(0.64)
PO_WIDER SOCIAL BENEFIT		2.133**
		(0.80)
PO_REDUCED OPERAT COSTS		1.482*
		(0.61)
PO_REDUCED CAPITAL COSTS		-1.083
		(0.68)
PO_PREIMUM PRICE OPP		-1.860
		(1.38)
PO_INCREASED PRODUCTION CAPACITY		0.590
		(1.15)
PO_INCREASED DEMAND FOR EXISTING PRODUCTS		-0.016
		(0.53)
PO_INCREASED DEMAND FOR NEW PRODUCTS		1.767*

			(0.87)
PO_INCREASED INVESTMENT OPP			0.681
			(1.16)
BIC	417.4	450.0	443.6

* p<0.05, ** p<0.01, *** p<0.001

Table 13 shows how the equation for "Perception of vulnerability" indirectly influence the firms' sustainability. Model 2 is a better suited specification than Model 1 as it includes risk drivers and impacts of physical risk to explain the perception of vulnerability. Risks occurring due to "Changes in precipitation", "Changes in temperature" and Changes in precipitation extremes (such as floods) and droughts are positive and statistically significant drivers for the perception of vulnerability to physical risks. The data also shows that increased operating costs, increased capital costs and disruptions in production are also positive and significant predictors for the perception of vulnerability which indirectly affects sustainable responses accordingly.

Table 13: PERCEPTION OF VULNERABILITY TO PHYSICAL RISK

	PR_PERCEP1	PR_PERCEP2+
	b/se	b/se
Likelihood_of_Phys_Risk		
PR_Changes in Precipitation	0.527**	0.457**
	(0.22)	(0.23)
PR_Changes in Temperature	0.620***	0.410*
	(0.23)	(0.23)
PR_Droughts & Floods	0.671****	0.503**
	(0.20)	(0.20)
PR_Natural Resources	-0.021	-0.075
	(0.08)	(0.11)
PR_Other Drivers	-0.028	-0.310
	(0.21)	(0.23)

PR_WIDER SOCIAL DISADVA	0.348
	(0.42)
PR_INCREASED OPERATING COSTS	0.474**
	(0.24)
PR_INCREASED CAPITAL COSTS	0.720**
	(0.37)
PR_DISRUPTION IN PRODUCTION	0.533**
	(0.24)
PR_REVENUE LOSS	0.142
	(0.26)
R-sqr	
dfres	
BIC	960.1 970.5

* p<0.1, ** p<0.05, *** p<0.01, **** p<0.001

Supply Chain SMEs in Parts of Africa

Presented in Table 14 is a simultaneous model with equations for Physical Risk sustainability and perception on climate change opportunities. Model 1 is chosen and shows some of the following results: Foremost, “Lack of relevance” is found to be a statistically significant and a prevailing predictor in reducing the likelihood that an SME would engage in sustainable actions to respond to the threat of physical risk. Additionally, increased demand for existing products increases the chances of the SME to partake in sustainable actions. However, both reduced operational costs and increased operational costs reduce the likelihood of sustainable behavior. Contrary to findings from top companies, SMEs are less likely to act sustainably towards physical risk if their operations are affected, whether they are negatively or positively affected is irrelevant.

Table 14: Physical Risk Models

	Model 1 b/se	Model 2 b/se	Model 3 b/se	Model 4 b/se
PR_sustainable				

South Africa	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)
Nigeria	-16.522***	-23.535***	-2.027	-16.522***
	(2.11)	(3.65)	(1.07)	(2.11)
Kenya	2.227	20.991***	1.689	2.227
	(2.48)	(2.24)	(1.34)	(2.48)
Egypt	0.851	10.965***	0.879	0.851
	(1.67)	(2.15)	(1.27)	(1.67)
Ghana	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)
Zimbabwe	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)
Cameroon	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)
Containers	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)
Air	-6.954	-20.607	-3.375	-6.954
	(5.68)	(.)	(1.86)	(5.68)
Trading	18.269	35.074***	2.500	18.269
	(.)	(3.23)	(1.57)	(.)
Agriculture	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)
Ground	-7.622	-15.749***	-2.172	-7.622
	(3.99)	(3.10)	(1.53)	(3.99)
Food	0.912	-12.389	-2.090	0.912
	(2.56)	(.)	(1.27)	(2.56)
Media	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)
Durables	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)
TeleComm	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)

PERCEPTION ON CC O~0		0.000	0.000	0.000
PERCEPTION ON CC O~2		7.242	0.000	7.242
		(4.59)	(.)	(4.59)
PERCEPTION ON CC O~3		-1.663	-6.430	-1.663
		(3.35)	(3.57)	(3.35)
PERCEPTION ON CC O~4		0.956	20.990***	0.956
		(4.18)	(5.39)	(4.18)
PR_PERCEP_OF_V~0	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)
PR_PERCEP_OF_V~1	-2.617	-7.338**	0.764	-2.617
	(3.40)	(2.36)	(0.93)	(3.40)
PR_PERCEP_OF_V~2	1.981	12.033***	1.760	1.981
	(1.71)	(1.95)	(1.08)	(1.71)
PR_PERCEP_OF_V~3	-0.639	3.693*	2.383*	-0.639
	(2.41)	(1.85)	(1.11)	(2.41)
PR_PERCEP_OF_V~4	-1.711	-4.684	0.842	-1.711
	(2.39)	(2.47)	(.)	(2.39)
INCREASED DEMAND	8.827**	24.349***	1.124	8.827**
	(3.18)	(1.92)	(0.85)	(3.18)
COMPETITIVE ADVA	0.000	0.000	0.000	0.000
REDUCED COSTS	-1.652	-12.363***	0.537	-1.652
	(2.02)	(2.97)	(0.79)	(2.02)
REDUCED DEMAND	1.790	10.454***		1.790
	(1.39)	(1.59)		(1.39)
INCREASED COSTS	-9.708**	-35.315***		-9.708**
	(3.37)	(1.65)		(3.37)
DISRUPT PRDUCTN	-0.737	4.150		-0.737
	(1.44)	(2.61)		(1.44)
LACK OF CAPACITY	-1.837		-0.312	-1.837
	(3.30)		(1.53)	(3.30)
LACK OF RELEVANCE	-8.850	-23.002***	-1.138	-8.850
	(.)	(3.38)	(1.00)	(.)
LACK OF REGULATION	-1.619	0.125	0.056	-1.619

	(2.01)	(2.24)	(1.34)	(2.01)
WIDER SOCIAL BENEFIT				0.623
				(.)
constant	-1.841	-11.630***	-1.763	-1.841
	(1.89)	(2.60)	(1.02)	(1.89)
PERCEPTION ON CC OPPORTUNITIES				
INCREASED DEMAND	1.098*	1.098*		1.098*
	(0.53)	(0.54)		(0.53)
COMPETITIVE ADVA	1.297	1.295		1.297
	(0.98)	(1.00)		(0.98)
REDUCED COSTS	1.411*	1.411*		1.411*
	(0.59)	(0.61)		(0.59)
PR_PERCEPTION OF VULNERABILITY				
REDUCED DEMAND			1.069	
			(1.43)	
SOCIAL DISADVANTAGE			0.516	
			(1.15)	
INCREASED OPERATIO~S			0.664	
			(0.89)	
R-sqr				
dfres				
BIC	278.4	265.9	330.5	278.4

* p<0.05, ** p<0.01, *** p<0.001

4.1.2.1 Marginal Effects:

The average partial effects for Top companies and SMEs for the latent variable that predicts the likelihood of sustainable responses to physical risk are shown in Table 15 below. Initially,

we see that for Top companies, the frequency of monitoring physical risks and opportunities once and twice a year (or more) increases the chances for sustainable actions by 31% and 33,5% respectively. While impacts of opportunities such as wider social benefits increase the likelihood of sustainable responses by 17%; reduced operating costs by 12%, and increased demand for new products/business services by almost 15%. We also observe that "Perception of vulnerability" to physical risks is positively associated with sustainable behavior, increasing the likelihood of sustainable performance by a percentage range between 35% to 64,2% for each level. Certain industries have a significant influence in predicting the likelihood that the top company would adopt a sustainable response to physical risk: The Mining industry is 36,5% more likely to implement sustainable responses if all things are held constant; while Real Estate, Oil & Gas and Trading industries are more likely to do so as well by, 22,2%, 15,9% and 42,2% respectively. Logistics (Air & Ground) however maintains a negative influence on the likelihood of sustainable behavior, reducing these chances by 34,4%.

