Professional Agricultural Workers Journal

Volume 3
Number 1 *Professional Agricultural Workers Journal (PAWJ)* 11

9-25-2015

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THE REAL COST OF GOING CLEAN: THE POTENTIAL IMPACT OF SOUTH AFRICA'S 2016 CARBON TAX ON AGRICULTURAL PRODUCTION

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Abstract

From 2016, South Africa will implement a carbon tax. The study analyzed the design of the tax and utilized a Computable General Equilibrium model to estimate the impact that the tax will have on the Agricultural Sector. The results suggest that the direct impact on the sector will be minimal; however, there are significant indirect impacts. These indirect impacts occur through the rising prices of intermediate inputs which experience more significant direct impacts of the tax. The study then dissected the indirect impacts to highlight what the key effects on the sector are likely to be. It was found that certain products will be severely hit, especially starches, dairy, sugar, fish, fruits and vegetables, meat, and forestry. While there is a key cause for concern, if the right courses of action are taken, then there is evidence to suggest that the negative impact of the shock can be significantly offset.
Keywords: Carbon Tax, Agricultural Production, Real Cost

Introduction

Starting from the beginning of 2016, producers in South Africa will be subject to a national carbon tax. The purpose of the tax is to incentivize behavior which will lead to South Africa evolving into a low carbon economy (National Treasury, 2013). The carbon tax comes at a difficult time, particularly for South Africa's Agricultural Sector. In particular, some of the key export markets for South African agricultural products have not been performing well in recent years (Western Cape Government Provincial Treasury [WCGPT], 2012). In addition, global warming and the resulting climate change means that farmers face challenging conditions under which to produce. At the same time, recent years have seen a sharp rise in the number and stringency of standards to which agricultural exporters have to comply in order to gain access into foreign markets (Wilson and Otsuki, 2004). This means that there is very little room for error, and it is important that actions are tailored to outcomes which are in line with reality.

This study utilized a static Computable General Equilibrium (CGE) model to assess what the actual impact of the carbon tax will be on South Africa's Agricultural Sector. CGE models have the advantage of being able to assess both the direct and indirect impacts of a particular shock (Lofgren et al., 2002; Wing, 2004), making it the ideal tool with which to analyze a carbon tax. The direct impact of the carbon tax will come from the tax revenue that producers have to pay based on their greenhouse gas emissions. However, assessing the full impact of the tax can be a complex procedure due to the potential for significant indirect costs which can be difficult to identify. These indirect impacts occur through the changes in the prices of intermediate inputs which are used in production. The paper continues in the next section with a brief overview of the upcoming carbon tax. The following section then discusses the methodology used in the impact assessment, followed by the results of the assessment. Finally, the paper ends with some concluding comments.

The 2015 Carbon Tax

South Africa's carbon tax was confirmed in the country's 2013 budget speech (Gordhan, 2013). The initial date for the implementation of the tax was 2015; however, in the 2014 budget speech it was announced that the implementation date would be pushed back to the beginning of 2016 (Gordhan, 2014). The country's commitment to reducing greenhouse gas emissions is evident in numerous national and provincial policy documents. Of particular notice is the country's 2013 National Development Plan (NDP) which outlines the country's vision going forward to 2030. A whole chapter of the NDP is devoted to a transition to a low carbon economy. The plan calls for "clear long-term strategies for both adapting to the effects of climate change through adaptation policies and reducing its carbon emissions to a sustainable level through mitigation policies" (National Planning Commission [NPC], 2013, p. 180).

Phase one of this tax will be implemented from 2016-2021, and phase two set to commence after 2021. To allow for a smoother transition to a low carbon economy, it has been proposed to initially introduce a modest carbon tax of R120 (approximately US$ 9[1]) per ton of carbon dioxide equivalent greenhouse gases. The tax rate will be expected to increase at 10% per annum until 2021. This is expected to provide a significant long-term price signal to influence behavior (Andersen, 2008). After phase 1, a new annual rate of increase will have to be determined and announced in the Budget (National Treasury, 2013). The carbon price (tax base) will be determined by means of a fossil fuel input tax on coal, crude oil, and natural gases, based on their carbon content. All emission factors and procedures will be approved by the Department of Environmental Affairs (DEA) and will be in line with the International Panel on Climate Change (IPCC) (National Treasury, 2013).

