Modelling Carbon Pricing on Balance of Trade

IMPLICATIONS OF A GLOBAL CARBON CHARGE ON ECONOMIES IN SUB-SAHARAN AFRICA

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Introduction

Global trade flows are increasingly gaining traction in the global climate policy discourse. Peters *et al* note that between 1990 and 2008 alone, international trade was responsible for the displacement of 16 Gt CO2 from Annex B to non-Annex B countries. (Peters, Minx and Weber)

Increased research in the development of Multi-regional Input-Output Tables (MRIO) which encompass global supply chains now facilitate comprehensive analysis of both territorial and consumption-based emissions across world regions, including sub-Saharan Africa.

The sub- Saharan Africa region contributes minimally to the overall global climate burden. Economies in the region are endowed by natural resources but are characterized by very low levels of domestic manufacturing activity. As a result, these economies rely heavily on imported consumer goods from Annex 1 and Annex B countries. Such goods include automobiles, electronics, and processed agricultural products as well as manufactured textiles.

This term paper aims to first quantify production-based emissions and territorial-based GHG emissions for this region. In its fifth assessment report of the Working Group II, the Inter-governmental Panel on Climate Change (IPCC) defines carbon footprinting and outlines the objectives of performing carbon footprint analyses, including targeting and tracking the progress of mitigation efforts, forecasting the outcomes of certain policy actions and lastly, in order to assess the appropriate baselines for levying carbon taxes.

The latter objective is the core focus of this paper. In its second phase, this paper will assess the impact of a uniformly applied carbon charge on trade and emissions mitigation in the region. The 2015 Paris Climate Agreement proposes the application of a carbon charge per ton of carbon emitted into the atmosphere, with proposals of approximately $40 -$50 per ton of carbon emission.

Research Question

The two overarching research questions for this paper were:

1. What is the additional carbon footprint due to final demand in sub-Saharan Africa?

2. How can a uniformly-applied carbon charge effectively mitigate emissions in economies with a trade emissions deficit?

Hypothesis and Assumptions

The overriding assumption of this paper is that a deficit of both trade and carbon emissions occurs the destination region if its consumption based emissions does not exceed its territorial-based emissions.

Scope of Study

The geographical focus of this analysis is the sub-Saharan Africa region. The region forms a contiguous trading block with the rest of the world. Further, the sub-Saharan Africa region is consistently ranked low among the world's emitters. The region is overall responsible for a paltry 3.2% of the global climate burden, and South Africa alone accounts for half of this value. Mining, Oil and Gas, Agriculture and the automobile industry were the key primary sectors evaluated.

Methodology and Data Description

The specific data set developed and used in this analysis was the Input Output table developed in 2012 and sourced from the EXIOBASE central data source for global input and out-put analyses. The IOT data set provides data generated distinctly for both the South Africa and the rest of Africa, thus allowing for clear and separate carbon footprint and trade volume analysis for the Rest of the World — including South Africa — and Rest of the World Africa. For the purposes of this analysis, these regions are denoted as RoW and RoA respectively.

To help effectively answer the key questions of this study, the methodology was organized into three key sequential steps as described below.

1. Diagonal of the Matrix of Final Demand

I first diagonalized the y matrix to obtain the consumption based and territorial emissions. Secondly, I defined the Leontif inverse and then normalized the inter-industry flow matrix Z for the input-output flows between the rest of the world to sub-Saharan Africa, as described by the system of equations below, which stems from the structural decomposition analysis first postulated by Leontief in 1936.

$$\begin{aligned} Ax + y &= x \\ y &= x - Ax = (I - A)x \\ x &= (I - A)^{-1} \\ y &\equiv Ly \end{aligned} \qquad \text{(Equation 1.)}$$

Where;
A is the input per unit of output in Z
x_{RoA} *is the total output of Rest of the world Africa*
'y_{RoA} *is the flow to final demand in rest of the world Africa*
I is the identity matrix such that:

$$I = \begin{matrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{matrix}$$

L is the Leontief inverse

2. Characterization Matrix and Footprints' Multiplier

I defined the characterization matrix to obtain the multiplier for the four footprint categories analyzed per unit of final demand. The footprints analyzed were Ecological, Land, Water and Carbon footprints.

