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Carbon Tax and Environmental Quality in South Africa

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ABSTRACT

Carbon taxes are considered an important environmental policy instrument for the improvement of environment quality in developing countries. Despite these premises, the implementation of the carbon tax policy in developing countries has lagged behind. The aim of this study is to analyse how carbon tax influence environmental quality and economic performance in South Africa. Such a country-oriented inquiry is envisaged to have some positive policy implications for the South African economy and other developing nations. The analysis was conducted using a static computable general equilibrium (CGE) model of South Africa, which was expected to capture the observed structure of South Africa's economy. Furthermore, the parameters of the CGE equations were calibrated to observed data from a social accounting matrix (SAM) for 2015. The results show that environmental tax has negative effects on gross domestic product with the energy sectors which are generally the most polluting sectors suffering higher output losses due to the environmental tax. Household consumption is significant reduced by 2.34% due to the reduction in emissions as a result of carbon tax policy. According to the study findings, policy-makers should consider an initial 5% carbon tax policy which may results in achieving reasonably good environmental quality without losing on investment, fixed capital investment and government revenue.

Keywords: GHG Emissions, CO_2 Emission, CGE Modelling, Economic Growth, South Africa
JEL Classifications: H60, Q53, Q56

1. INTRODUCTION

South Africa has recently been experiencing rapid economic growth which has also been associated with environmental pollution problem. The rising energy demand of fossil fuels and non-renewable sources in the country have triggered the greenhouse gas emissions and carbon emissions. Consequently, the effects of the pollution resulting from heavy industry carbon-emissions generating activities have had negative effects on the economy of the country. It is generally accepted that pollution brings about huge economic and health costs to the country's economy (Lu et al., 2010, Cole et al,. 2005 & Dervis et al,. 1982). Most countries initiated environmental regulations and tax policies to limit the industries use of coal, oil, and other non-renewable energy sources. Hence, the investigation into the efficacy of these policies among countries who have implemented such policies.

To control the heavy pollution from the energy industries, the South African government enacted the carbon tax policy designed to ensure safe and healthy environment through effective regulation of the emission of pollution generating activities into the environment. The policy tool is in line with the International Labour Organization (ILO) recommendation that pollution mitigation and adaptation efforts on climate change are obligatory to reduce its ramifications on the human existence. The South African's Carbon Tax Bill has the intention of building an effective climate change response and a long-term transition to a climate resilient and lower-carbon economy and society. The bill is envisaged to provide some form of motivation for large emitters of greenhouse gas (GHG) to reduce their emissions. According to the bill, the rate of the carbon tax on GHG emissions must be equal to R120 (at 7.05 USD) per ton of carbon dioxide. Furthermore, in order to ensure a smooth transition to a low carbon economy, a number of transitional tax-free allowances were suggested (Department of Environmental Affairs, 2019).

Environmental tax is believed to be an effective measure to build low-carbon and sustainable economies. However, the appropriate and desired tax level is still debatable and inconclusive. Other studies argue that the tax level should be sufficiently higher to meet the emission target (de Elzen et al., 2007), yet other studies state that the tax level should be equal to the social cost of carbon (Tol, 2005). Studies by Floros and Uvlacho (2005) confirmed that carbon tax could slow down climate warming, yet Lee (2008) argue that the tax does have negative effects on global warming. This, however, doesn't mean that a carbon tax in South Africa would not have significant effects on the economy. Most studies on the impact of carbon tax applied partial equilibrium and assumed competitive markets (Pearce, 1991). The current study differs from previous studies by applying a multisectoral general equilibrium model for energy and environmental policy analysis for the modelling of carbon tax. The effects of carbon tax on the economy and emissions are analysed separately as carbon tax could change the structure of income distribution in the economy (Garidzirai, 2020; Putra et al., 2021; Hieu, 2022).

Even though it has been established that the climate change has a severe impact on the society, a limited number of studies exist regarding this matter in the South African context. It is thus very important to have an integrated assessment of the impact of environmental policy on the South Africa economy. Apart from the contribution to literature in the area of climate change, a country-oriented inquiry such as the current study is essential for more targeted policy intervention in the country and other developing nations.

Therefore, the aim of the study is to investigate the impact of carbon tax on inclusive growth and environmental quality in South Africa. In order to achieve this, the study will analyse the cumulative effects of the tax levied on energy commodities by adopting an environmental static CGE model for South Africa and apply different degrees of carbon tax into the economy.

The rest of the paper is organised as follows: section 2 provides literature review, section 3 outlines data and simulation techniques. Section 4 analyses results and the section 5 provides conclusion and recommendations.