The Agricultural Sector contributes significantly to greenhouse gas (GHG) emissions, mainly through enteric fermentation and manure management. As these emissions are difficult to measure and also require a complex baseline, it has been proposed that all agricultural related emissions should be excluded from the carbon tax for phase one, except for fuel-related emissions in line with those already discussed. The same thinking applies to the waste sector and these sectors will be reviewed for phase two of the tax implementation (National Treasury, 2013).

The carbon tax system will incorporate a tax-free threshold for phase one, to be reviewed for phase two. The reason for the threshold is to provide some support to address concerns of carbon-intensive sectors and businesses that are locally-based and trade-exposed regarding their competitiveness, as well as addressing some distributional concerns. The tax-free percentage threshold is expected to be reduced for phase two and be replaced with absolute emission thresholds (National Treasury, 2013). The Treasury's Carbon Tax Policy paper does not give a clear indication on how the revenue generated from the carbon tax will be recycled except to suggest some possible avenues that they could explore. These avenues include tax shifting, rebates, free basic electricity, supporting energy efficiency and demand side management (EEDSM) programs, supporting renewable energy programs, supporting public transport, and shifting freight from road to rail (National Treasury, 2013).

The successful adoption of the tax will rely heavily on the current structure of the economy, the recycling of all revenue collected from the tax, the incentives that will be provided for

[1] Based on an exchange rate of R12.1983 to US$1 as provided for by the International Monetary Fund (IMF, 2015) for 30 June 2015

both technical and behavioral changes, and how well environmental policy is coordinated with energy, industrial, trade and transport policies (National Treasury, 2013). In order to ensure behavior that will enhance and maintain economic growth, it is important to be aware of where the main pressures will come as a result of the carbon tax. The next section explains how this is done utilizing a static Computable General Equilibrium (CGE) model.

Methodology

Computable General Equilibrium (CGE) models provide a representation of an economy, linking economic activities, commodity outputs, factors of production, intermediate inputs and institutions. These relationships are based on the present structure of the economy as well as equations derived from economic theory (Lofgren et al., 2002). It, thus, allows users to obtain an estimate of the economy-wide implications of a particular shock or intervention. This study utilizes a static CGE model developed at the International Food Policy Research Institute (IFPRI) by Lofgren et al. (2002). It has been adapted and applied to the 2009 Social Accounting Matrix (SAM) for South Africa (Davies and Thurlow, 2011). For a detailed description of the South African model see Thurlow and van Seventer (2002).The South African SAM distinguishes economic activities from the commodities they produce and use intermediately in production. Thus, one activity can produce a number of different commodities and one commodity can be produced by different activities (Thurlow and van Seventer, 2002).

Ideally, a carbon tax would be applied directly to greenhouse gas emissions. This has been acknowledged as the first-best solution, but there are administrative capacity constraints which make this currently an unfeasible option for South Africa. The second-best option is to use fossil fuel inputs as a proxy for the tax base. This could be either upstream, taxing fuels as they enter the economy based on their carbon content, or downstream, taxing fuels as they are used based on their carbon content. It has been decided to introduce the carbon tax as a tax on fuel usage based on their emission factors which are to be derived from either approved emissions factors or through measuring and monitoring which is transparent and can be verified (National Treasury, 2013).

To apply a tax based on fuel usage requires emission factors to be calculated to reveal emissions per unit of fuel used. Combining the amount of each fuel used domestically in the economy from South Africa’s 2009 SAM (Davies and Thurlow, 2011) with the amount of emissions attributed to domestic use of that fuel obtained from South Africa’s 2009 Energy Balances (Department of Energy [DE], 2009), allows for an estimation of the tons of CO2-eq greenhouse gas emissions per monetary unit of each activity in the economy. The emissions calculations are shown in Table 1. In the SAM, electricity and gas are lumped together as one activity; it is, therefore, difficult to estimate the amount of emissions per unit of activity. Because of this difficulty and given that natural gas emissions are very small and, hence, will not have a strong distortionary influence, the small amount of emissions from natural gas is attributed to petroleum, giving the amounts in the “Adjusted Emissions” column. This is the same methodology used in a 2009 World Bank study of the effect of the proposed carbon tax on emissions in South Africa (Devarajan et al., 2009).