3. Deficit Analysis

The four footprint factors and the economic factor were each multiplied by the difference between the territorial-based emissions and the consumption-based emissions to obtain the emissions deficit between RoW and RoA.

$$D_{Afr} = \sum_{Ci}^{Tn} YD * [CFM]^T \quad \text{(Equation 2.)}$$

Where;

D_{Afr} is the carbon footprint deficit in RoA

YD is the total difference in final demand between territorial and consumption-based demand summed over matrix vectors of first indexed consumption to final matrix vector of territorial demand

$[CFM]^T$ is the matrix transpose of the carbon footprint emission factor multiplier

4. Carbon Pricing Analysis

Using the three range values for the social cost of carbon as recommended by the US government' Inter-Agency Working Group, I dynamically modeled the tax gains under each price scenario. These range values include $11, $39 and $46 all levied per ton of CO_2 in total carbon footprint deficit. It was also assumed that the carbon charge was implemented in the form of a border adjustment tax.

Results

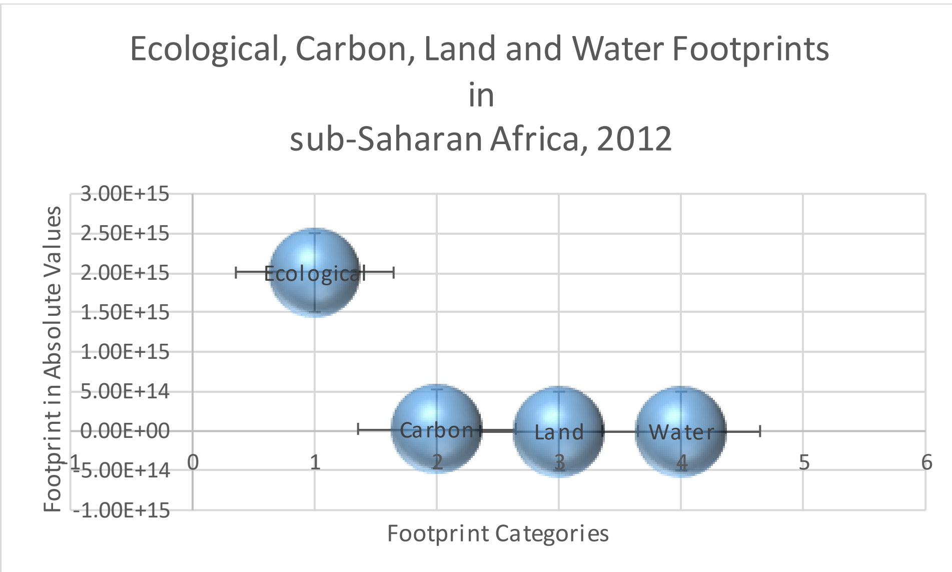
In 2012, sub-Saharan Africa, excluding South Africa, imported additional products and services of a value of Euros €3.55 billion that it exported to the Rest of the World and South Africa.

Despite the trade deficit, the region had a positive carbon deficit in the same year. Imports into the region in 2012 accounted for an additional $2.8*10^{10}$MT of CO_2 (eq) from trade imports of carbon intensive products.

Figure 1. Carbon Footprint from additional trade vs Economic Trade Deficit of Sub-Saharan Africa (excluding South Africa) with the rest of the world in 2012.