Furthermore, Table 15 also exposes that when physical risk is not considered a relevant threat to SME operations, this significantly reduces the chances of sustainable behavior by almost 92%. On the other hand, the impacts of opportunities from the physical effects of climate change such as increased demand for existing products increase the chances of sustainable action by 95,6%. And, Increased and Reduced operational costs decrease the probability of sustainable conduct by 88,5% and over 20%, respectively. But, reduced operational costs are no longer significant predictors. Another observation from Table 15 is that; SMEs in Nigeria are significantly less likely to have sustainable responses to physical risk than any other country in the dataset. While SMEs in the logistics industry for Air travel and Ground travel, when all things remain constant, are less likely to behave sustainably by probabilities 36,3% and 31,1% respectively. However, the Trading industry shows a 31,7% increase in the probability that SMEs would undertake sustainable actions against physical risks.

Table 15. Estimation Results for Marginal Effects of Predictors against Physical Risk

	Top Companies in SA	SMEs in Parts of Africa
CHEMICALS	-0.121	_
	(-0.84)	
TELECOM	0.147	_
	(0.94)	
CONSTRUCTION	-0.0951	_

	(-0.77)	
MINING	0.365****	_
	(3.34)	
FINANCE	-0.151	_
	(-1.36)	
TRADING	0.422****	0.317***
	(5.77)	(3.01)
RETAILING	-0.224*	_
	(-1.87)	
FOOD AND BEVERAGE	0.0144	-0.0446
	(0.16)	(-0.16)
REALESTATE	0.222***	_
	(2.66)	
LOGISTICS (A&G)	-0.344****	_
	(-4.04)	
LOGISTICS: AIR	_	-0.363***
		(-2.96)
LOGISTICS: GROUND	_	-0.311***
		(-2.77)
HEALTH CARE	0.0513	_
	(0.63)	
CONTAINERS	0.0807	_
	(0.83)	
ELECTRICITY	0.0621	_
	(0.41)	
OIL & GAS	0.159**	_
	(2.01)	
NIGERIA	_	-0.277**
		(-2.47)

KENYA	_	0.174
		(0.64)
EGYPT	_	0.165
		(0.74)
1.GOVERNANCE	-0.196	_
	(-1.07)	
2.GOVERNANCE	-0.288	_
	(-1.50)	
INCENTIVES	0.0648	_
	(1.38)	
BUSINESS_STRATEGY	0.0821	_
	(1.64)	
FUTURE	0.0190	_
	(1.06)	
2.FREQUENCY	0.336****	_
	(5.80)	
3.FREQUENCY	0.313****	_
	(5.79)	
1.Perception of Vulnerability	0.642****	-0.0767
	(5.49)	(-0.41)
2.Perception of Vulnerability	0.366****	0.251
	(3.38)	(1.45)
3.Perception of Vulnerability	0.390****	0.246
	(4.11)	(0.116)
4.Perception of Vulnerability	0.356****	0.15
	(3.86)	(0.60)
PO_Change in Precipitation	-0.175***	_
	(-3.75)	
PO_Change in Temperatures	-0.0167	_

	(-0.28)	
PO_Droughts/Floods	0.00249	_
	(0.07)	
PO_Natural Resources	0.00204	_
	(0.04)	
PO_Other Opportunity Drivers	-0.0201	_
	(-0.38)	
PO_Wider Social Benefit	0.178***	_
	(3.18)	
PO_Reduced Operating Costs	0.123**	-0.233
	(2.33)	(-1.19)
PO_Reduced Capital Costs	-0.0913	_
	(-1.51)	
PO_Premium Price Opp	-0.157	_
	(-1.51)	
PO_Increased Production-	0.0487	_
Capacity	(0.51)	
PO_Increased Demand for-	-0.00253	0.956***
Existing Products	(-0.07)	(2.72)
PO_Increased Demand New-	0.148**	_
Products	(2.40)	
PO_Increased Investments	0.0566	_
	(0.61)	
PR_Reduced Demand	_	0.164
		(0.85)
PR_Increased Operating Costs	_	-0.885**
		(-2.10)
PR_Disruption in Production	_	0.00658
		(0.03)

Lack of Relevance	_	-0.917**
		(-1.98)
Lack of Regulation	_	0.0233
		(0.08)
N	408	62

t statistics in parentheses

*p<0.1, ** p<0.05, *** p<0.01, **** p<0.001

Finally, Table 16 shows the margins calculated for the perception of vulnerability for the top companies, when there's a certainty (at outcome=4), "Changes in precipitation" increase the perception of vulnerability by almost 9%. Similarly, "Changes in temperatures" also positively improve perception by 8% and when there are extreme weather conditions, this probability of choosing sustainable actions changes by 9,89%. And, impacts of physical risks such as Increased Capital Costs, Increased Operating Costs and Disruptions in Production moves the perception of vulnerability towards certainty by 13,9%, 9,13% and 10,3% thus affecting sustainable responses in similarly.

Table 16. Average Partial effects of Perception of vulnerability pertaining to Physical Risk as derived from the chosen regression models for Top companies in SA.

{dy/dx}	Outcome (1)	Outcome (2)	Outcome (3)	Outcome (4)
PR_Precipitation	-0.00354	-0.0430*	0.00725	0.0881*
PR_Temperature	-0.00317	-0.0385*	0.00650	0.0789*
PR_Drought~s	-0.00389	-0.0473**	0.00798	0.0969**
PR_Natural Resources	0.000582	0.00708	-0.00119	-0.0145
PR_WSD	-0.00269	-0.0328	0.00553	0.0671

PR_IOC	-0.00366	-0.0446**	0.00752	0.0913**
PR_ICC	-0.00557	-0.0677*	0.0114	0.139**
PR_DOP	-0.00412	-0.0501**	0.00845	0.103**
PR_RDRL	-0.00110	-0.0133	0.00225	0.0273
N	427	427	427	427

t statistics in parentheses

* p<0.1 ** p<0.05, *** p<0.01, **** p<0.001

4.2 Discussion

4.2.1.1 Climate change responses by Country

"Because the natural and social systems of different geographical regions are heterogeneous, local knowledge can be a critical ingredient to solving local problems because it is time specific, area specific and culturally acceptable." Ogalleh et al. (2012, p. 17). The data on SMEs was collected from 7 African countries and the results showed how mitigation and adaptation strategies vary across borders. Nigerian and Kenyan firms are the only ones that have significance when it comes to country of origin for the SMES. They are both more likely to be significantly sustainable in mitigating transition risk than in physical risk. Notable mitigation actions from Kenya include a vision advocating for a 10% requirement for forest cover in all farmlands by 2030 and the promotion of geothermal energy, among other proactive and resilient policy strategies to mitigate carbon emissions (Hogarth, Haywood & Whitley, 2015). Outside South Africa, Nigeria is expected to have the highest GDP per capita in the continent, it has made some successful climate change strides in its current national development plan (Vision 2020) by increasing the share of the energy mix of hydro-power and other fossil fuel alternatives and to increase forest cover from 6% to 10% in an attempt to promote low carbon activities as taken from The 2015 Global Climate Legislation Study. Nigeria signed the Paris Accord in 2016 and ratified it in 2017, to reduce GHG emissions by limiting the need and usage of fossil fuels and incentivizing the adoption of renewable energy alternatives. The data from our study is consistent with these notions that may explain why Nigerian (and Kenyan) SMEs are significantly more likely to be sustainable in mitigating transition risk. These findings are of value when considering other developing economies that are just as fossil fuel consumption intense and how the level of commitment and follow-through by governments and policymakers vary when it comes to mitigating transition risk.