Table 1. South Africa Fossil Fuels Emission Factors, 2009

	Emissions *(Million tCO_2-eq)*	**Adjusted Emissions** *(Million tCO_2-eq)*	**Domestic Use** *(Billion Rand)*	**Emissions Factor** *(tCO2-eq per Million Rand Output)*
Coal	409.65	409.65	44.17	9 274.86
Natural Gas	2.18	0.00	89.72	0.00
Petroleum	82.28	84.46	179.28	471.09
Data Source:	*(DE, 2009)*	*Calculated*	*(Davies & Thurlow, 2011)*	*Calculated*

*Note: US$1 = R12.20 (IMF, 2015)

The carbon tax is modelled as an activity tax on activities based on their usage of the fossil fuels in Table 1 as intermediate inputs. More formally, a carbon tax rate on unit activity is applied based on the following formula:

$$c_a = \frac{r \cdot \sum_i (f_i \cdot q_i)}{a}$$

Where:

- c_a = carbon tax rate for activity a (% tax per million Rand output)
- r = carbon tax rate set as rand tax per tCO_2-eq emissions
- i = set of fossil fuels {coal; natural gas; petroleum}
- f_i = emissions factor for fuel *i* (see Table 3.1)
- q_i = total annual quantity of fuel *i* used as intermediate input in activity *a* (million rand, taken from SAM)
- a = total annual output from activity *a* (million rand, taken from SAM)

This way of modelling the tax rate requires the assumption that all fossil fuels acquired are used and also that households and firms have the same CO_2 coefficients for fossil fuel consumption.

The carbon tax rate proposed by the Treasury to be implemented in 2015 is R120 per tCO2-eq emissions. This will then go up by 10% per annum until the end of 2019 when the tax rate will be reviewed (National Treasury, 2013). Thus, the proposed tax rate will increase from R120 per ton to approximately R200 per ton going into 2020. With this in mind, a tax rate of R200 (approximately US$16[2]) per tCO2-eq emissions is chosen for the static CGE model. This is the same rate used in a similar recent CGE analysis done by the World Institute for Development Economics Research looking at South Africa (Arndt et al., 2011).

The proposed carbon tax has tax free thresholds which will be active during the initial stages (National Treasury, 2013). Due to the nature of the CGE model, it is not possible to include these thresholds into the modelling. However, this analysis is interested in identifying the potential impacts rather than trying to precisely quantify them. For this reason, modelling the tax-free thresholds is not necessary.

[2] Based on an exchange rate of R12.1983 to US$1 as provided for by the International Monetary Fund (IMF, 2015) for 30 June 2015

The modelling required the following assumptions be made:

- The Consumer Price Index (CPI) is fixed, and the Domestic Producer Price Index is flexible
- Investment is savings-driven (neo-classical). The economy's marginal propensity to save remains constant and investment adjusts to maintain equality between investment and savings.
- The exchange rate is fixed, and foreign savings can adjust. This assumption is made under the pretence that South Africa's activities do not exert a strong influence on global prices.
- All other direct tax rates are held constant, and government savings is allowed to adjust. This is important later when viewing government revenues generated through the carbon tax. We are unable to accurately model the revenue recycling due to no definitive plan for how the revenues are going to be utilized (National Treasury, 2013). However, by allowing government savings to adjust, we can get an idea of the extent to which revenues are created.
- Capital was assumed to be fully employed and activity specific.
- Land was assumed to be fully employed and mobile.
- Labor was assumed to be unemployed and mobile, except skilled labor (labor with a tertiary education) which was assumed to be fully employed and mobile. The reason for this is South Africa's high rate of unemployment among unskilled workers and shortage of skilled workers (Department of Labor [DL], 2012).

The modelling used four different scenarios to assess the main implications of the tax