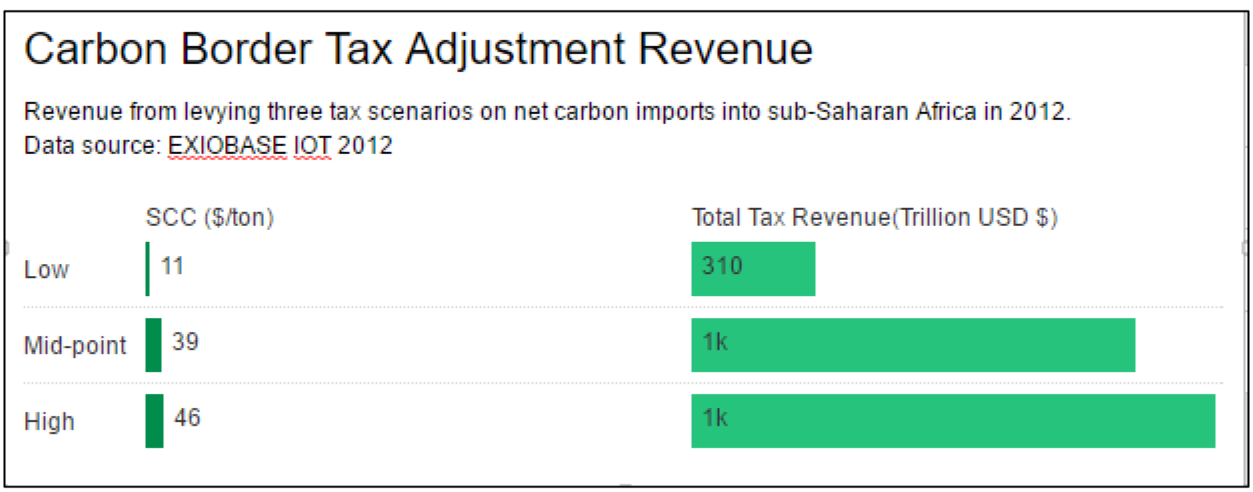
The deficits above represent a deficit of 8000 Mt per additional Euro of import. When normalized by population figures in sub-Saharan Africa in 2007, the implied deficit is 0.01 grams per person per Euro per Year. (0.01g/person/Euro/Year)

Figure 2. Ecological, Carbon, Land and Water Footprints of sub-Saharan Africa in 2012 Absolute Values



Ecological footprints, measured in (non-trade linked) ranked highest, followed by carbon, land and water footprints respectively. It is however worth noting that the constituent components of the ecological footprint value are land and water footprints.

Figure 3: Carbon Tax Revenue from net carbon imports in sub-Saharan Africa, 2012.



Based on the three IAWG SCC scenarios, the least total potential tax revenue that can be collected from the implementation of a carbon charge on net imports into the sub-Saharan Africa region is $310 billion for the year 2012. Inflation-adjusted values for the SCC as well positive or negative growth in the carbon deficit will be key in determining the total tax revenue that can be collected in future time periods.

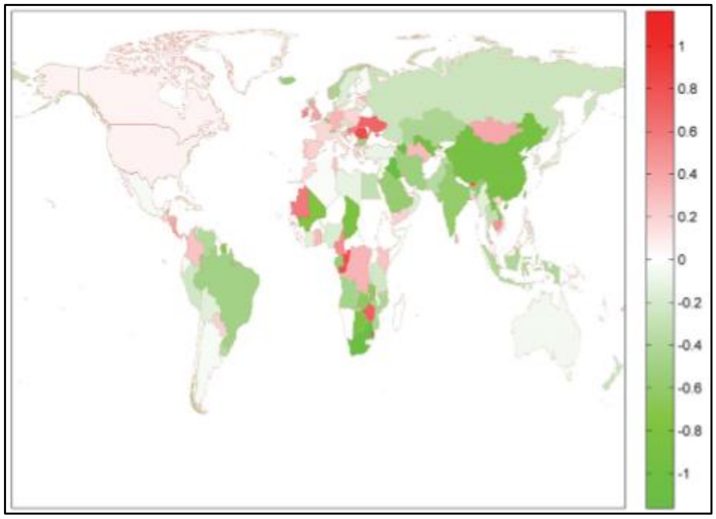
Discussion

Malik and Lan refer to countries that outsource carbon intensive products from other countries as "outsourcers." The concept of emissions outsourcing is also reinforced by Aichele and Felbermay who allude to stringency in environmental regulations in certain jurisdictions as a key factor for countries to outsource emissions from other jurisdictions that have lax environmental regulations. They argue that policy stringency has subsequently led to the occurrence of 'carbon leakage' which is essentially defined as a state of 'regulatory arbitrage' where high levels of regulatory stringency lead to price changes and which in turn result in the movement of the production of carbon intensive goods to jurisdictions with lax regulatory policies.

