The welfare effects of Reversed Border Tax Adjustments as a remedy under unilateral environmental taxation: A South African case study

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ABSTRACT

Border Tax Adjustments (BTAs) resurfaced recently in national policy debates as a possible measure to counter the anti-competitiveness effect of unilateral environmental taxes. There seems to be no consensus in the literature on the effectiveness of BTAs under environmental taxes. This paper aims firstly to provide a theoretical Heckscher-Ohlin analysis that not only challenges the effectiveness of BTAs, but also proposes an alternative approach to mitigate the welfare effects of environmental taxes. Secondly, the paper evaluate the effectiveness of the alternative approach, to negate the economic impact on competitiveness of an electricity generation tax, without sacrificing the environmental benefits of the tax, in the case of South Africa.

Using conventional Heckscher-Ohlin methodology, in a small country, we show that policy makers should, instead of implementing BTAs, consider the opposite of BTAs to mitigate the welfare effects of environmental taxes. We show that gains from trade, due to a reduction in import tariffs, could, under certain assumptions, offset the initial tax induced welfare loss.

The paper then applies the Global Trade Analysis Project (GTAP) model to evaluate the impact of an electricity generation tax on the South African, SACU and SADC economies and explores the possibility to reduce the economic impact of the electricity generation tax through traditional border tax adjustments. The results show that an electricity generation tax will lead to a contraction of the South African gross domestic product. However, traditional BTAs are unable to address these negative impacts. The paper then test the proposed reversed BTA approach where gains from trade are utilised to negate the negative impacts of an electricity generation tax, while retaining the environmental benefits associated with the electricity generation tax. This is achieved through a reduction in import tariffs, as this reduction will reduce production costs and thereby restore the competitiveness of South Africa. The reduction in import tariffs not only negates the negative GDP impact of the electricity generation tax, but most the CO_2 abatement from the electricity generation tax is retained.

1. Introduction[2]

Economic measures, such as environmental taxes, use the price mechanism to internalise the externalities of fossil fuel use and have the potential to reach environmental targets at least cost to the economy. The aim is to equalise the marginal abatement costs across all agents, ensuring that action is taken where this is most efficient and cheapest (UP 2007).

Taxes on emissions (Pigouvian taxes) involve setting a charge per unit of emissions equal to the total value of the damage caused by an extra unit of emissions (Norregaard & Reppelin-Hill 2000). This signals the true social costs to the emitter,

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who then has a financial incentive to reduce emissions up to the point where the profit/loss due to a unit reduction in emissions is equal to the damage involved.

In general, the environmental taxes have three effects on an economy (Van Heerden et al. 2006):

i. An environmental tax leads to an increase in production costs. This will lead to a general increase in the price level of the economy. The higher production costs will increase import demand and decrease export demand. As a result, output in trade related services, especially energy intensive products, will decrease. Therefore, labour will be reallocated from these sectors to non-traded sectors.
ii. An environmental tax will increase government revenue, but purchasing power and household consumption will decrease if this revenue is not recycled.
iii. The distortion created by the tax will induce a change in consumer behaviour, for example, substitution away from energy and energy-rich sectors. This could lead, in the long run, to more efficient technologies.

All three effects contribute to a reduction of carbon emissions, through a reduction in energy demand, in the taxing country (Van Heerden et al. 2006).

Border Tax Adjustments (BTAs) resurfaced recently in national policy debates as a possible measure to counter the anti-competitiveness effect of unilateral environmental taxes. There seems to be no consensus in the literature on the effectiveness of BTAs under environmental taxes.

This paper firstly aims to provide a theoretical analysis that not only challenges the effectiveness of BTAs, but also proposes an alternative approach to mitigate the welfare effects of environmental taxes. In the model, we utilize the conventional Heckscher-Ohlin methodology to illustrate the welfare impact of unilateral environmental taxation. Then we show that, under certain assumptions, reversed BTAs might offset the adverse competitiveness impact of unilateral environmental taxation.

Secondly, the paper evaluates the effectiveness of the alternative approach to negate the economic impact on competitiveness of an electricity generation tax, without sacrificing the environmental benefits of the tax, in the case of South Africa.

In the next section we define BTAs, and this is followed by a review of the rationale for BTAs under unilateral carbon taxes, a brief historical background as well as a literature review of the effectiveness of BTAs. The proposition of neutrality for complete BTAs is then discussed.

In Section 5 we utilise Heckscher-Ohlin methodology and show that in a two country world, partial BTAs, in the form of import tariffs, should not be implemented, but instead be reversed to mitigate the welfare effects of environmental taxation. Gains from trade will be the source of welfare gain that offsets the taxation impact. Section 6 test the proposed reversed BTA approach, in the case of South Africa, where gains from trade are utilised to negate the negative impacts of an electricity generation tax, while retaining the environmental benefits associated with the electricity generation tax.

2. The definition of Border Tax Adjustments

The final report of the General Agreement of Tariffs and Trade (GATT) working party (1970 p1) defined a border tax adjustment (BTA) as*: "any fiscal measure which puts into effect, in whole or in part, the destination principle"*. The destination principle implies that exported products can be reimbursed for all or some of the taxes levied in the exporting country and taxes can be levied on imported products up to the equivalent of taxes levied domestically in the importing country (GATT 1970).

A BTA is therefore a tax on imported products, corresponding to the tax paid on domestic products, and the exemption from domestic taxes on products when they are exported (Ismer and Neuhoff 2004). The objective of BTAs, in the absence of harmonized tax systems among trading partners, is the insurance of trade neutrality of domestic taxation, thereby protecting the international competitiveness of domestic industries (Goh 2004).

Ismer and Neuhoff (2004) proposed a system of BTAs where taxes imposed at the border and the taxes refunded upon export, mirror taxes that would have been paid when producing the products domestically. They also noted that due to information constraints this is not directly possible, but they suggested an indirect method.

In the next section, BTAs will be explored as a protector of international competitiveness under environmental taxes. However, Whalley (2009) defined two types of BTAs which could be implemented in the presence of environmental taxes. The first type is to tax imported goods in a way that reflect the cost of emissions trading, if the products were to be produced domestically. The second type is to use tax equivalents based on the enforcement of emission allowance trading for all importers. In other words, an importer must buy emission rights in the importing country to meet the required offsets, while exporters could sell their emission permits in the domestic country (Whalley 2009).