i. **Elementary Carbon Tax:** This scenario is a straightforward application of the tax, the rate of which carbon is calculated to equate to R200 per tCO_2-eq emissions based on the 2009 SAM. The tax is then applied to the level of output from each activity based on this calculation. This scenario assumes that there are no behavioral changes resulting from the tax
ii. **Carbon Efficiency:** The elementary carbon tax is applied, but it is assumed that the tax effectively incentivizes firms to become less intensive in their use of GHG emitting inputs. This is modelled through a 20% decline in the use of both petroleum and coal across all activities. We assume this is observable, so the tax rate on activity adjusts accordingly with the change in the use of intermediate inputs
iii. **Alternative Electricity**: The elementary carbon tax is applied, but it is assumed that there is a push for South Africa to produce alternative, cleaner energy. As shown in Section 2, the energy sector is the largest contributor to GHG emissions. This is largely due to the high reliance on coal in electricity production (Winkler, 2007; Dabrowski et al., 2008; South African National Energy Development Institute [SANEDI], 2011). As shown in Table 1, the use of coal results in very high GHG emissions. We model this push for cleaner energy as a 50% decline in the intermediate use of coal for electricity production.
iv. **Agriculture Tax-Free:** This scenario is the same as the "elementary tax" scenario, but agricultural activities are not taxed. This will remove the direct impact of the tax and highlight the degree to which the agricultural sector will be impacted indirectly.

The actual percentages used are not of great significance; the model is representing a system that is extremely complex and large. The modelling provides an accurate representation of the South African economy to the greatest extent possible. In addition, due to the nature of the general equilibrium model as well as the constraints imposed by data availability, the modelling is a reasonable approximation of the situation in the economy. As such, it should not be used as a forecasting tool but rather as a tool to reveal the impacts a shock may have on the economy given its current structure. With this in mind, the concern is more with the relative changes and the directions in which they occur and less with the absolute magnitude of impacts. The next section reports on some of the key changes which were observed under the modelled scenarios. While not exhaustive, the section highlights the impacts which are likely to have the biggest bearing on agricultural production.

Results and Discussion

As discussed, agricultural emissions mainly occur through enteric fermentation and manure management which are not included in the emissions tax base for the roll out of the tax. Despite this, the CGE model revealed a significant change in agricultural activity resulting from the carbon tax.

Figure 1 shows the change in domestic agricultural activity after the modelled carbon tax is implemented. Under the elementary tax, agricultural activity dropped by approximately 7.3%. The "carbon efficiency" and "alternative electricity" scenarios indicate the outcome if producers change behaviour and become more fossil fuel efficient. Under both of these scenarios most of the negative impact is offset, with activity falling by only approximately 2.3% under "carbon efficiency" scenario and 2.9% under the "alternative electricity scenario.

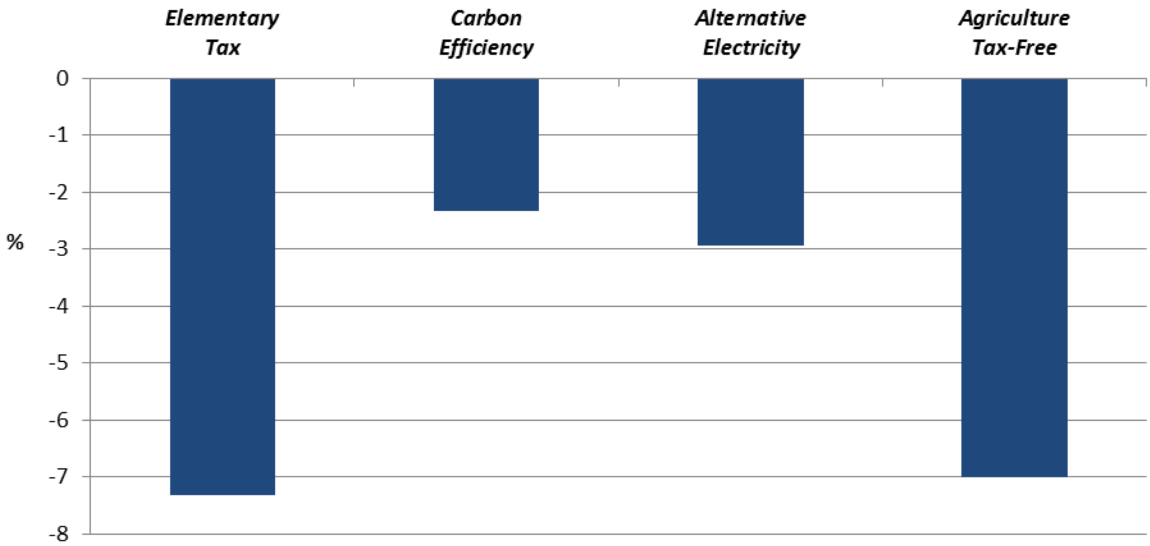

Figure 1. Percentage Change in Domestic Agricultural Activity Output Resulting from Carbon Tax

It should be noted that the modelling assumes that the behavioral changes are able to occur without cost as preferences change. In reality, there may be costs as firms are required to research and adopt new technologies or undertake production methods which are less efficient. If it were not less cost efficient, then firms would have adopted these methods of their own accord. Here there may be an important role for the State, to use the new tax revenues from the tax to take on these extra costs to help ensure that the right behavioral changes occur.