2. LITERATURE REVIEW

The relationship between the environment and economic development are fundamental, and as a result, the issue of climate change has captivated scientific interest in both developing and developed countries. The scientific evidence in this matter is illustrated by the various studies ((Zafeiriou and Azam, 2017; Zou, 2018; Park et al., 2018; Wier, 1998; Haseeb et al., 2019; Agboola and Bekun, 2019). These studies empirically tested the relationship between several economic drivers and Carbon Dioxide (CO_2) emissions and hence examined the concept of Environmental Kuznets Curve (EKC) using different approaches, time periods and different countries or regions. Serdeczny et al. (2016) warned that in the Sub-Saharan African region the consequences of climate change will be experienced in numerous ways through both natural and human systems. They maintained that the prognoses for region point to a warming trend in the inland subtropics; repeated occurrence of extreme heat events; increasing aridity; and changes in rainfall.

Environmental taxes are an efficient policy instrument to decrease GHG emissions and enhance environmental protection. These environmental taxes and subsidies also do have the effect of generating revenues or new public expenses that can be included in wider projects of greening the public intervention in the economic system. Despite these premises, the actual implementation of the carbon taxes in developing countries has often lagged behind their full potential (IEEP, 2014; EEA, 2016). In some cases, their design and contents have influenced their effectiveness and impact, which, to date, have been relatively small, leading to marginal changes in the fiscal system. In other cases, the shrinking of environmental tax bases and the non-increase of nominal rates have provoked a progressive downward tendency of revenue shares (Strout, 1985; Kosonen, 2010; OECD, 2017).

In South Africa, carbon taxes which were explicitly introduced for environmental purposes represent a very insignificant share of total environmental tax revenues, while no resource tax is reported in the database. More recently, environmentally-related concerns increasingly influenced the implementation and design of new instruments – as in the case of the auctioning of tradable permits. The effectiveness of the carbon-tax was studied by many authors, and the results differ according to the impact and objectives. The study joins the Pigouvian tax is implemented on those goods which create negative externalities; the main aim of such taxes is to make the price of a good equal to social marginal costs and create socially efficient resource allocation tax theory, which deals with the environmental charges by adding the carbon-tax into total charges.

A number of empirical studies have been carried out in both developing and developed countries to assess the impact of carbon tax on the economy (Forsund, 1988; Copeland at al., 1994, Jorgenson and Wilcoxen, 1990; Reinert and Roland-Holst,2001& Levinson , 2004). Recently Karen Fisher-Vanden and Ian Sue Wing (2007) employed a CGE simulation of the Chinese economy for climate policy analysis. The authors constructed an analytical model to show that efficiency-improving and quality-enhancing R&D have opposing influences on energy and emission intensities, with the efficiency- improving R&D having an attenuating effect and quality enhancing R& D having an amplifying effect. They found that the balance of these opposing forces depends on the elasticity of upstream output with respect to efficiency improving R&D, the elasticity of downstream output with respect to upstream quality enhancing R&D occurring upstream, and the relative shares of emissions intensive inputs in the costs of production of upstream versus downstream industries. They construct a theoretical model in which there are two industries, one upstream (U) and the other downstream (D), where the latter uses the output of the former as an input to production. The numerical economic simulations using the CGE model of China's economy which is calibrated based on econometric estimates of the sectoral impacts.

Callan et al. (2009) studied the effects of tax policies on the carbon and the recycling of the incomes through the distribution of income in the Irish Republic. The study argued that a tax on the carbon of €20/t CO_2 would cost the poor households less than €3/week and the richest households of more than €4/week. A tax on carbon is regressive; therefore, the revenues from taxes are used to increase the social security benefits and the tax credits. The households through the distribution of income can be better without exhausting the revenues from taxes carbon total.

Beghin et al. (1997) developed a theoretical computable general equilibrium (CGE) model (applied in Chile 2003) which underlies six country case studies. The research describes the base model specification for a series of six country case studies undertaken at the OECD Development Centre to analyze the links between growth and emissions, and emissions and trade instruments. The CGE model of this research attempts to capture some of the key features relating to environmental emissions. Lu et al. (2010) investigated the impact of the tax on carbon for the case of China. By building a model of recursive balance general dynamics, the authors have examined the damping effects of the complementary policies. The authors studied the role of taxes and the effects of damping of the complementary policies by building a model of recursive balance general dynamics. The simulation results identified that the carbon-tax is an effective political tool because it can reduce the pollution level by mitigating the carbon level. The dynamic EGC analysis proves that the impact of the carbon-tax on GDP growth is relatively small, while the reduction in carbon emissions is relatively large.