Unfortunately, Nigeria is not more likely to be sustainable in adaptation measures against the physical effects of climate change. This may be a form of maladaptation when the focus is only on mitigating transition risk because of global pressure, this leaves the economy more likely to succumb to unsustainable adaptation measures in times of extreme weather disasters such as flooding and droughts. Their responses may be a result of lack of financial resources or other policy and incentive structures, but in fact, most developing economies are only ever sustainable in one area of climate change risk and rarely in both areas. This is a huge hindrance to sustainability thus we require further research and analysis on this phenomenon.

Our results did not show any of the other countries of origin as significant identifiers for sustainable practises in both transition and physical risks in SMEs. However, a brief comparative discussion on the other countries is included to show the heterogeneity in the sample of countries in terms of institutional and contextual policy barriers. Although not significant, South African SMEs (in the supply chain) are not sustainable in mitigating both transition risk and physical risk and this could be attributed to a variety of reasons. South Africa has put in place one of the most elaborate and consultative climate governance systems observable among developing and emerging economies. This has been done through the likes of South Africa's National Climate Change Response White Paper (NCCRWP) (DEA, 2011) and the National Development Plan (NDP) (NPC 2011) which present a vision for an effective response to climate change. However, polices on adaptation and resilience have had little focus to date and action is yet to be seen. A draft National Climate Change Adaptation strategy was released in 2017 for public comment but has not yet been approved. A systemic issue that could become a roadblock for the implementation of South Africa's nationally determined contribution (NDC) to the Paris Agreement in addition to the lack of alignment and policy coherence: in other words, the gap between climate change goals and the objectives set in other key strategies and policy documents determine the trajectory of development. As compiled by (Averchenkova, Gannon and Curran, 2019) limited public sector capacity and dedicated financial resources hamper climate change governance. There is a shortage of capacity to deal with climate change and related policies within the Government due to limited human and financial resources needed to augment governance capacities to work on climate change financing policy implementation and the underlying investments in the low-carbon and climate-resilient transition. Another key challenge is the mistrust of public–private engagement due to corruption and concerns around continuity, and a lack of transparency on how feedback from stakeholders is dealt with. These issues are prevalent throughout South Africa's political discourse and economic structure. Evidence emerged of widespread corruption and 'state capture' (see Public Protector of South Africa, 2016 and Bhorat et al., 2017) but climate is a policy area where constructive interaction between the public and private sector is particularly important for making progress. While historically South Africa has publicly supported climate action in international fora, action in the country has been less evident and have been characterised by delays in the development and implementation of policies designed to reduce greenhouse gas emissions or adapt to climate change impacts such as the carbon tax and carbon budgets. In the same vein, previous research also found environmental regulations hardly play any role in regulating SMEs such as Hamann et al. (2017) study on wine producing SMEs in South Africa. There is a need to strengthen delivery and implementation mechanisms in a

transparent and intentional manner that improve the chances of policy engagement and tangible results. And as observed in most African countries, there is a need for strategic approach to allocating financial resources to sustainable mitigation and adaptation policies.

The results found in this paper suggest that Egyptian SMEs are not significantly influenced by the country's policies and governance when they respond to climate change. In fact, (Aboelmaged, 2017) also found that while environmental pressures from customers, competitors and media significantly influence sustainable practices in Egyptian SMEs, environmental regulations do not. This result contradicts prior research that patronises the role of environmental laws and rules in influencing sustainable practices such as (Shankar et al., 2016). A plausible interpretation of this finding is the weak enforcement of environmental laws in Egypt shown by (Ramadan and Nadim, 2004) in the hazardous waste management. In addition, there is a lack of technical capacity within the higher environmental authority in Egypt to monitor and coordinate environmental legislations (Mobarak, 2001). "It seems that the environmental regulation enforcement authorities did not wish to be 'tough' on the industries in this regard for justifiable social and economic reasons" (El-Zayat et al., 2006: p. 213). However, our results can only be applicable to the SMEs in the supply chain based on the data collected by the CDP and cannot be generalized, but once again, accountability and the need for policy alignment, coherence and coordination can lead to significant changes in enforcing environmental laws in Egypt.

Ghana also did not appear as a significant explanatory variable for sustainable mitigation and adaptation practises among Ghanaian SMEs in the supply chain. Despite its efforts to internalise international agreements and transition to a green economy, through certain national legislation, multiple policies and strategies such as the Control and Prevention of Bushfires Act (1990), Energy Efficiency (LI 1815; LI 1932; LI 1937; LI 1958; LI 1970), Environmental Protection Agency Act (1994), Forest Plantation Development Fund Act (2000), Renewable Energy Act (2011), etc. The country is yet to record any significant achievement in that regard. Ghana has formulated some of the best environmental policies in the West African sub-region, yet the country still struggles with some of the negative ramifications of climate change. (Ali, Anufriev and Amfo, 2021) point out factors such as weak institutions. For example, after submitting the 2014 National Inventory Report (NIR) to the United Nations Convention Framework Convention on Climate Change (UNFCCC), Ghana failed to update the data on greenhouse gas emissions. Between 2012 and 2019, no data exist on the country's greenhouse gas emissions, and this poses a serious challenge to fully understanding the country's environmental challenges. Additionally, there is inadequate funding for green technologies innovations. An unofficial IMF report projects Ghana's debt to GDP to rise to about 74.7% of GDP by 2021(Ali, Anufriev and Amfo, 2021). The rising debt possess a threat to both the fiscal and monetary economy, including revenue mobilization, the exchange rate and inflation. This also affects the financing of green projects and initiatives, especially because Ghana is predominantly an import-led economy. Finally political will is a huge threat due to the lack of commitments by successive governments to implement such policies. The will and commitment to adequately finance green initiatives have been lacking. In instances where government has expressed the commitment via the signing of protocols in support of green economy development and implementing the relevant policies, the challenge has always been

the actual implementation. It is imperative to point out that to successfully adopt green economy initiatives, government's commitment must go beyond merely signing international agreements and treaties and developing policies to actual implementation. With the right funding, Ghana would benefit from advancing critical policy reforms to allocate resources and benefits to communities.

As seen in most of our regressions, Cameroon and Zimbabwe fell out of the estimation results due to multi-collinearity however, previous studies have noted the following barriers to sustainable mitigation of transition and adaptation to physical risks. During the 21st conference for the United Nations framework convention on climate change, Cameroon announced its ambitious commitment. These commitments perfectly align with the country's desire to be emergent by 2035 and the urgent need to save the planet from environmental destruction (Ashu, 2019). However, the government's response to climate change in Cameroon has been mixed. At the international and regional levels Cameroon is active in a number of processes, including through its participation in the Central African Forests Commission (COMIFAC), established in 2005 as part of a commitment to sustainable forest management in the Congo Basin. At the national level the government's response to climate change is less clear. Political obligations around climate change have not yet emerged in Cameroon despite the country's high level international commitments (Brown and Sonwa, 2015). Where the government is engaging in climate change the focus is largely on mitigation, although the government is also working with UNDP to prepare its first National Adaptation Plan of Action (NAPA) which is expected to increase understanding around adaptation needs. However, the success of these processes remains heavily dependent on donor assistance and it is arguable that without donor interest and support the government may not have chosen to pursue these activities (Whitfield and Jones, 2009).