The "Agriculture Tax-Free" scenario shows the outcome for a scenario where agriculture is exempt from the carbon tax. This essentially takes out the direct impact of the tax on the country's agriculture sector. Interestingly, there was very little difference between the "elementary tax" and "agriculture tax-free" scenarios with the drop in activity still about 7% under the "agriculture tax-free" scenario. The comparison between the "elementary tax" and “agriculture tax-free” scenarios revealed that the direct impact of the carbon tax on agriculture will be minimal. Figure 2 breaks down the decline in agricultural activity into direct impact and indirect impact, through the change in prices of intermediate goods and services. Only 7% of the decline is attributable to the direct impact of the tax, and 93% of the decline is attributable to the indirect impact.

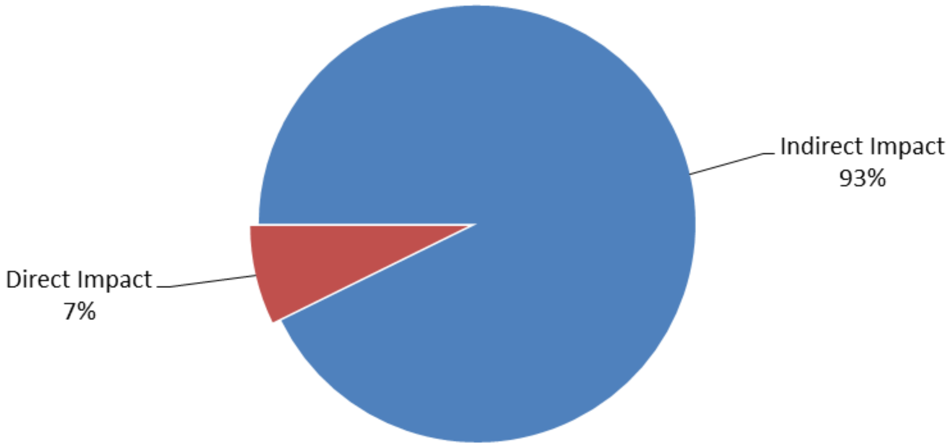

Figure 2. Indirect vs. Direct Impacts of the South African Carbon Tax on the Agricultural Sector

While, the direct impact is easy to account for as it is implicit in the design of the tax, the indirect impacts can come from a variety of different sources, and hence, identifying the main cause of the impact can be difficult to accurately identify. A good place to start is by looking at the changes in commodity prices after the carbon tax has been implemented. The CGE model provides 85 different commodity categories. The percentage changes in the price of each commodity resulting from the carbon tax under the “elementary tax” scenario are shown in Figure 3. What is particularly striking is the price increase in the price of electricity, which rises by approximately 48%.

The degree to which a particular commodity impacts on the Agricultural Sector will depend on the degree of the price changes shown in Figure 3, and on the intensity with which that commodity is used in agricultural production. It stands to reason that a large price increase in a commodity that is not used intensively in agricultural production will not have a significant impact on the sector. Similarly, even a small price increase in a commodity used intensively in agricultural production can have a significant impact on the sector.

To get an idea of the combined effect resulting from a commodity price change, a new index is created, AC, calculated as follows:

$$AC = \alpha.\beta$$

Where:

α = the magnitude of the increase in the price of the commodity following the shock

β = the amount of the commodity required to produce one unit of output from the activity

The resulting product of the two factors determines relative influences on agricultural activity or production. The top ten commodity categories influencing agricultural activity, based on the AC index, are provided in Table 2 and also displayed graphically in Figure 4.