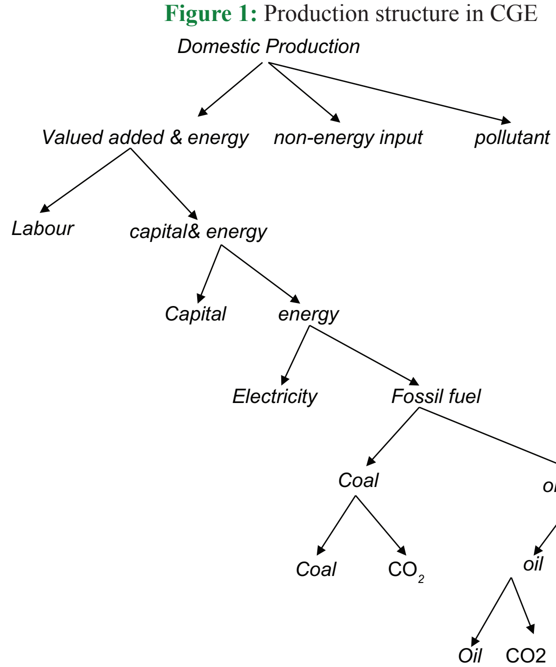
Robinson (1990) developed a two-component general equilibrium framework to evaluate the efficiency of two policy instruments - pollution taxes and government pollution cleaning - in an economy where pollution is treated as a public good. The first component is a CGE model which incorporates pollution and pollution cleaning. Pollution is generated as a fixed-proportions by product of certain production activities and enters the households' utility functions as a public good. Pollution cleaning is undertaken by the government and financed via Pigouvian taxes. For an exogenously determined pollution cleaning and specified tax rate, the solutions of the CGE model satisfy the market equilibrium conditions but are not welfare maximizing. This happens because the amount of the public good, pollution and its price, the Pigouvian tax, are not optimally determined, i.e. they do not maximize social welfare. Using an iterative nonlinear optimization procedure (the second component), Robinson maximizes the social welfare function corresponding to the economy simulated in the CGE model over the values of the policy instruments. Since his CGE model contains only one consumer, the social welfare function is equivalent to the representative consumer's utility function.

Based on the literature review, there is overwhelming scientific evidence about the effects of CO_2 emission on climate change. carbon emissions have been considered a grim global threat which demands an urgent global response. The most worrying matter is that air pollution is not only affecting Mpumalanga only, but the satellite data shows that the whole country is affected by the pollution which blows across (Meth, 2018). As raised by the Department of Environmental Affairs (2019), the concern is that climate change caused by the impact of the air pollution, as indicated, continues to negatively impact the South African economy directly and indirectly, thus posing a threat to people's livelihoods. It has been estimated that more than 53% of South African citizens are largely affected by climate change. This indicated a high level of vulnerability and the extent to which people's livelihoods were threatened mainly due to hunger and drought posed by climate change. This study therefore seeks to analyse the macroeconomic effects of limiting carbon emissions by measuring the economic gains and loss on the carbon tax policy

3. METHODOLOGY

The above-mentioned studies have used several environmental techniques to analyse the effects of carbon tax policy. In this study, a macroeconomic approach was chosen. The CGE model adopted for this study comprises of three main modules which are the production module, foreign account module, domestic demand module and the final demand module with a nested structure consisting of constant elasticity of substitution production. Total sectoral output is determined by value-added and energy which are composed of intermediate input from energy and non-energy input. As in Li and Masui (2018), the energy input is disaggregated into electricity inputs and fossil energy. The consumption of different fossil fuels is used to calculate carbon emissions. The CGE model was calibrated using the General Algebraic Modelling System (GAMS) language which was solved using the Mixed Complimentary Programming (MCP) problem. Scale and share parameters were captured in a Microsoft excel file which is used into GAMS via the Data Exchange (GDX) file. Using this model, two carbon tax rates (5% and 10%) were simulated in line with the department targets, and these carbon tax rates were calculated

Figure 1: Production structure in CGE



Adopted from Li and Masui (2018)

by multiplying the exogenous carbon tax with the carbon content per unit of domestic production (Figure 1).

The dataset used for this study is the Internal Food Policy Research Institute (IFPRI) social accounting matrix for 2015. The model parameters are specified based on previous studies and empirical literature. For the purposes of this study, the paper adopted the shared socioeconomic pathway framework based on O'Neill et al., 2014 to construct modeling scenarios based on different carbon tax levels. These scenarios include Business as Usual, low carbon tax rates and high carbon tax rates, and these are designed to assess the policy impacts of envisaged environmental protection act. Since carbon dioxide emissions vary among different economic sectors, the energy sector is disaggregated to have a deeper understanding of the policy implication especially on energy generation sectors which are the main emitters of carbon dioxide.