Similarly for Zimbabwe, the Government signed the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 at the Rio Earth Summit and ratified it in November of the same year. Like the rest of Africa, it is constrained by its inability to put appropriate measures in place in order to respond to climate change requirements because of the lack of human, institutional and financial resources. The main focus on sustainability is adaptation to physical risks as the country is vulnerable to droughts and flooding and this affects the Agriculture sector (which is the highest source of GDP revenue in the country) thus the government in conjunction with The UNDP Regional Environment Project, 2013, help to implement educational training centres in rural areas to improve adaptation practices and has since implemented a variety of policies to help farmers in Zimbabwe adapt to climate change. However, efforts to mitigate carbon emissions have been minimal. Zimbabwe signed the Agreement on 22 April 2016, ratified it on 7 August 2017 and was entered into force on 6 September 2017. Under these and previous influences, Zimbabwe evoked the implementation of policies such as the National Climate Change Response Strategy (NCCRS) in 2014; Intended Nationally Determined Contribution (INDC) in 2015; National Climate Policy (NCP) of 2017; the First, Second and Third National Communication to the UNFCCC to move to a greener economy. Nonetheless, effective responses in the energy sector tend to be constrained by limited funding for project development, lack of feasibility studies for wind power generation to prove the achievable capacity, lack of financing to upgrade feasibility studies of some small

hydropower sites which were carried out back in the 1990s and lack of capacity to install and maintain renewable energy systems (Chanza and Gundu-Jakarasi, 2020). The weaknesses in institutional capacity for support mechanisms and existing challenges such as political discourse, economic hardships and hyper-inflation hinder the effectiveness of policy against climate change, but there remain promising nuances in unlocking development benefits to the country, institutions and individuals.

4.2.1.2 Climate change responses by Industry

A significant finding from our analysis of sector responses showed the similarity between top companies and SMEs in the Logistics industry which is the only significant industry for SMEs when responding to both transition risk and physical risk. In addition to the logistics industry, top companies in the chemicals, food & beverages, retailing, trading, construction and healthcare industries have been found to more likely to engage in unsustainable responses when it comes to low carbon emission. More than half of the time, the Chemicals and Logistics (both air and ground travel for top companies and just air travel for SMEs) are either reactively coping or deferring any action towards mitigating transition risk. According to (International Energy Agency, 2012) the Logistics sector emits the second most amount of anthropogenic carbon dioxide emissions. Ground logistics accounts for 72% of this sector's emissions and Global aviation for 11%, these have also steadily increased in the past decade and there are still no viable alternatives for fossil fuels. The emissions resulting from the movements of goods and the emissions caused by people traveling (by car, plane, train, etc...) are examples of indirect and direct emissions, respectively. But since the distance travelled by goods during production is continuing to grow, this is creating more indirect emissions and fewer initiatives for manufacturing industries to transition to low carbon. The International Energy Agency also name manufacturing and industrial processes which include the chemical, food & beverages and construction industry, as the third largest source of man-made carbon emissions as their processes of production utilizes fossil fuels and generate heat and steam that contribute immensely to GHG emissions. These effects spill into the tertiary sector (retailing and trading) as our findings suggest. Additionally, when it comes to responding to physical risk, the transportation industry is still reactively coping or deferring any responses while industries that are directly impacted by extreme physical climate hazards such as Oil & Gas, Real Estate and Trading are responding either proactively, and/or continuously. Climate change action is required across all fields of life, and more specifically across all industries in the corporate community regardless of size or geography and these findings point to the areas that need to receive more attention from policymakers and regulators to achieve sustainability.

4.2.2 Impacts on the Bottom line

Another take away from the results is that most companies will have sustainable responses against climate change if it will improve their bottom line. In a 2002 report (Innovest Strategic Value Advisors, 2002, p. 2) Ceres states: “The bottom line … is straightforward: climate change represents a potential multi-billion dollar risk to a wide variety of U.S. businesses and

industries. It should, therefore, command the same level of attention and urgency as any other business risk of this magnitude."

Our findings show how the impacts of risks and opportunities that directly affect the bottom line, either positively or negatively, lead to more sustainable actions against climate change risks. We observe in companies that a decrease in investments and capital availability, demand/revenue loss and increased operating costs and benefits such as increased production capacity and competitive advantage, significantly stimulate the chances of sustainable responses to transition risks. Similarly for physical risks, they showed that disruptions to production and increased capital and operating costs stimulate sustainable actions. While benefits from physical effects of climate change such as increased demand in new products/business services and reduced operating costs significantly improve the likelihood that the firms respond proactively, and/or continuously to the effects of physical risk. As a result, these risks and opportunity factors drive sustainability in top companies and can thus be manipulated by the interested parties in inducing a favourable action against climate change risk. Based on these findings, top companies of similar structures can be advised on the significance of these factors on their vulnerability to climate change and the subsequent responses that are more likely to lead them onto a sustainable path.

On the other hand, SMEs are not always motivated by the same impacts to choose sustainable action against climate change risk. Indeed, just as top companies they are also stimulated by a decrease in demand/revenue to become more sustainable and impacts such as increasing and decreasing operating costs lead to the same conclusions (any impact on operating costs prompts a higher likelihood for sustainable responses). But in most cases, impacts of risks and opportunities are not even significant drivers for action against climate change for SMEs. The most remarkable finding is, perhaps, that most SMEs perceive no impacts on their business or are simply unsure/unaware of the threats posed by climate change hence they do nothing in response or are more likely to engage in reactive responses. Our results for SMEs show a strong positive correlation between lack of relevance and unsustainable action such as deferred or reactive measures. (Spence et al., 2011) echo these findings too showing that people may not take actions to mitigate and/or adapt to climate change because they lack first-hand experience of its potential consequences thus believing the risks are not relevant to their business. In line with this, if people especially SME managers/owners can relate to the potential consequences of climate change impacts, then they are more likely to feel that their behaviour can lead to changes in these impacts. This is why the next section on perception is another significant component of determining drivers for sustainable action.

4.2.3 Perception of vulnerability to risks and opportunities

Risk and opportunity perceptions can essentially compel or constrain vital economic and social actions needed to address and reduce the risks and dangers of global climate change. The most common response exhibited was that all firms have a significant perception of vulnerability to risk, when the risk is viewed at least as more likely to occur than not, this has a positive impact on the probability that they will engage in sustainable mitigation and adaptation measures. The only significant difference between the two is in magnitude, SMEs are twice more likely to be sustainable in transition risk as a result of strong perceptions of vulnerability. Since strong

perception can lead to sustainable climate action, we can manipulate the drivers for perception, as suggested by our model, into nudging strong perceptions and lead to more sustainable actions from more firms.