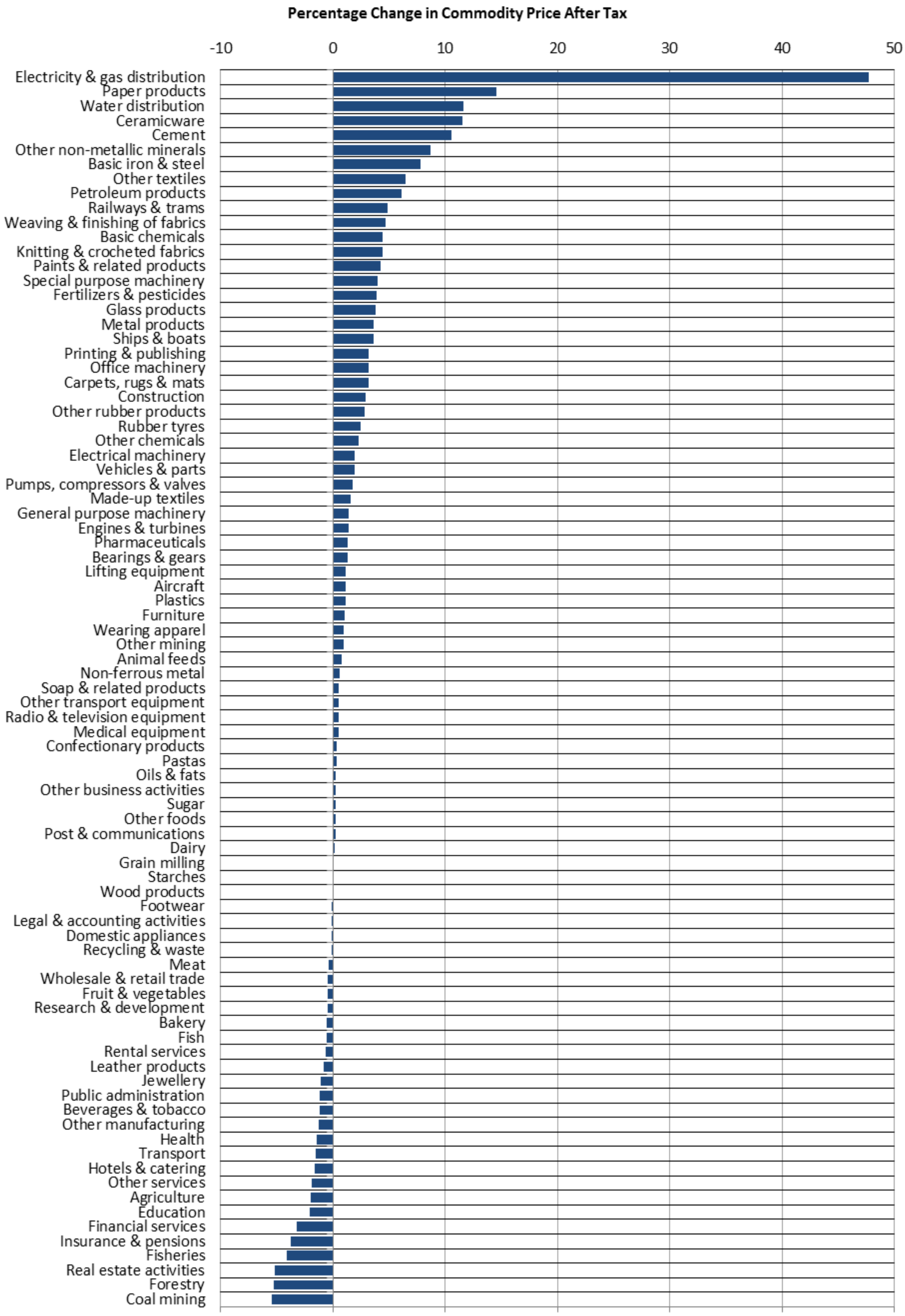

Figure 3. Change in Average Commodity Price Resulting from Carbon Tax

Table 2. Impact of Commodity Price Increases on Agricultural Activity or Output Decline

#	Commodity	Percentage Price Change After Shock (α)	Intermediate Units Per Unit Agricultural Activity/ Output (β)	AC (α.β)
1	Electricity & gas distribution	47.70	0.0207	0.9894
2	Fertilizers & pesticides	3.93	0.1979	0.7769
3	Petroleum products	6.14	0.0559	0.3435
4	Metal products	3.63	0.0369	0.1339
5	Animal feeds	0.80	0.1461	0.1165
6	Water distribution	11.63	0.0052	0.0604
7	Pharmaceuticals	1.36	0.0291	0.0395
8	Made-up textiles	1.62	0.0202	0.0326
9	Special purpose machinery	3.96	0.0074	0.0294
10	Vehicles & parts	1.92	0.0132	0.0254