Governments can attempt to restrict the tax burden of an environmental tax on domestic consumption through the implementation of BTAs. Exporters are refunded for the environmental tax paid on exported products, while imported products are taxed. These taxes could be based on the characteristics of the technology used in the production of the concerned products. However, BTAs tend to be imprecise and the administrative and compliance costs could be high. There is also the potential that countries might use BTAs to favour domestic producers. BTAs might even be referred to the World Trade Organisation to rule on whether these adjustments constitute undue protection of national interest (UP 2007).

Ismer and Neuhoff (2004) addressed the information constraints when implementing BTAs and proposed an indirect approach to induce participants to reveal information. They concluded, in the case of electricity, that adjustments should follow Carbon Emission Certificate price increases, relative to a situation without these Certificates. Alexecva-Talebi, Löschel and Mennel (2008) compared the effectiveness of BTAs and Integrated Emission Trading (IET). They found BTAs to be more effective in protecting domestic competitiveness, and IET more effective in reducing foreign emissions.

However, there seems to be no literature exploring the possibility of reversing BTAs, where gains from trade can be used to counter the competitiveness effects of an environmental tax.

3. Carbon BTAs as a remedy

Rationale for BTAs under unilateral carbon taxes

Hoerner and Muller (1996) argue that energy taxes, based on the polluter pays principle, are justified if the object is to reduce greenhouse gas emissions. This will encourage more efficient fuel use, discourage energy consumption and shift the use of fossil fuels to other energy sources. Such a tax will penalize energy-intensive industries and reduce emissions (Goh 2004).

Since different countries, in order to reduce carbon emissions, levy different tax rates and use different instruments, all departing from different initial stand points, the world currently faces unequal carbon prices across various countries (Lockwood and Whalley 2008). Furthermore, new or higher energy taxes raise concerns on the impact of the taxing country's international competitiveness, especially to energy intensive, export-orientated sectors in countries engaging in unilateral abatement actions (Alexecva-Talebi, Löschel and Mennel 2008).

Ismer and Neuhoff (2004) proposed BTAs as a remedy to protect international competitiveness under energy taxation. If there is no corresponding energy tax abroad, BTAs should mimic the energy tax levied on domestic goods, as well as compensate exports for the energy tax paid domestically (Alexecva-Talebi Löschel and Mennel 2008).

The rational for BTAs stems from the additional liability, in the form of energy taxes, which domestic producers encounter when competing globally. This is seen as a disadvantage to the domestic producers and therefore there might be a justification for some form of remedy to maintain the competitiveness of domestic industries. Especially, since this disadvantage is the result of an attempt to address global environmental problems through emission reduction efforts (Lockwood and Whalley 2008).

Furthermore, Lockwood and Whalley (2008) state that BTAs are claimed to provide more certainty to those engaged in initiatives to reduce emissions, especially long term investments in key sectors.

Gros (2009) emphasised that the key issue in the economics of global climate change is whether those countries acting unilaterally to reduce emissions should be entitled to impose BTAs to protect the competitiveness of their economies against those countries in which carbon is not priced. However, the literature mainly focuses on the competitiveness of energy-intensive industries and carbon leakage (Gros 2009).

Lastly, it should be remembered that BTAs are only one of the tax instruments available to address the competitiveness impact of energy taxes. Other instruments include changing corporate tax rates by sector, R&D tax credits, depreciation rates and many other tax-related measures. (Whalley 2009) In addition to BTAs, without exception, OECD countries, when introducing environmentally related taxes, have used one or more of the following instruments to soften the impact on sectors most affected (De Kam 2002):

- revenue recycling,
- exemptions for specific activities, sectors or products, or
- reduced tax rates for certain sectors, products or inputs.

Historical background

According to Whalley (2009) the debate around carbon motivated BTAs has thus far not taken pre-existing literature on BTAs into consideration. The earlier BTA debate could be traced back to the formation of the European Union and the Treaty of Rome which stipulated sequenced integration. Between the launch of the Tokyo Round in 1973 and the conclusion of the Kennedy Round under the GATT in 1967, pressure built in the United States for a broader tax negotiation to be included in the, then, emerging trade round in GATT, as a result of the European tax system. However, no GATT negotiation took place on this issue in the Tokyo Round (Whalley 2009), mainly due to the neutrality argument made in academic literature as discussed in the next section.

BTAs resurfaced more recently in national policy debates as a possible measure to counter the anti-competitiveness effect of energy taxes. For example, in 1996, a research panel report prepared for the Japanese Environmental Agency suggested the possibility of BTAs *"for products exchanged in the international market when dealing with countries that do not make similar economic measures to protect the environment"* (Government of Japan 1996 p11).

In terms of the Kyoto protocol, no specific trade related measures, such as BTAs, are mandated. But the protocol recognises a range of policies and measures that might be implemented by governments in an attempt to address climate change (Goh 2004). There have been increasing calls from especially Europe for the use of trade measures, including BTAs, in the enforcement of Kyoto protocol objectives. However, environmental taxes have been on the agenda of the WTO committee on trade and environment since 1994, and remain a contentious issue (Charnovitz 2003).

In 2003, Biermann and Brohm stated that there were no BTA schemes in place for taxes on energy inputs used in the production of final goods. But Goh (2004) argues that recent moves in the EU to harmonize energy taxes between EU member states is likely to provide further momentum to the BTA debate. Furthermore, it is expected that environmental and industry groups will increasingly exert pressure on high energy taxing governments to introduce such measures (Goh 2004). This has been echoed by Lockwood and Whalley (2008), saying that some OECD countries see these pressures as inevitably leading to BTAs.

The effectiveness of BTAs

According to Gros (2009), there is no consensus in the literature on the effectiveness of BTAs to correct the distortional effects on the competitiveness of a country that result from national climate mitigation policies.