While this concept holds true in evaluating cumulative global carbon leakage from jurisdictions such as the European Union or North America as well as the manufacturing effects in large 'carbon sinks' such as China and India, the scenario in sub-Saharan Africa could not be more different. Excluding South Africa, the outsourcing of carbon intensive products by many sub-Saharan African economies to the rest of the world is nether the result of a conscious nor rational investment decision but is rather due to pre-existing inefficiencies in domestic production by poorly competitive economies in the region. UN DESA cites unfavorable market liberalization policies as among reasons which limit the competitiveness of these economies. Because of this state, economies in sub-Saharan Africa are compelled to import more than they export and the imbalance in trade, as described in figure one has led to an overall net importation of carbon emissions embodied in products used in the region.

Hertwich and Peters note that on average, the per capita footprint in African countries is about 1 tCO2e/y national. For perspective, this value increases up to an average of 30 tCO2e/y in developed countries such as Luxembourg and the United States. However, the findings of this paper interestingly suggest that the per capita carbon footprint deficit due to final demand in RoA lies on the upper bond of this range. The carbon deficit of total net carbon imports in the region was 2.8+E10 MT of CO_2 (eq). When normalized by the region's total population in 2007 figures, the per capita carbon footprint in sub-Saharan Africa is 35 MT CO_2 (eq) per person in the year 2012. This large value could potentially be due to outlier effects in 2012.

Figure 4. Leaks and Sinks from Outsourcing. Malik and Lan. 2016.



The findings of this paper were also divergent from Malik and Jan's visualization of global sinks and leaks specific to outsourcing activities, where the red and pick regions represent countries which import more carbon intensive products from other countries while the green zones represent carbon sinks which have high levels of domestic manufacturing activities In the paper, they note that carbon emissions have grown in some African countries because of growth in the export of natural resources, including, minerals, crude oil and agricultural commodities. Their findings show that with the exception of 8 countries and regions which had incomplete data, the region is largely a carbon sink. Their conclusion differs from what this paper finds to be an existing carbon import deficit in sub-Saharan Africa which implies that, in 2012, there was a net import of carbon into the region, effectively qualifying it as a carbon 'outsourcer.'

Because of limitations of available and granular inter-regional trade flow data points in the IOT 2012 data set, the tax gains from the implementation of a border tax adjustment on territorial emissions in RoA were not considered at the time the research was conducted.

In the final step in the analysis was the modelling of the net tax revenue gains realized in RoA from a carbon charge levied on the carbon footprint deficit in the region. Additionally, the potential tax gains from bilateral trade between RoA and each of its five top trading partners were quantified. This latter analysis provides a benchmark for which policy makers working on mitigation strategies which intersect trade and the environment could potentially use to model implementation measures.

Charging a carbon tax on the net carbon imports has the potential to raise an additional USD$350 billion per year for sub-Saharan African economies. The collection of this taxes in the destination region is the implementation policy with a greater distributional impact.

Conclusion and Future Analysis

Because the IOT data set only includes input-output data specific to the year 2012, this analysis did not consider any benchmark estimates and was therefore limited in its ability to forecast growth in the carbon emissions deficit relative to future trends in the economic deficit from global trade in sub-Saharan Africa.

This limitation notwithstanding, the analysis is useful in providing a snapshot of how emissions deficit tracks with trade deficit in low and middle income economies such as those in the sub-Saharan Africa region. Peters, Minx, Weber et al make a case for the active monitoring of emissions transfers via international trade in order to ensure that policies which are implemented to address global Greenhouse Gas Emissions are appropriate and effective.

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