ENERGY EMISSIONS INPUT-OUTPUT ANALYSIS IN SOUTH AFRICA

BY

SHOMENTHREE MOODLEY

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Acronyms

CGE	Computable General Equilibrium
CH_4	Methane
CO_2	Carbon dioxide
CO_2 eq	Carbon dioxide equivalent
CPI	Consumer Price Index
DEAT	Department of Environmental Affairs and Tourism
DME	Department of Minerals and Energy
DOE	Department of Energy
EIA	Energy Information Administration
GDP	Gross Domestic Product
GEAR	Growth Employment and Redistribution
GHG	Greenhouse gas
Gt	Gigatonne
GW	Gigawatt
GWh	Gigawatthour
IEA	International Energy Agency
IO	Input-Output
IPCC	Intergovernmental Panel on Climate Change
kg	kilogram
kl	kilolitre
MW	Megawatt
MWh	Megawatthour
N_2O	Nitrous oxide
OPEC	Organisation of Petroleum Exporting Countries
PPI	Producer Price Index
PV	Photovoltaics
RDP	Reconstruction and Development Program
SAM	Social Accounting Matrix
TJ	Terrajoules
toe	tonne of oil equivalent
UNFCCC	United Nations Framework Convention on Climate Change

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Abstract

Given the energy intensive nature of the South African economy and the country's dependence on fossil fuels, the reduction of greenhouse gas (GHG) emissions poses a serious problem to poverty alleviation, economic growth and employment. This study assesses the inter-industry and macro-economic impacts of carbon dioxide emissions reduction in South Africa. A monetary energy input-output table was developed using data from supply and use tables and a physical energy-emissions input-output table was developed from the national energy balance and the country's GHG inventory. Both tables were used to develop the energy-emissions input-output model.

Carbon dioxide taxes and energy subsidy reform were selected as potential economic policy instruments for analysis in South Africa. The energy-emissions input-output model was used to analyse the implications of the selected policy scenarios in terms of their effect on gross domestic product (GDP), employment, household consumption, energy consumption and energy emissions reduction.

According to the energy-emissions input-output model developed in this study, financial and community services, construction and accommodation and machinery and equipment have the largest final demand and value added while nuclear energy, natural gas and biomass have the smallest final demand and value added.

Renewable energy is labour intensive but not energy intensive as this energy sector has the highest labour to value added and the lowest energy to labour and energy to value added ratios. The petroleum products sector is the least labour intensive and the most energy intensive as it has a low labour to value added ratio and high energy to labour

and energy to value added ratios. For every one unit increase in biomass, renewable energy and nuclear energy results in the largest increase in output, income and employment while machinery and equipment, natural gas and gold and other mining sectors have the lowest increase in simple and total output, income and employment multipliers.

There is not much movement between natural gas, nuclear energy, renewable energy and biomass and the rest of the economy. Coal and crude oil have a relatively moderate impact and are moderately impacted on by other industries in the economy. Although almost all other industries in the economy depend heavily on electricity and petroleum products, these two industries are not as heavily dependent on other industries.

Coal is responsible for the largest direct primary energy emissions followed by crude oil while natural gas; nuclear energy, renewable energy and biomass have a low direct impact. The electricity sector accounts for the highest indirect impact on coal emissions and petroleum products have the highest indirect impact on crude oil emissions. The petroleum products sector has the highest indirect impact on natural gas emissions.

The electricity sector is largely responsible for the direct impact on coal emissions in terms of total economic output and the petroleum products sector accounts for all crude oil emissions from output. Natural gas, renewable energy, nuclear energy and biomass have no effect on direct emission output ratio. The iron and metals sector has the largest direct impact on electricity emissions per output and transport and communication has the highest direct impact on petroleum products emission per output. The largest indirect coal pollution per output impact is in the electricity sector,

followed by petroleum products and iron and metals, while machinery and equipment has the smallest indirect impact on coal emissions per output. Petroleum products have the largest indirect crude oil pollution per output and the petroleum products sector is the only sector with an indirect impact on natural gas emissions per output.

The iron and metals sector has the largest indirect electricity emission per output followed by household consumption and financial and community services while natural gas has the smallest indirect electricity emissions per output followed by machinery and equipment. Nuclear energy, renewable energy and biomass have no indirect petroleum products emissions per output. Machinery and equipment and crude oil have the lowest indirect petroleum products emissions per output.

Inter-industry analysis indicates that the tax on coal results in the largest decrease in total output in the electricity and petroleum products sectors while output in the petroleum products and gold and other mining sectors decreases the most with the tax on oil. The tax on electricity has the largest negative impact on the iron and metals and financial and community services sectors and the tax on petroleum products results in the largest decrease in the transport and communication and financial and community services sectors. The electricity and coal mining sectors suffer the largest decrease in output as a result of energy subsidy reform.

Macro-economic impacts were analysed according to real and marginal decreases. Real changes were used to assess the impact of each policy in terms of direct changes to each specific variable. Marginal decreases were calculated as a ratio of decreasing GDP for each variable hence marginal employment equals change in employment as a

ratio of change in GDP and marginal household consumption equals change in household consumption as change a ratio of change in GDP. Marginal excess burden of taxes was calculated as changes in tax revenue, as a ratio of decrease in GDP. In terms of decreasing GDP, employment and household consumption, the lower the marginal burden the better the policy.

Although the tax on coal offers the highest reduction in real energy emissions, this scenario also results in the highest reduction in GDP, employment and household consumption. Therefore the coal tax is not considered as the best option for carbon dioxide emissions reduction in South Africa.

The electricity tax offers a moderate reduction in real energy emissions, GDP, employment and household consumption. It is concluded that the electricity tax could be an option for carbon dioxide emissions reduction in South Africa. However energy subsidy reform offers higher energy emissions reduction and a moderate reduction in GDP, employment and household consumption. This scenario is recognised as the most efficient option for carbon dioxide reduction in South Africa in terms of real changes.

The tax on coal indicates high marginal decreases in employment and household consumption, moderate marginal tax revenue and moderate marginal decrease in energy consumption and energy emissions reduction. The tax on crude oil indicates low marginal decreases in employment and household consumption, low marginal excess burden on taxes, low marginal decrease in energy consumption and a moderate marginal decrease in energy emissions.

The tax on petroleum products indicates low marginal decreases in employment and household consumption, low marginal excess burden on taxes and a high marginal decrease in energy consumption and energy emissions. Energy subsidy reform offers moderate marginal decreases in employment and household consumption, low marginal excess burden on taxes and a low marginal decrease in energy consumption and energy emissions.

The comparison of marginal burdens of energy emissions reduction policies indicates that energy subsidy reform offers the best option as this scenario has moderate marginal decreases in employment and household consumption, low marginal excess burden on taxes and a low marginal decrease in energy consumption and energy emissions. The tax on crude oil is selected as the second best alternative as this scenario has low marginal decreases in employment and household consumption, low marginal excess burden on taxes, low marginal decrease in energy consumption and a moderate marginal decrease in energy emissions.

Therefore in terms of real and marginal reduction in energy emissions, energy consumption, GDP, employment and household consumption, energy subsidy reform proves to be the best policy instrument in terms of energy emissions reduction, energy consumption, poverty alleviation, economic growth and employment.