Majocchi and Missaglia (2001) used a computable general equilibrium (CGE) model and showed that BTAs are likely to produce not only a better environment, but also less unemployment across the EU-15 countries. Demailly and Quirion (2005) found that BTAs are an efficient remedy for leakage, specifically in the cement industry. (Alexecva-Talebi, Löschel and Mennel 2008). Also, Mathiesen and Maestad (2002) showed that BTAs can be effective in preventing carbon leakage in the steel industry.

McKibben and Wilcoxen (2008) found that the administrative complexity outweighs the benefits of BTAs. Also, Veenendaal and Manders (2008), considered the effectiveness of a carbon BTA on the competitiveness of the EU, under the assumption that the EU is the only country to follow this approach. They showed that production and employment are negatively affected by a carbon tax and that a BTA can mitigate the loss of competitiveness and halve the loss in employment and production. However, refunds are found to be welfare decreasing in Europe and import levies welfare increasing, implying that overall effects of BTAs for Europe are ambiguous. They concluded that the impact of BTAs are too modest to justify its implementation.

Ismer and Neuhoff (2004), presented a formal partial equilibrium model of a carbon abatement policy coupled with BTAs. They showed that a BTA, at the level of additional cost incurred for procurement of CO_2 emission permits during production of processed materials using best available technology, limit the distortions of a carbon abatement policy. They conclude by stating that BTAs or an emission trading scheme makes economic sense.

Gros (2009), considered the impact of a carbon BTA on global welfare. The main finding was that the introduction of a carbon BTA, in the form of a carbon import tariff, increases not only the welfare of the importing country, but also global welfare, if carbon is inefficiently priced abroad. Thus, a relatively high domestic carbon price justifies a relatively high import tariff. Gros (2009) also noted that if there is relatively higher carbon intensity abroad, a higher import tariff imposed by the home country becomes more desirable, since this will shift production to the home country, leading to lower global environmental costs. The optimal tariff rate would be somewhat lower than the domestic carbon price (Gros 2009).

4. BTA neutrality proposition

The current debate on carbon BTAs surfaced as a possible remedy for leakages that might result from unilateral carbon commitments (Whalley 2009). Most of the debate focused on WTO compatibility of BTAs (Demaret and Stewardson 1994, Goh 2004, Ismer and Neuhoff 2007, De Cendra 2006,). Only Ismer and Neuhoff (2004) provided a partial equilibrium analysis, but this did not take into account the price level or exchange rate effects. Lockwood and Whalley (2008) related the current debate on BTAs to earlier literature and showed that the principle of neutrality still applies.

According to Walley (2009), the analysis of the impacts of BTAs in earlier literature seems to be forgotten. Especially, the well known proposition that if BTAs are common across all products they will have no real effects on trade and offer no protection to domestic producers (Meade 1974, Whalley 1979, Grossman 1980, Lockwood, Menza and Myles 1994). According to Meade (1974), if a country imposes a 10 percent duty on all imports and a 10 percent subsidy on all exports, it will equate a 10 percent devaluation of the currency. This will be offset, either by a 10 percent revaluation of the currency or a 10 percent increase in domestic inflation. Meade (1974) also showed that this will be the case for more than two countries. Furthermore, a BTA will do nothing to offset carbon leakage (Walley 2009). Lockwood and Whalley (2008) argued that the same argument should apply for the current carbon BTAs and that in the current debate there seems to be a misconception between relative price effects and price level effects as a result of BTAs. If the neutrality concept holds, BTAs, contrary to popular belief, will not offset the competitiveness effects of environmental policies (Lockwood and Whalley 2008).

5. BTAs: A Heckscher-Ohlin Approach

As discussed in the previous section, the neutrality proposition implies that complete BTAs will have no effect on the real domestic economy. However, BTAs are seldom complete and might therefore have an impact on the real domestic economy. In this section we consider the case where there is an import tariff, but no export refunds; so we can expect an impact on the real economy. In other words, only partial BTAs or partial reversed BTAs are considered.

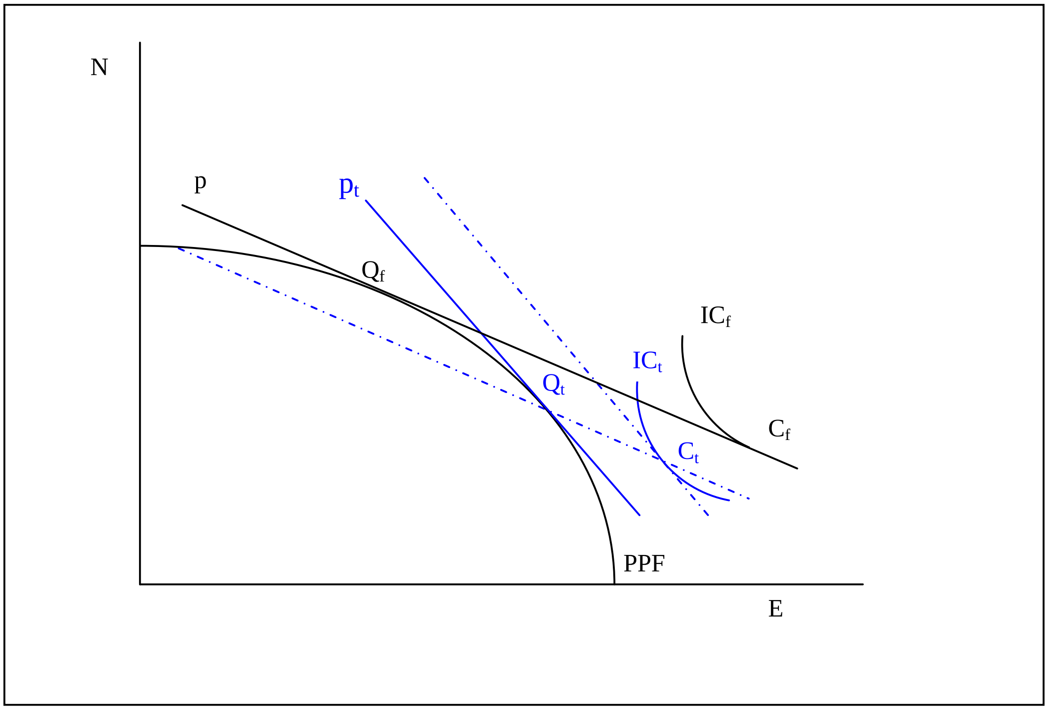
We utilize the conventional Heckscher-Ohlin methodology to illustrate, consistent with literature (for example Salvatore 1998, Pugel 2007), the equilibrium welfare level under a normal system of import tariffs and the absence of unilateral environmental taxes. Then we introduce a unilateral environmental tax, in the form of a tax on energy intensive production based on carbon content, and establish the new equilibrium welfare level. Lastly, we explore the possibility to restore the pre-environmental tax welfare level through the application of BTAs or reversed BTAs.