4. RESULTS AND DISCUSSION

Using the IFPRI South Africa CGE model, the impact of carbon tax as an environmental policy are examined from the different policy simulations. This section presents the results obtained from different policy simulations carried out using CGE modelling designed in this study. The simulations carried out are based on IFPRI SAM of South African economy. Table 1 shows the simulation results of the policy impacts on the macroeconomic indicators, including GDP, household consumption, government consumption, export, and import. The numbers in the brackets are the percentage changes compared to the BaU scenario.

To capture the economy-wide effects of the carbon tax policy, a 5%- and 10%-unit carbon tax is imposed on the model where the unit of carbon tax is calculated by multiplying the exogenous carbon tax with the carbon content per unit domestic production. Changes in CO_2 emission is given by the difference between the baseline value and the simulated value and the effects of the tax are for the short run. Table 1 shows the impact of carbon tax on carbon emissions and effects on macroeconomic variables.

The results showed that the imposition of carbon dioxide tax reduces carbon dioxide emissions, which is a good move towards environmental sustainability. However, the reduction in carbon tax is also associated with a decrease in domestic production, real and nominal GDP and household consumption. A reduction in carbon emission by 1.42% leads to a reduction in real GDP by 1.17% while a 2.75 reduction in carbon emissions reduces real GDP by 2.45%. This reduction in carbon emission due to the imposition of carbon tax will reduce household consumption 2.34% and at 4.39 %. The only noticeable positive change was observed in government revenue and investment. The study results showed that household consumption decreased by 2.34% at 5% carbon tax and at 4.39% at 10% level of carbon tax from the baseline. As the tax rate increases, welfare is decreased due to loss in household consumption and an increase in household tax by almost 2%, which is a major setback to inclusive growth which is a major policy objective for National Development Plan (NDP) 2030.

Table 1: Empirical results

Sectors	% change from BaU	
	5% carbon tax	10% carbon tax
Carbon dioxide emission	–1.42	–2.75
Domestic production	–0.377	–1.75
Energy sector output	–4.388	–6.882
Real GDP	–1.172	–2.450
Government revenue	15.44	20.83
Household consumption	–2.339	–4.386
Investment	0.431	0.09
Exports	–4.740	–5.774
Household tax	1.983	2.689
Household consumption share of GDP	–0.452	–0.810

Source: Author's calculations, based on simulation results

More specifically, the results showed that the imposition of carbon tax on domestic production sectors reduce the carbon emissions. A 5% and 10% simulation indicate that imposition of carbon tax result in lower carbon emissions, domestic production, exports, energy sector production, real GDP, Household consumption share of GDP (Table 1). However, the government revenue is positive in all the simulations in 5% tax (15.44) and 20.835 at 10% carbon tax level. investment share of nominal GDP is positive (0.43%) at 5% tax and 0.09% at 10% tax which showed that investment is higher at low level of carbon tax than when the carbon tax becomes higher (10% carbon tax).

The results showed that the imposition of successively higher carbon tax (5%- and 10%-unit carbon tax) result in 1.42%, and 2.57% reduction in carbon emissions respectively. However, these reductions in carbon emissions are associated with significant decrease in economic performance. Real GDP decreased by 0.37%, and 1.75%. Output in the energy sector which are generally the major polluters, decreased by 4.39% and 6,88% respectively Exports decreased by 4.74% and 5.77% while household consumption decreased by 2,34% and 4.39%, respectively. Household consumption as a share of GDP decreased by 0.45% and 0,81% respectively. However, government revenue increased by 15.44% and 20.83%.

5. CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to adopt an environmental CGE model to analyse the impacts of an environmental tax on the South Africa economy. The results from this study are in line with the principles of environmental management, especially the polluter pay principle. This study suggests that an initial carbon tax can be applied for the central purpose of reducing the rate of growth of carbon emissions. The study findings provide several suggestions and message to policy makers, who are considering carbon taxation policy together with economic development. This study serves as a guide to selection of more feasible and appealing environmental policies.

From the results, the increase in carbon tax leads to a decrease in the level of pollution generated by the energy sector. However, the decrease in carbon emissions is associated with decreased production, which translates to a significant decrease in real GDP. This study recommended that for analysis of the full distributive and accumulative impacts of the environmental policy the model should be extend to include other pollutants associated with environmental pollution such as nitrogen and sulphur dioxide.

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