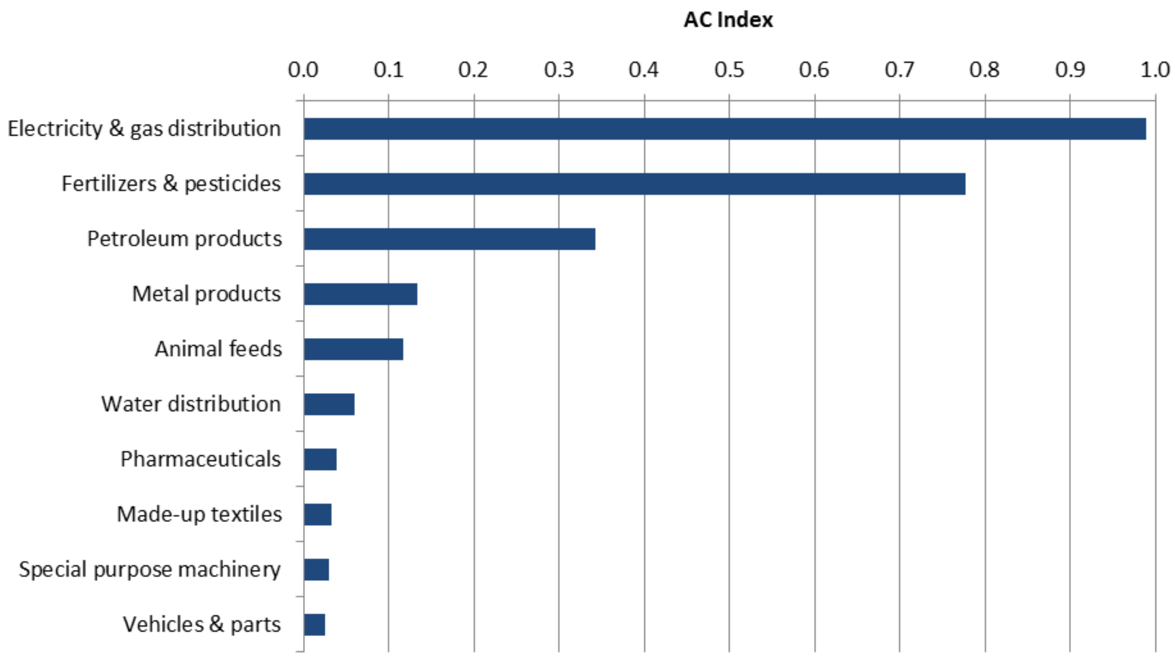

Figure 4. Intermediate Commodities Most Influencing Agricultural Activity or Output Decline

Electricity and gas distribution topped the list due to the price increase being so large as well as being much used in agriculture, with an index of 0.9894; followed by fertilizers and pesticides (0.7769); petroleum products (0.3435); metal products (0.1339); animal feeds (0.1165); water distribution (0.0604); pharmaceuticals (0.0395); made-up textiles (0.0326); special purpose machinery (0.0294); and vehicles and parts (0.0254).

So far the analysis has been focused on agricultural activity very generally; however, the impact will be felt more by the producers of certain agricultural products relative to others. Figure 5 shows the percentage change in output for specific agricultural commodity groups under the “elementary tax” scenario. All commodity groups showed a decline in output, the hardest hit were starches, dairy, and sugar, respectively, which declined by approximately 9.4%, 9.1%, and about 9%. The least hit was forestry, but even here, output fell by almost 7%.