Setting up the model

Suppose small country A imports energy intensive products (E) and exports non-energy intensive products (N).

Free trade consumption equilibrium is illustrated in Figure 1 at C_f on indifference curve IC_f and country A will produce at Q_f. If an import tariff is imposed on energy intensive products, the free trade equilibrium of domestic production (Q_f) and domestic consumption (C_f) will no longer be attainable. Since country A is a small country, the international price line will remain unchanged. However, the domestic price line will change after the imposition of the import tariff. If the international price ratio is $p = \frac{p_e}{p_n}$ and the domestic price ratio is p_t, then $p_t = p(1+t)$ and $p_t > p$.

Figure 1: The effect of a tariff on energy intensive products



The equilibrium conditions can be stated as:

$$MRS = MRT = p_t = p(1+t) > p$$

$$p_{te}(e_c - e_p) + p_n(n_c - n_p) = 0$$

And

$$p_t = \frac{p_{te}}{p_n}$$

Where:

MRS = marginal rate of substitution
MRT = marginal rate of transformation
t = import tax
p = international price ratio
p_t = domestic price ratio including the tax
p_{te} = domestic price of energy intensive products
p_n = domestic price of non-energy intensive products
e_c = domestic consumption of energy intensive products
e_p = domestic production of energy intensive products
n_c = domestic consumption of non-energy intensive products
n_p = domestic production of non-energy intensive products

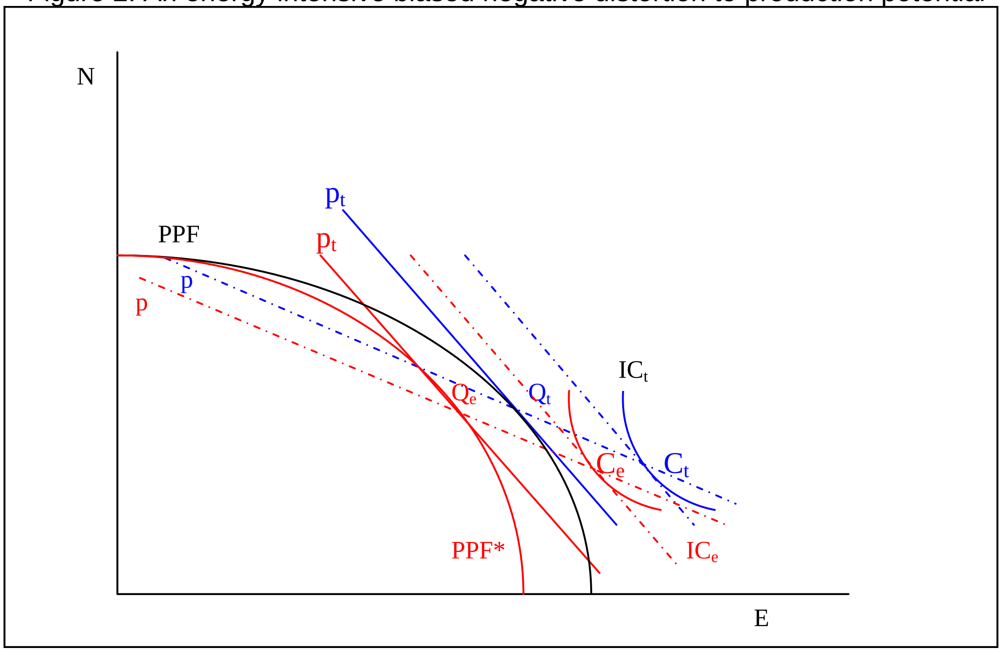
The import tariff on energy intensive products will distort the free trade equilibrium and the post-tariff consumer equilibrium (C_t) will be on a lower indifference curve than under free trade (C_f) while the country will produce more energy intensive products and less non-energy intensive products at Q_t.

Introducing an environmental tax

A distortion, to represent a unilateral environmental tax, in the form of a tax on energy intensive production based on carbon content, is introduced in Figure 2, the tax shifts the production possibility frontier inwards from PPF to PPF*. This distortion affects the production potential of energy intensive products proportionally more than the production potential of non-energy intensive products.

However, since country A is assumed to be a small economy, the world price ratio as well as domestic price ratio is unaffected, so that:
The international price ratio = p
and the domestic price ratio is p_t, where $p_t = p(1+t)$ and $p_t > p$.

Figure 2: An energy intensive biased negative distortion to production potential



Since the price ratios remain constant and the PPF moves to PPF*, country A will be in new consumption equilibrium at C_e on IC_e and will produce at Q_e as this is the only point where the equilibrium conditions still hold. However, $C_e < C_t$ therefore the welfare of country A decreased due to the environmental tax.