For example, top companies are strongly influenced by emissions reporting obligation when it comes to responding to transition risk. They are likely pressured by investors, shareholders and global standards to "appear" proactive and/or concurrent in low carbon emission efforts. The results show that despite the motivations behind, this is a significant driver for strong perceptions and thus sustainable actions. So a policy recommendation that makes emissions reporting mandatory can be a tool to drive sustainable action in the corporate community. However, this may not be as effective on a whole because of some competing literature, for instance (Harmes 2011, p. 118) concludes in a theoretical study on investor environmentalism, "the potential of using institutional investors to create real financial incentives for climate change mitigation…..has been considerably overestimated and there is not even a strong theoretical case for why carbon disclosure should work in this regard." All the same, (Elum et al., 2017) take notice of how carbon disclosure empowers economic agents such as the civil society in the fight against the financial risk of climate change, and provides useful information for key actors such as venture capitalists, campaigning NGOs, and governments. While carbon disclosure may not change the immediate nature of investment decisions, it might instigate a change in behaviour of business actors in the long-run when it is enforced and the goal is to commit to reducing carbon emissions regardless of financial incentives or not.

Incidentally, regulation & litigation is another prime driver for top companies while lack of regulation is an issue for SMEs in predicting sustainable action against transition risk. Authors (Hönke et al., 2008) found evidence that multinational companies are exploiting weak government regulation in the area of the environment in the case of South Africa. Regardless of the limited capabilities of South African government institutions to implement legislation due to a lack of resources and skills, "a very decisive driver in the environmental policy field, is clearly the active community of non-governmental organizations in South Africa. Together with community-based organizations, NGOs are continuously making a considerable contribution to the shaping and implementation of environmental policies, at the national, but more significantly at the local level" Hönke et al. (2008, p. 36). Thus, the incentivization of these ventures would be a big step in securing a shift in perception and sustainable action.

The findings for drivers designed for the perception of vulnerability to physical risk (for top companies) are straightforward. Changes in precipitation or temperatures have a direct link to how strongly they perceive their vulnerability and thus responses. This is consistent with (Spence et al., 2011) who show that responders who report direct experience of extreme precipitation are more apprehensive about climate change and feel more confident that their actions will have an effect on climate change and thus more inclined to undertake sustainable behaviours. Conversely, this also implies that those who are not directly affected by the negative effects of climate variability do not perceive this as a viable risk and thus it is not a significant driver for sustainable action for them. This gap leaves room for further research on the perception of vulnerability to physical risk-targeted to groups that believe are not directly affected because of lack of experience (due to geographical location or any other factors not

directly related to intentional adaptive capacity). Lack of knowledge contributes to a feeling of uncertainty about climate change, which ultimately results in scepticism about the reality of these physical effects and the need for action (Tobler et al., 2012). We need more studies (outside of just farming, mining or tourism) that prove that education actually shifts perception and drive sustainable activities. But for this to occur we need a decentralized educational system that is Africa oriented to correct some of these misconceptions.

Lastly, the perception of opportunities from low carbon emissions is just as important as the risks for all firms, but the perception of opportunities from physical effects is not significant in driving sustainable action. It is also important to note from (Slovic, 2000; Leiserowitz 2006) that perceptions are not only influenced by data-driven conclusions and technical descriptions of perils and incentives of climate change but also by psychological and societal acumens, such as individual circumstances, positive and negative affect and feelings, imagery, morality, culture and political attitudes towards the world– dimensions of perception that our study does not explore.

5. CONCLUSION

With admission of certain limitations, this study takes the first step to understand the nature of mitigation and adaptation responses by both top companies and SMEs operating in Africa using the subsets aforementioned. We conclude with a summary of four important findings in line with our objectives; Policy and appropriate legislation are critical drivers of climate change action by private companies in Africa. Secondly, local knowledge integration into climate policies in terms of firm size, geography and industry are likely to increase the legitimacy of the decision-making process for firms. This can also make implemented policies reliable and give firms control of sustainable practices that attempt to bring about change in corporate Africa at local levels. Thirdly, impacts that directly affect the bottom line for most businesses can be targeted for nudging the corporate community towards sustainable practices. Last of all, although "perceptions are not a surrogate for general environmental beliefs but they have their own power to account for behavioral intentions." (O'Connor, Bard, and Fisher, 1999, p. 467) The process of decentralized education allocates decision-making control from the central Ministries of Education to intermediate and local governments, NGOs, communities, and schools to better deal with the misconceptions that lead to unsustainable climate action. Although the process requires strong political commitment and leadership to succeed, future research with more refined theoretical frameworks, variables, and methodology can provide effective tools to help businesses and communities that are lagging behind towards sustainability. Our contributions include bringing econometric findings to policymakers, encouraging transformative global business practices that can help dozens of countries develop national plans to cut greenhouse gas emissions and boost the capacity to adapt and build resilience against the risks of climate change.

Acknowledgements

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6. Appendices

Appendix A. Measurements and Descriptive Statistics

Table 17. Variable definitions and Abbreviations

CODE	Potential Impact
Trans	TRANSITION RISK
Phys	PHYSICAL RISK
WSD	WIDER SOCIAL DISADVANTAGE (measure of the impact of climate change on the extent to which people living in communities are affected)
IOC	INCREASED OPERTAIONAL COSTS (higher compliance costs, increased insurance premiums, administrative costs, fines, penalties etc.)
ICC	INCREASED CAPITAL COSTS
NBI	NEGATIVE BRAND IMAGE (reputational damage)
DOP	DISRUPTION OF PRODUCTION (inability to do business)
DRL	DEMAND/ REVENUE LOSS
DMV	DECREASED MARKET VALUATION
DIN	DECREASED INVESTMENT OPPORTUNITIES AND CAPITAL AVAILABILITY
WSB	WIDER SOCIAL BENEFIT
ROC	REDUCED OPERTAIONAL COSTS
RCC	REDUCED CAPITAL COSTS
PPO	PREIMUM PRICE OPPORTUNITIES
IPC	INCREASED PRODUCTION CAPACITY
ICA	INCREASED COMPETETIVE ADVANTAGE
IDEP	INCREASED DEMAND FOR EXISTING PRODUCTS OR BUSINESS SERVICES
IDNP	INCREASED DEMAND FOR NEW PRODUCTS OR BUSINESS SERVICES
IMV	INCREASED MARKET VALUATION

IINV	INCREASED INVESTMENT OPPOTNITIES AND CAPITAL AVAILABILITY
Trans_OTHER	Brand and employee engagement, Lower carbon emissions and efficiency gains such as income from emissions credits, lower quantum of claims for electric geyser bursts which causes secondary damage Societal benefit – lower coal generated electricity usage, Preferred distributor, Raising consumer awareness.
Phys_OTHER	Other: Continued production
	Other: Increased Revenue
	Other: Disruption of travel and transportation, and therefore a greater reliance on electronic communication services.
	Other: Decreased reliance on fossil fuel based resources e.g. coal.
	Other: Increased negotiation power. Decreased reliance on one geographical region as a source of supply.
Trans_risk_OTHER	Write-offs, asset impairment and early retirement of existing assets due to technology changes;
Phys_risk_Other	LOSS OF REVENUE AND GROWTH POSSIBILITIES
	REDUCED CAPITAL AVAILABILITY AND INEVSTMENT OPPOTURNITIES
	Reduction in Asset and Security Value
	Uncertainty in relation to crop yields could lead to increased price volatility in relation to the underlying products, Loss of potential revenue, New business models required,

Table 18. Variable Names and Description

Variable Name	Description of Drivers
	PHYSICAL RISK AND OPPORTUNITY DRIVER:
Change in precipitation	Change in mean (average) precipitation and/precipitation patterns
Change in Temperature	Change in mean (average) temperature and/or temperature extremes
Droughts or Floods	Change in precipitation extremes and droughts
Natural Resources	Induced changes in natural resources
Other	other- Rising sea level, snow, ice, tropical cyclones, hurricanes and typhoons
	TRANSITION RISK DRIVER:
Market	Market: changing consumer behaviour; Increasing humanitarian demands; Induced changes in human and cultural environment; Fluctuating socio-economic conditions; Increased cost of raw materials; Uncertainty in market signals
Reputation	Reputation: Increased stakeholder concern or negative stakeholder feedback; Shifts in consumer preferences; Stigmatization of sector;
ERO	Emissions-reporting obligations;
Policy & Law	Regulation and Litigation (*Current and Emerging policies*): carbon tax; cap and trading schemes; voluntary and international agreements; air pollution limits; Increased pricing of GHG emissions; Mandates on and regulation of existing products and services;

Technology	Technology: Costs to transition to lower emissions technology; Substitution of existing products and services with lower emissions options; Unsuccessful investment in new technologies
Lack of Regulation	
	TRANSITION OPPORTUNITY DRIVER
CCB	Changing consumer behaviour
Reputation	
ICHC	Induced changes in human and cultural environment
FSC	Fluctuating socio-economic conditions

Appendix B. Descriptive Statistics for SMEs.