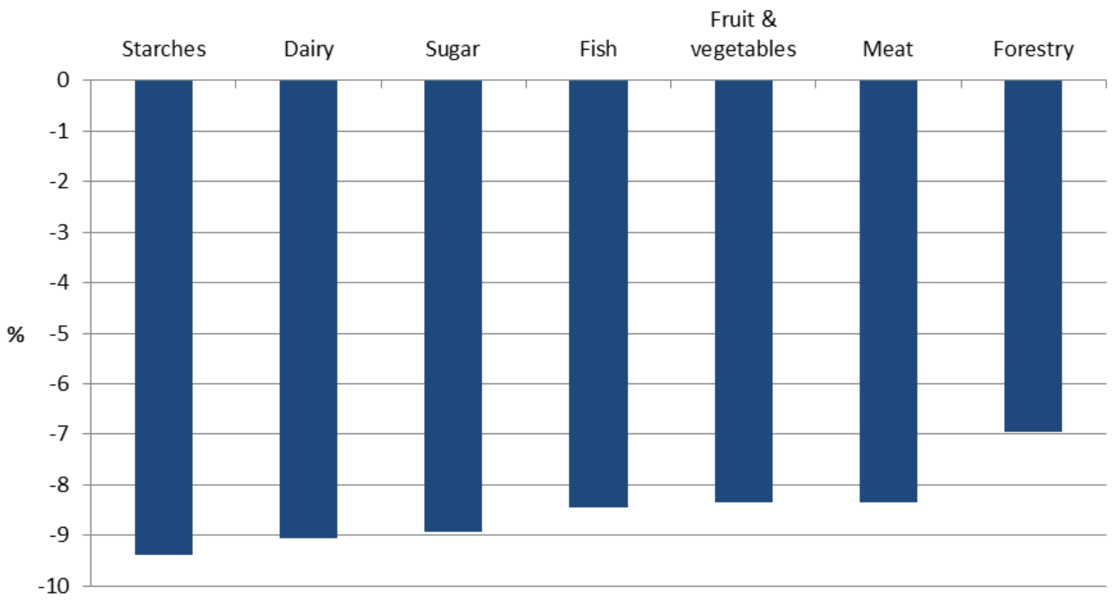

Figure 5. Changes in Agricultural Commodity Outputs Resulting from Carbon Tax

In relation to the rest of the economy, agricultural producers will be hit particularly hard by the impact of the carbon tax. The hardest hit agricultural commodity group, starches, was in the top ten hardest hit commodity groups out of 85 in the entire economy (not shown in Figure). Even though forestry showed the smallest decline of the seven agricultural commodity groups which were inspected, the decline was the 34th hardest hit out of the 85 commodity groups in the economy.

Conclusion

This study has found that in terms of the design for the initial implementation of the tax, the main impact on the South African Agricultural Sector is not going to be the direct impact as producers are taxed on their greenhouse gas emissions. In actual fact, the direct impact on Agriculture will be negligible due to the fact that there is no tax to be applied to emissions from enteric fermentation and manure management which are the main sources of emissions from agricultural producers.

Where the impact is going to be felt is through the indirect impacts as producers face higher costs for certain intermediate goods needed in production. The CGE model employed in this study revealed that these indirect impacts will put a serious strain on the country's agricultural sector. In particular, there was a huge increase in the electricity price. There was also a small but significant rise in the price of fertilizers and pesticides which, due to the high intensity with which fertilizers and pesticides are used in agricultural production, is likely to have a strong impact on agricultural production. There was also significant strain placed on the sector through the rising price of petroleum products. This means that in order to avoid significant drops in profits, agricultural producers need to become more efficient in their use of these inputs.

At the commodity level, the CGE model showed that agriculture will be affected more than the average economy with seven major agricultural commodity groups falling in the top half of commodities in terms of how hard they are hit. Starches came out as the most impacted agricultural commodity group; followed by dairy, and then sugar. Forestry was the least affected; however, there was still a very significant decline in output.

The results of the study have implications worth mentioning. The negative impact of the carbon tax on agriculture can be significantly offset if desired changes in behavior occur. This echoes the National Treasury's claim that the successful implementation of the tax will depend, among other things, behavioral changes. This also highlights the importance of how the tax revenues are recycled as this could be a key factor in influencing behavior to achieve desired outcomes. One way tax revenues could be used is in the form of investments in renewable energy or research and development into less carbon-intensive methods of production.

The importance of electricity also highlights the need for alternative forms of electricity production in South Africa. Farmers should be looking for ways of producing power on their farms from renewable energy sources to help ease the burden of the steep rise in electricity prices. The rise in electricity prices and increased demand for renewables also provides an opportunity for the Agricultural Sector. In particular, more research is needed around the opportunities for growing crops for biofuel production.

As a final point, it is important that agricultural producers do still start trying to cut back on greenhouse gas emissions through enteric fermentation and manure management. While these are not included in the initial tax base, there is a plan by the National Treasury to review this in 2020 with the possibility of being included in the tax base thereafter.

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