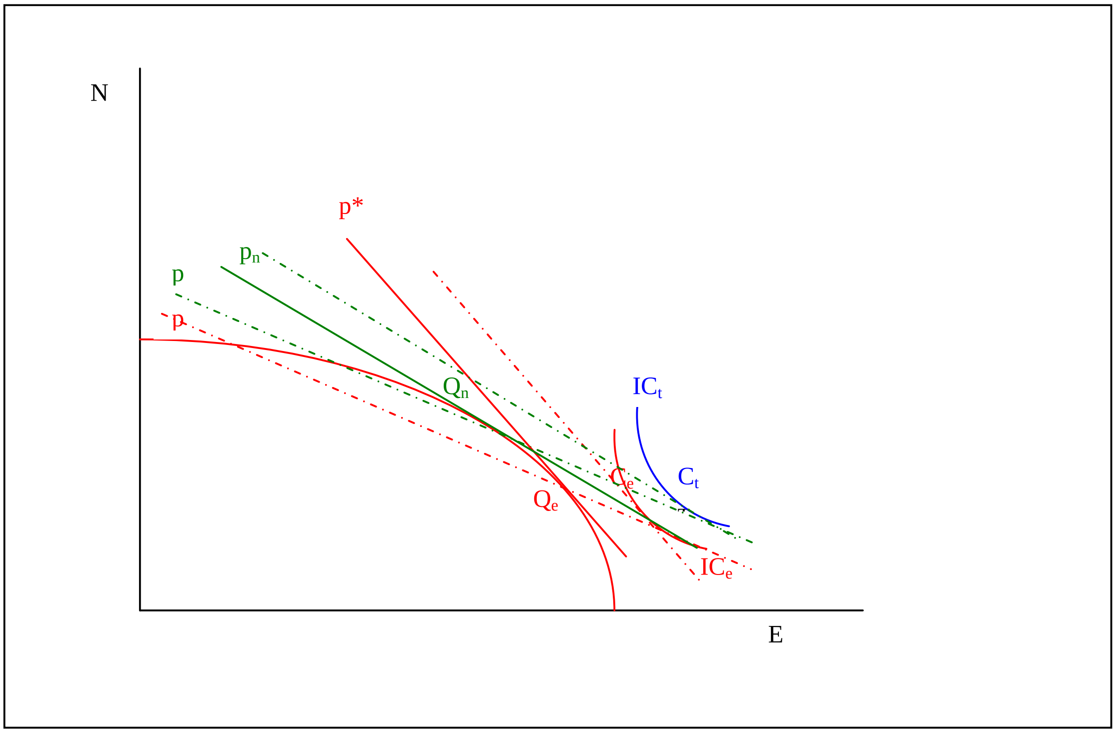
Introducing a reversed border tax adjustments

Conventional BTAs will in this case entail an import tax on energy intensive products, based on the carbon content. In the small country case, the international price ratio will still be p, but the domestic price ratio (p_t) will change. The new domestic price ratio (p_{bta}) will then be $p_{bta} = p(1+t+bta)$ where bta represents the effective import tax rate from the BTA. Assuming $bta > 0$ and since $p_t = p(1+t)$ and $p_t > p$, $p_{bta} > p_t > p$. Such a BTA will create a new reinforcing distortion to the economy. Where the environmental tax reduced welfare from C_t to C_e, the BTA will further reduce welfare to levels below C_e as C_e is not attainable any more.

Since conventional BTAs will result in even more welfare losses than the unilateral environmental tax, the question could be asked whether reversing BTAs could not offset the initial welfare losses of the environmental tax. In other words, whether trade liberalisation could restore the welfare loss incurred as a result of the environmental tax through gains of trade.

Country A is a small country, therefore it can not affect the world price ratio p, but it can affect the domestic price ratio, $p_t = p(1+t)$, through an import tax (t) adjustment. As illustrated in Figure 3, since $p_t > p$, a reduction in the import tariff can decrease the slope of the domestic price line to p_n where $p < p_n < p_t$ and the new tax rate t_n is $0 < t_n < t$.

Figure 3: Reversing the impact of the distortion



Consumption in country A will return to equilibrium C_t, while production will be at point Q_n. At Q_n production of non-energy intensive products are greater than at Q_e, while the production of energy intensive products are lower at Q_n than at Q_e.

Therefore, some environmental benefit will be achieved, since the production of energy-intensive products is reduced, without sacrificing welfare as the country still consumes at C_t .

6. CASE STUDY: SOUTH AFRICA

In the 2008 Budget Review, the South African government announced the intention to levy a 2c/kWh tax on the sale of electricity generated from non-renewable sources. This tax is to be collected at the source from the producers/generators of electricity. This measure is intended to serve a dual purpose of helping to manage the current electricity supply shortages and to protect the environment (National Treasury 2008).

The primary objective of this case study is to evaluate the effectiveness of traditional border tax adjustments in negating the competitiveness and economic impacts of such an electricity generation tax, without sacrificing the environmental benefits of the tax, in the case of South Africa. If traditional BTAs are unable to achieve this, we will empirically test the approach proposed in the previous section, which we will refer to as, “reversed BTAs” where gains from trade could be utilised to negate the negative impacts of an electricity generation tax, while retaining the environmental benefits associated with the electricity generation tax.

6.1 THE SOUTH AFRICAN ELECTRICITY CONSUMPTION AND TARIFF PROTECTION PROFILE

South African industries: Production, export and electricity needs

The South African electricity usage is characterised by a few energy intensive industries as shown in Table 1. The Mining and extraction industry contributes only 3 percent to domestic production at market prices and 14.58 percent to exports at market prices, but consumes more than 50 percent of electricity. Also, the “Electricity” and “Utility and construction” industries consume 25 percent of electricity, but only contribute 6.17 percent to domestic production and 0.58 percent to exports at market prices[3]. On the other hand, “Grains and Crops”, “Livestock and Meat products”, “”Processed food” as well as “Textiles and Clothing” together consume 0.29 percent of electricity, but contribute 11.17 percent of domestic production and 11.45 percent of exports at market prices.

[3] However, it should be noted that these sectors are important providers of raw materials especially to manufacturing.