Trend of changes in responses

The diagrams below show the plots of the changes in behaviour over time under each of the 3 risks. Most of the plots don't show any systematic direction that the responses have taken or are headed. Perhaps some of the variability is owing to the small sample size and the short time period that was available for analysis. The Paris Summit Agreement of 2015 is a major climate change event and can be used as a point of reference to observe a shift in perception businesses as the agreement requires moving to low-carbon production for the countries committed.

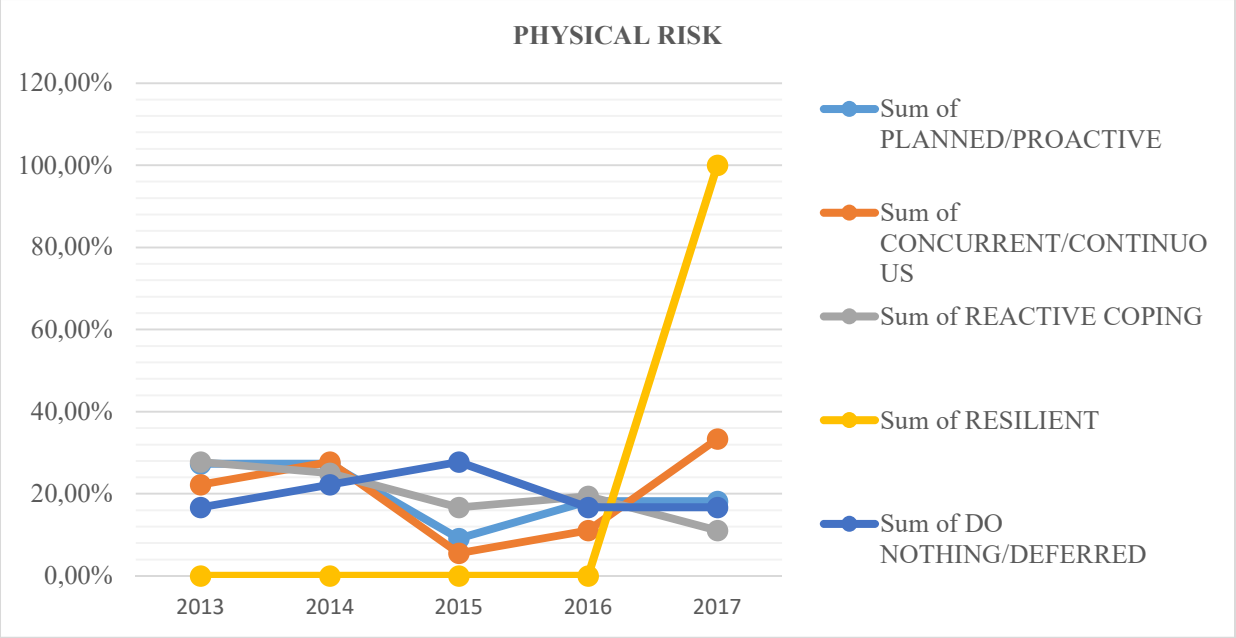


Figure 5. Trend of changes in physical risk.

What is immediately noticeable in Figure 5 is how any resilient action has only taken place in 2017 ever since 2013. After 2015, the percentages of those that "do nothing" plummets and is somewhat constant till 2017. There appears to be a slight downward slope for those that are reactively behaving, with 2017 having the lowest number of reactive adaptation. Both planned and continuous behaviour have a random "V" shaped pattern for the period, there is no significant trend of how firms are responding in the case for sustainable behaviour.

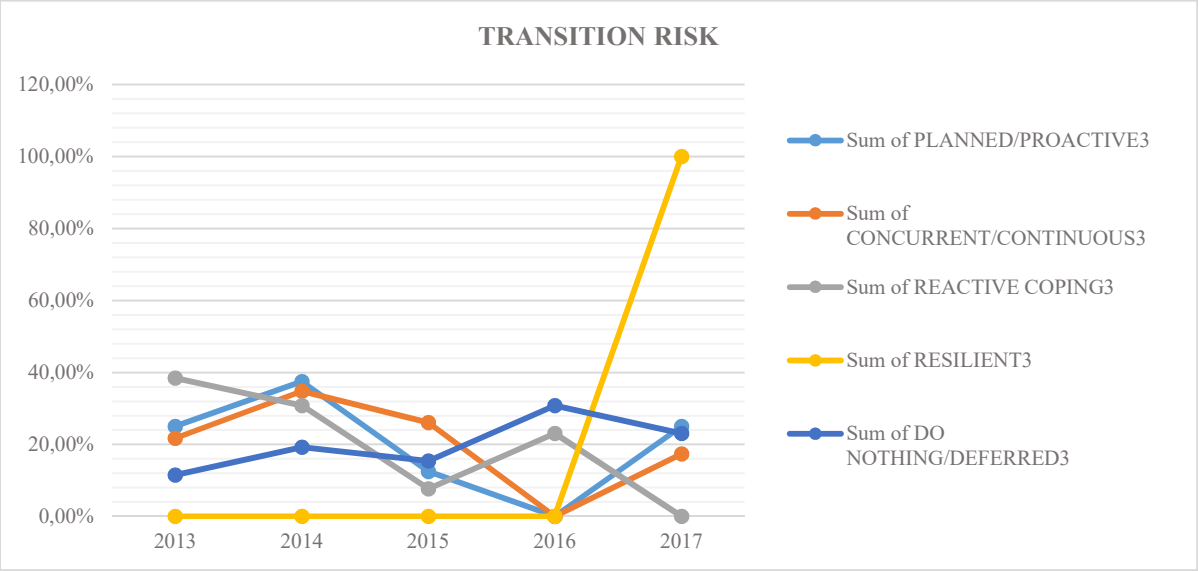


Figure 6. Trend of changes in transition risk.

As in Figure 5, Figure 6 also shows that resilient responses against transition risk where only recorded in 2016, the proportions for "do nothing" seem to be steadily increasing over time while the proportions of reactive coping appear to be decreasing by 2017. Once more planned and continuous behaviours have synchronised movement in an unpredicted and random manner.