Table 1: Electricity consumption, contribution to GDP and international trade by industry in 2004 (in percent terms)

Industry	ELECTRICITY USED IN PRODUCTION	DOMESTIC PRODUCTION AT MARKET PRICES	EXPORTS AT MARKET PRICES	IMPORTS AT MARKET PRICES
Electricity	14.06	1.53	0.45	0.41
Grains and crops	0.00	1.59	4.13	4.92
Livestock and meat products	0.04	2.15	0.65	0.68
Mining and extraction	50.89	3.05	14.58	14.98
Processed food	0.05	5.21	4.77	5.38
Textiles and clothing	0.20	2.22	1.90	1.92
Light Manufacturing	1.95	11.15	16.38	16.38
Heavy Manufacturing	8.37	18.46	44.12	43.64
Utilities and construction	10.96	4.64	0.13	0.12
Transport and communication	3.57	17.99	6.75	6.06
Other services	9.90	32.01	6.12	5.50
Total	100.00	100.00	100.00	100.00

Source: GTAP database, Preliminary version 7

Industrial tariff protection by region

South Africa pursued an import substitution policy, through high trade tariffs and physical import controls, during the 1960s and 1970s (Gunnar and Subramanian, 2000). During 1985, an import surcharge was introduced, but this system was replaced by the Generalised Export Incentive Scheme (GEIS) in 1990 (Ssekabira Ntege and Harmse 2003). At that time South Africa had a highly complex trade regime, with more than 13 000 tariff lines (Roberts 2000). Since the 1990s, South Africa liberalised its trade regime. Various tariffs were phased out over a five year period starting in 1995 (Gunnar and Subramanian, 2000). The liberalisation also included the termination of GEIS by 1997, liberalisation of sensitive industries over an eight year period, reduction in tariff lines, and the replacement of quantitative restrictions imposed on agricultural imports (Gunnar and Subramanian, 2000).

The number of eight-digit tariff lines has been reduced to 6 618 in 2009. Furthermore, the number of tariff lines in the South African Tariff Book compared favourably with international standards, with 53 percent of these tariff lines at zero in 2009 (ITAC 2009). Formula duties comprised only 1.8 percent of the tariff lines in 2009, compared to 25 percent in the early 1990s, and are mainly applicable to agricultural products.

In the attempt to negate the negative economic impact of an electricity generation tax through border tax adjustments, industry protection implemented through import tariffs should be considered. The average weighted *ad valorem* tariffs by industry per region are shown in Table 2.

The absence of tariffs reflects the free movement of goods and services within the Southern African Customs Union (SACU). “Processed Food” and “Textiles and Clothing” are the most protected industries in trade between South Africa and the rest of SADC. In addition to these two industries, “Light Manufacturing” is also protected by relatively high tariffs in trade between South Africa and the European Union as well as the rest of the world. Overall, import tariffs from the EU to South Africa are lower than the import tariffs from the rest of the world to South Africa, due to the Trade Development Cooperation Agreement (TDCA) between South Africa and the EU.

Table 2: Average weighted *ad valorem* tariffs by industry

	Rest of SACU	Rest of SADC	EU	Rest of the world
Electricity	0.00	0.00	0.00	0.00
Grains and crops	0.02	0.64	4.31	3.95
Livestock and meat products	0.00	0.23	5.78	10.46
Mining and extraction	0.00	0.01	0.05	0.02
Processed food	0.00	4.83	11.41	12.05
Textiles and clothing	0.00	6.42	11.68	27.07
Light Manufacturing	0.01	0.68	11.71	13.96
Heavy Manufacturing	0.00	0.00	1.60	2.96
Utilities and construction	0.00	0.00	0.00	0.00
Transport and communication	0.00	0.00	0.00	0.00
Other services	0.00	0.00	0.00	0.00

Source: GTAP database, Preliminary version 7

In the next section, the model and data are discussed. This is followed by an analysis of the results.

6.2 MODEL AND DATA

The case study applies the Global Trade Analysis Project (GTAP) model, which is coordinated by the Centre for Global Trade Analysis at Purdue University. The GTAP model is the pre-eminent modelling framework for the analysis of trade and environmental issues across countries (www.gtap.agecon.purdue.edu). Nearly all analyses of Free Trade Agreements by governments and individual academics have utilised aspects of the GTAP model and/or database.

The GTAP model

GTAP, a multi-region computable general equilibrium (CGE) model, is designed for comparative static analysis of trade related issues. GTAP databases are defined in terms of three primary sets, namely, the set of countries and regions, the set of primary factors and the set of sectors and produced commodities (Rutherford and Paltsev 2000). The aggregation of GTAP used for this model distinguishes four regions as shown in Table 3, namely South Africa, SACU countries excluding South Africa, SADC countries excluding SACU and the rest of the world. Table A1 in the Appendix shows the aggregation of the 57 GTAP sectors into 11 sectors. Furthermore, there are three other agents in each region, the government, a capital creator and a representative household.

Table 3: Regional aggregation of GTAP

Identifier	Countries in Region
South Africa	South Africa
SACUexclSA	Lesotho, Swaziland, Namibia and Botswana
SADCexclSACU	Zambia, Malawi, Mozambique, Mauritius, Angola, Tanzania, Zimbabwe, the DRC and Madagascar
EU_25	Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, United Kingdom
Restofworld	The rest of the world

International transport margins are explicitly modelled in the GTAP model, while a consumer demand system is designed to capture differential price and income responsiveness across countries. Also, a global bank is designed to mediate between world savings and investment (Hertel and Will 1999). GTAP utilise macroeconomic data to update the regional input-output tables to a common base year, 2004 for the GTAP database as used in this paper. All the coefficients in the regional input-output models are initially in national currency units and then scaled-up to external GDP data in 2004 US dollars. Then, gross capital formation, government consumption and private consumption are used to update the values for these aggregates in the regional input-output tables (Hertel 1997).

The behaviour of agents is optimised in competitive markets and this determines the regional demands and supplies of goods and services in GTAP. This optimising behaviour also determines the sector demand for primary factors (land, capital, labour and natural resources). The labour market is disaggregated into a skilled labour market and an unskilled labour market while there is a single, homogenous capital good. Standard comparative static applications of the model fix the total supplies of all endowment factors (capital, labour, land and natural resources) for each region. For the applications reported here, we adopt a different convention, with skilled labour fixed for each region, but unskilled labour allowed to move across regions to eliminate any initial disturbances to real wage rates. This provides a more accurate description of the South African economy, which is characterised by a limited supply of skilled labour in the skilled labour market and high structural unemployment in the unskilled labour market.

Other key assumptions:

- It is assumed that the rates of commodity taxes are not affected by the exogenously imposed shocks, other than the effects used to impose the shocks.
- National investment is responsive to changes in the rates of return on capital, but global investment is assumed to be fixed. Also, public as well as private consumption expenditures and nominal savings in each region are assumed to move with regional income. Therefore, the region benefiting the most from the exogenous shocks imposed will increase its share of global investment at the expense of other regions.
- GTAP contains different types of technical change variables. However, in these simulations we assume constant technological variables. For example, an electricity generation tax has no impact on the technological processes used in the production of electricity-intensive products.
- It is assumed that capital stocks are fixed, with rates of returns varying to accommodate the unchanged capital.

The GTAP database

The simulations reported in this research study are based on a preliminary release of Version 7 of the database. The GTAP database comprises: input/output data for each region; bilateral trade data derived from United Nations trade statistics; and support and protection data derived from a number of sources. Documentation for the Version 6 data set is given in Dimaranan (2006). The Version 7 database contains estimates of production costs, final demand values, bilateral trade values and various tax levels for 2005.

Scenarios

The version described in the previous section is used to model two scenarios. In the first scenario, South Africa imposes a unilateral 2c/kWh tax on electricity generation. Changes in trade volumes are those linked to a 2c/kWh increase in the tariff, which is equivalent to a sector-wide weighted average of 10 percent increase in the price of electricity (Blignaut, Chitiga-Mabugu and Mabugu 2005). The second scenario models the effects of a 10 percent electricity generation tax in South Africa, as well as import tax adjustments to eliminate the effect of the electricity tax on the real GDP and employment of South Africa. The import tax adjustments are simulated through a proportional reduction in import tariffs across all industries. Import tariffs are reduced to counter the reduction in imports resulting from the electricity generation tax. We modelled different trade weighted import tariff percentage reductions to establish an average percentage reduction that would reverse the negative effect of the electricity tax on the real GDP. Therefore, we reverse the traditional BTA approach, and negate the competitiveness impact of an environmental tax, through realised gains from trade.

The shocks for the electricity generation tax were imposed via changes to output taxes in the production of electricity. An output tax drives a wedge between the price received by producers and the price paid in the market.

6.3 RESULTS

A unilateral 2c/kWh electricity generation tax in South Africa will affect not only the South African economy, but also SACU, SADC, the EU and the rest of the world, via changes in South Africa’s export and import volumes. Seymore *et al* (2009) discussed the results of such an electricity generation tax and these results are summarised in Table 2. It should be noted that revenue neutrality was also simulated and the results reflected no statistically different differences from the results reported below.

As shown in Table 4, all the macroeconomic variables, with the exception of real export volume, decrease for South Africa. Contrary to the expected outcome, real import volume decreased by 0.69 percent and real export volume increased by 0.7 percent. As discussed in Seymore *et al* (2009), this is the result of weaker domestic demand for domestic production outweighing the reduction in production, leading to lower domestic prices and a resulting increase in exports. Imports decreased due to lower domestic demand.

Table 4: Results of a ten percent tax on the generation of electricity

10 PERCENT TAX	SouthAfrica	SACUexclSA	SADCexclSACU	EU_25	restof world
Real GDP	-0.28	0.01	0.01	0.00	0.00
Real private consumption	-0.04	0.06	0.02	0.00	0.00
Real public consumption	-0.17	0.03	0.01	0.00	0.00
Real investment	-2.29	0.12	0.07	0.01	0.01
Real import volume	-0.69	0.13	0.04	0.00	0.00
Real export volume	0.70	0.02	0.00	0.00	-0.01
Terms of Trade	-0.15	0.06	0.02	0.00	0.00
Unskilled employment	-0.77	0.07	0.01	0.00	0.00
Skilled employment wage rate	-0.63	0.07	0.04	0.00	0.00
Industry production					
Electricity	-4.29	1.47	0.45	0.04	0.01
Grains and crops	0.31	-0.07	-0.02	-0.01	0.00
Livestock and meat products	-0.08	-0.05	0.00	0.00	0.00
Mining and extraction	-0.35	0.00	0.00	0.00	0.00
Processed food	0.01	-0.06	-0.02	0.00	0.00
Textiles and clothing	0.34	0.15	-0.02	0.00	-0.01
Light Manufacturing	0.12	-0.29	-0.14	0.00	0.00
Heavy Manufacturing	-0.18	0.01	-0.09	0.00	0.00
Utilities and construction	-1.84	0.10	0.06	0.01	0.01
Transport and communication	0.01	0.00	0.00	0.00	0.00
Other services	-0.19	0.04	0.01	0.00	0.00

Source: Seymore, R., Adams, P.D., Mabugu, M., Van Heerden, J.H. and Blignaut, J. 2009

The higher production costs translate into job losses, with unskilled employment contracting by 0.77 percent. Skilled employment wages decrease by -1.05 percent due to the contraction in real GDP.

As discussed above, one method that could be utilised to counter the negative impact of the electricity tax is border tax adjustments. However, as shown in Table 4, South Africa will experience an increase in exports. Therefore, export subsidies will not be an effective approach towards negating the effect of the electricity tax on the competitiveness of the country.

Table 5: Reversed Border tax adjustments:
South African import tariff changes (percentage points)

	SACUexclSA	SADCexclSACU	EU_25	restofworld
Electricity	0.00	0.00	0.00	0.00
Grains and crops	-0.01	-0.19	-1.23	-1.13
Livestock and meat products	0.00	-0.07	-1.63	-2.82
Mining and extraction	0.00	0.00	-0.02	-0.01
Processed food	0.00	-1.37	-3.05	-3.20
Textiles and clothing	0.00	-1.73	-3.12	-6.35
Light Manufacturing	0.00	-0.20	-3.12	-3.65
Heavy Manufacturing	0.00	-0.09	-0.47	-0.86
Utilities and construction	0.00	0.00	0.00	0.00
Transport and communication	0.00	0.00	0.00	0.00
Other services	0.00	0.00	0.00	0.00

Imports, on the other hand, are set to decrease. Since production inputs are priced at import parity pricing, a reduction in import tariffs will reduce production costs and thereby restore the competitiveness of South Africa. Therefore, the appropriate action to counter the contraction of the South African GDP as well as the increase in unemployment is a reduction in import tariffs. Scenario 2 modelled different trade weighted import tariff reductions to establish an average reduction level that would reverse the negative effect of the electricity tax on the real GDP, and result in a constant real GDP[4]. The new revised tariffs are provided in Table 6. The average reduction for import tariffs required were calculated at 29 percent, although this might seem high, the low baseline of the tariffs should be considered.