Responses to climate change risks by categories

By Subsidiary and Non-subsidiary Firms:

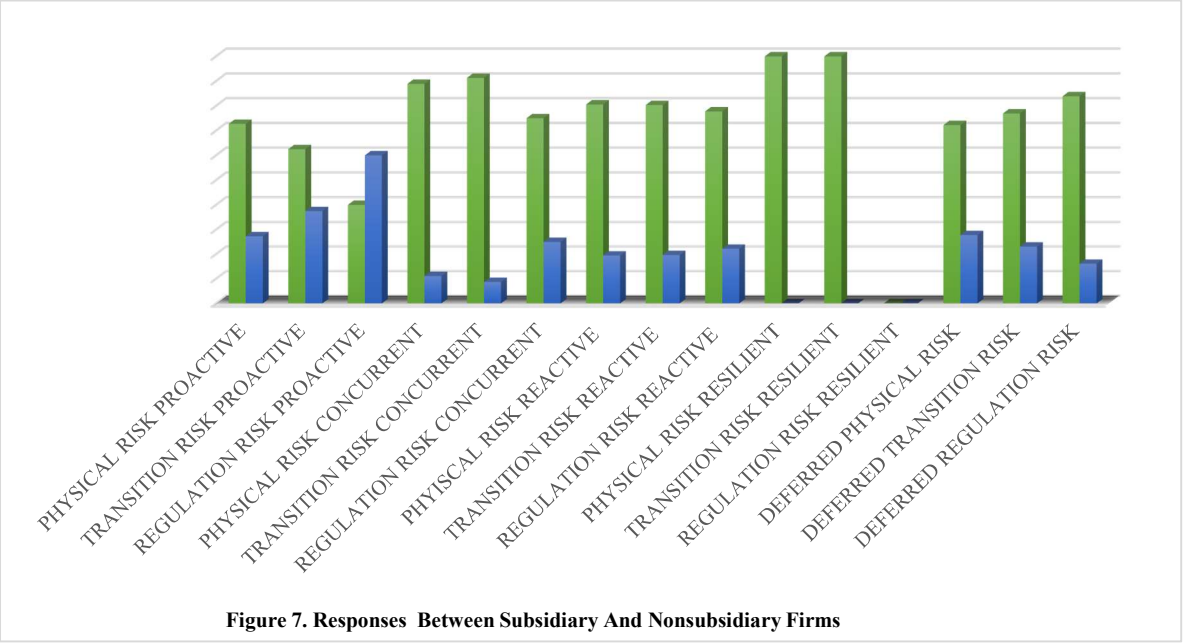
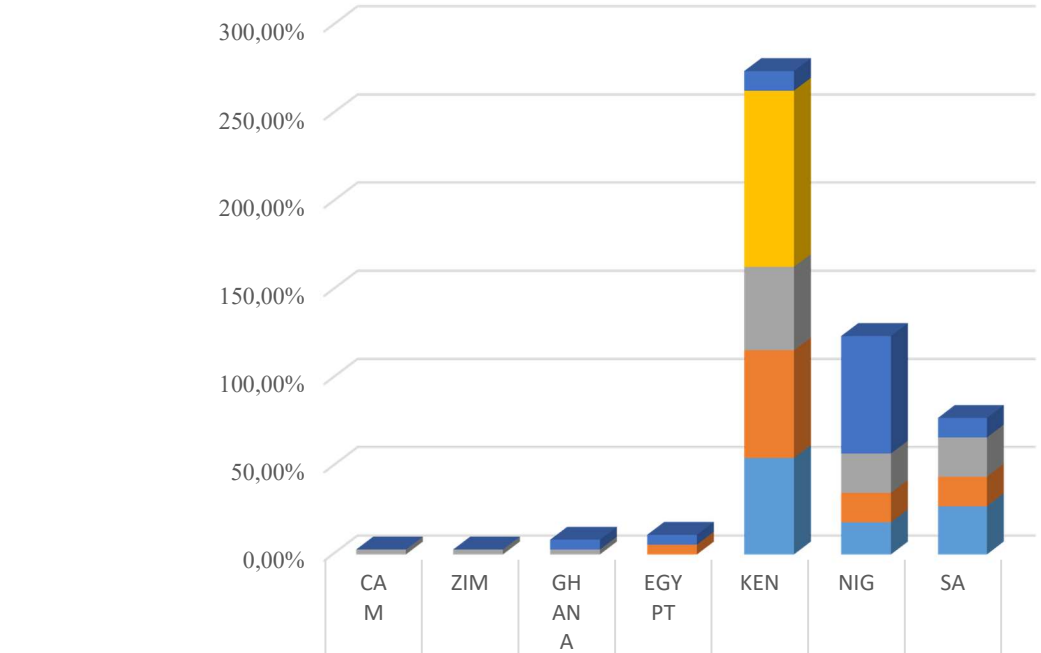


Figure 7. Responses Between Subsidiary And Nonsubsidiary Firms

The only thing that seems out of the ordinary in this comparison is that more subsidiaries firms are behaving proactively against the threat of regulation risk than non-subsidiary firm. And that none of the subsidiary companies are resilient in any of the risks.

By Country:



	CAM	ZIM	GHANA	EGYPT	KEN	NIG	SA
DO NOTHING/DEFERRED	0,00%	0,00%	5,56%	5,56%	11,11%	66,67%	11,11%
RESILIENT	0,00%	0,00%	0,00%	0,00%	100,00%	0,00%	0,00%
REACTIVE COPING	2,78%	2,78%	2,78%	0,00%	47,22%	22,22%	22,22%
CONCURRENT/CONTINUOUS	0,00%	0,00%	0,00%	5,56%	61,11%	16,67%	16,67%
PLANNED/PROACTIVE	0,00%	0,00%	0,00%	0,00%	54,55%	18,18%	27,27%

Figure 8. Physical Risk Responses Per Country

Perception of climate change impacts

Impact of Climate change Risks (Not Mutually Exclusive)

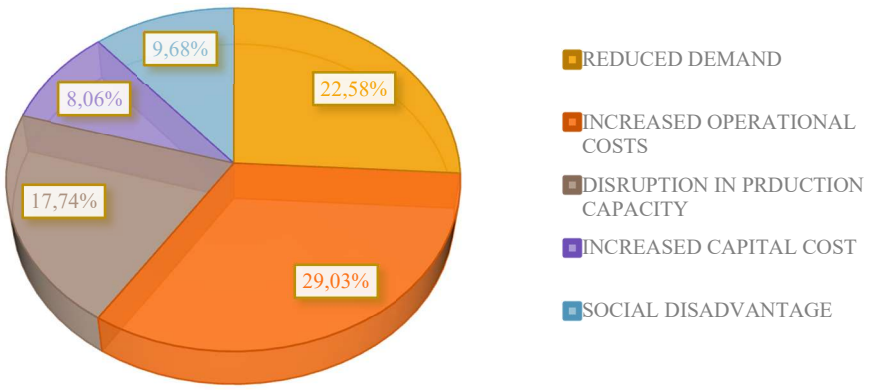


Figure 9. Count Of Total Population

Impact Imposed of Climate change Opportunities (Not Mutually Exclusive)

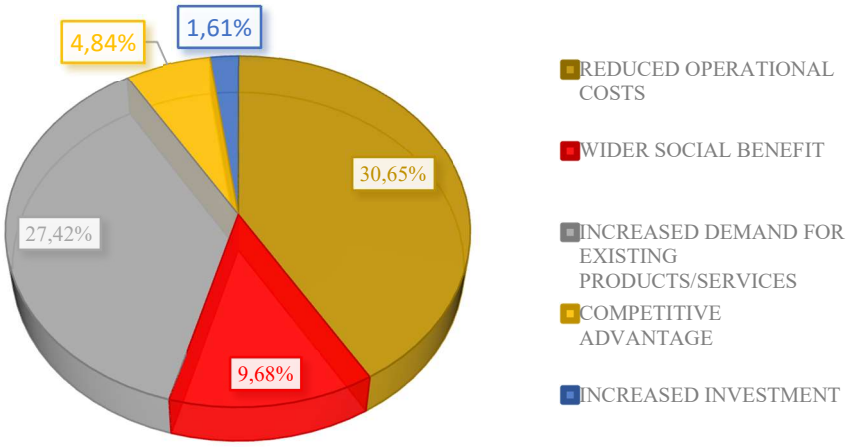
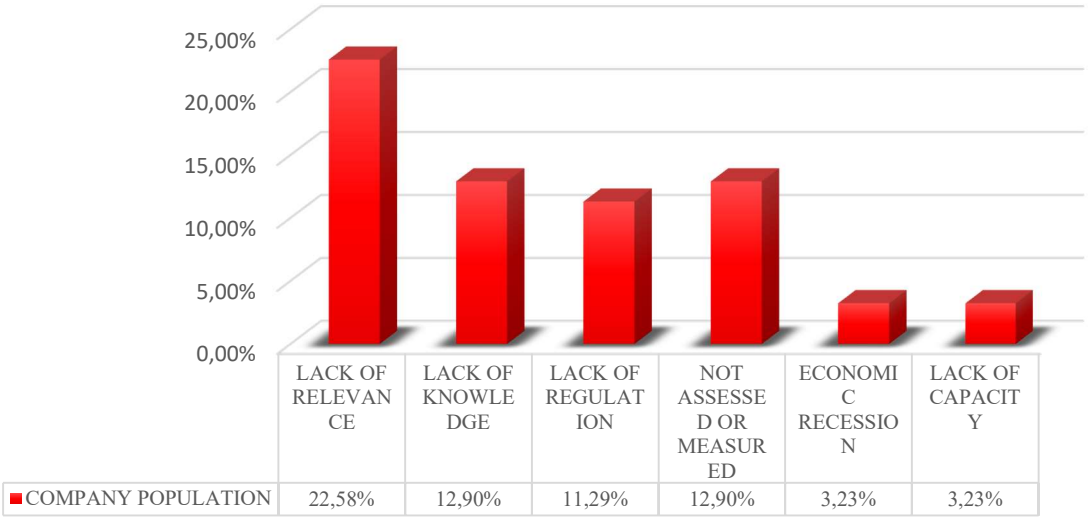


Figure 10. Company Population

Factors that contribute to unsustainable climate change practices

Internal Characteristics:



	LACK OF RELEVANCE	LACK OF KNOWLEDGE	LACK OF REGULATION	NOT ASSESSED OR MEASURED	ECONOMIC RECESSION	LACK OF CAPACITY
COMPANY POPULATION	22,58%	12,90%	11,29%	12,90%	3,23%	3,23%

Figure 11. Reasons For Non-engagement CC Risk (Not Mutuall Exclusive).

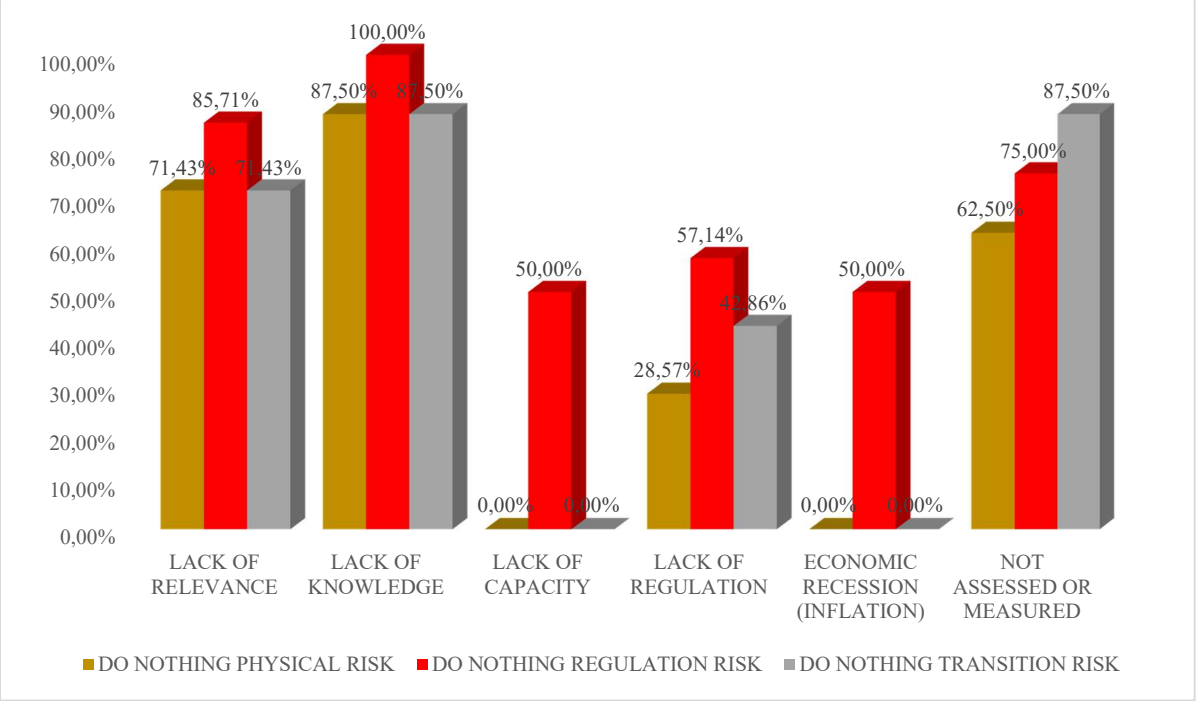


Figure 12. Proportion of unsustainable responses to climate change risks

71,43% of those who cited lack of relevance did not do anything to respond to physical risk; while only 43% of those who cite lack of relevance for transition risk do nothing. The percentages of those who cite lack of knowledge and end up deferring any actions are much higher for all the risks. Interestingly though, those who do not assess or measure transition risk have a higher proportion of those who end up doing nothing to transition to low carbon.

Appendix C. Estimation Results

Top Companies in South Africa

Appendix Table: PERCEPTION OF PHYSICAL OPPORTUNITIES

	PO_PERCEP1	PO_PERCEP2	PO_PERCEP3
	b/se	b/se	b/se
PO_Changes in Precipitation	0.605**	0.550**	0.438
	(0.25)	(0.26)	(0.28)
PO_Changes in Temperature	0.481**	0.671**	0.394
	(0.22)	(0.30)	(0.30)
PO_Droughts & Floods	0.603***	0.512**	0.357*
	(0.19)	(0.21)	(0.21)
PO_Natural Resources	0.755****	0.548**	0.247
	(0.20)	(0.22)	(0.23)
PO_other drivers	0.643	0.694*	0.658*
	(0.34)	(0.37)	(0.38)
PO_WIDER SOCIAL BENEFIT		0.133	0.389
		(0.28)	(0.31)
PO_REDUCED OP COSTS		0.400	0.664
		(0.79)	(0.77)
PO_PREIMUM P~I		-0.362	0.173
		(0.72)	(0.71)
PO_INCREASED~A		0.121	0.141
		(0.48)	(0.51)
PO_INCREASED~X		0.185	0.390
		(0.31)	(0.32)
PO_INCREASED~E		1.364****	1.536****
		(0.26)	(0.27)
PO_INCREASED~P		0.205	0.106
		(0.56)	(0.61)
PO_Other Imp~s		1.356****	1.374***

		(0.39)	(0.44)
PO_REDUCED O~S			0.896***
			(0.30)
R-sqr			
dfres			
BIC	974.4	950.8	938.1

* p<0.1, ** p<0.05, *** p<0.01, **** p<0.001

* p<0.05, ** p<0.01, *** p<0.001

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