As shown in Table 6, the import tax adjustments could succeed in neutralising the effect of an electricity generation tax on real GDP, however, this will be at the cost of a weaker terms of trade. Despite the weaker terms of trade, international trade will be stimulated and exports are expected to increase by 2.75 percent and imports are expected to increase by 2.24 percent. This will result in a 0.46 percent improvement in the South African trade balance. Furthermore, it should be noted that under scenario 2, government spending decrease by 0.11 percent, as compared to 0.17 percent under scenario 1. This is mainly due to lower import tariff revenue, in contrast to the 0.17 percent decrease in scenario 1 mainly due to GDP contraction leading to lower general tax revenue. Consumer spending will also decrease by 0.15 percent under scenario 2, compared to 0.04 percent under scenario 1, as the real increase in exports outweigh the real increase in imports, leaving fewer products for domestic consumption.

[4] This was done through a trail and error.

Table 6: Results after border tax adjustments

	SOUTH AFRICA (Percentage change)
Real GDP	0.00
Real private consumption	-0.15
Real public consumption	-0.11
Real investment	-0.28
Real import volume	2.24
Real export volume	2.75
Terms of Trade	-0.50
Unskilled employment	-0.20
Skilled employment wage rate	-0.12
Industry production	
Electricity	-3.97
Grains and crops	0.57
Livestock and meat products	-0.14
Mining and extraction	-0.06
Processed food	-0.02
Textiles and clothing	-2.91
Light Manufacturing	-0.70
Heavy Manufacturing	0.56
Utilities and construction	-0.28
Transport and communication	0.09
Other services	0.01

On an industry level, “Grains and Crops” and “Heavy Manufacturing” at 0.57 percent and 0.56 percent respectively are set to record the highest increase in production, while “Textile, Clothing and Footwear” are set to decrease output by 2.91 percent. This is in line with expectations, as the “Grains and Crops” and “Heavy Manufacturing” industries are highly reliant on capital imports and fuel to increase production. On the other hand, the Textile, Clothing and Footwear industry will be even more exposed to a highly competitive international market. This will probably cause some relatively unproductive producers to exit the market.

We also tested for a neutral unskilled employment policy, where the negative impacts on employment and wages of an electricity generation tax was countered through tariff reductions. A 39.98 percent reduction in the overall level of baseline tariffs was found to be appropriate. A 39.98 percent reduction not only neutralised the impact on employment, but also resulted in a small positive net effect on the real GDP.

It is important to note that the proposed tariff reductions will be in line with the current trade liberalisation policy approach in South Africa. As discussed above, South Africa is not only simplifying the South African Tariff Book, but is also committed towards tariff reductions.

The CO_2 abatement before and after the reversed BTAs has been calculated, using the greenhouse gas emissions inventory as developed by Blignaut, Chitiga-Mabugu and Mabugu (2005). Economic benefits accruing to CO_2 abatement was calculated at R100 per ton, based on a low estimate of approximately Euro8 for a Certifiable Emissions Reduction Certificate. As reflected in Table 7, reversed BTAs will reduce the CO_2 reduction benefit from R 970 million to R 824 million, this small forfeiture of CO_2 abatement benefits is due to the structural shift in the economy towards non-energy intensive sectors, as shown in Table 6.

Table 7: CO2 abatement benefit: with and without reversed border tax adjustments

		BEFORE reversed BTAs		AFTER reversed BTAs	
	CO2 emissions (Mt)	Change in CO2 emissions (Mt)	Benefit (million)	Change in CO2 emissions (Mt)	Benefit (million)
Electricity	221.14	-9.49	948.68	-8.78	877.92
Grains and crops	7.87	0.02	-2.44	0.04	-4.48
Livestock and meat products	1.75	0.00	0.14	0.00	0.24
Mining and extraction	7.87	-0.03	2.75	0.00	0.47
Processed food	0.00	0.00	0.00	0.00	0.00
Textiles and clothing	0.00	0.00	0.00	0.00	0.00
Light Manufacturing	16.17	0.02	-1.94	-0.11	11.32
Heavy Manufacturing	102.27	-0.18	18.41	0.57	-57.27
Utilities and construction	2.62	-0.05	4.82	-0.01	0.73
Transport and communication	45.01	0.00	-0.45	0.04	-4.05
Other services	2.62	0.00	0.50	0.00	-0.03
Total	407.31	-9.70	970.48	-8.25	824.86

The Stroud quadrature method was used to conduct a sensitivity analysis. The model was solved 22 times and the price elasticity for electricity in the South African economy (0.47) has been found to be robust at a 10 percent variation.

7 CONLUSION

Border Tax Adjustments (BTAs) resurfaced recently in national policy debates as a possible measure to counter the anti-competitiveness effect of unilateral environmental taxes. This paper traced the debate and discussed the rational for BTAs, the effectiveness thereof, as well as the neutrality proposition.

Using conventional Heckscher-Ohlin methodology, in a small country, we showed that policy makers should, instead of implementing BTAs, consider the opposite of BTAs to mitigate the welfare effects of environmental taxes. We showed that gains from trade, due to a reduction in import tariffs, could, under certain assumptions, offset the initial tax induced welfare loss.

We suggest that further research could expand the small country Heckscher-Ohlin analysis, under a unilateral environmental tax, as presented in this paper, by considering a big country case, as well as multilateral implementation of environmental taxes.

In the South African case study we evaluated the effectiveness of border tax adjustments to negate the competitiveness and economic impacts of such an electricity generation tax, without sacrificing the environmental benefits of the tax.

The results showed that, an electricity generation tax will lead to a contraction of the South African GDP. However, traditional BTAs were unable to address these negative impacts. We tested the proposed reversed BTA approach where gains from trade were utilised to negate the negative impacts of an electricity generation tax, while retaining the environmental benefits associated with the electricity generation tax. This was achieved through a reduction in import tariffs, as this reduction will reduce production costs and thereby restore the competitiveness of South Africa. The reduction in import tariffs not only negated the negative GDP impact of the electricity generation tax, but the bulk of CO_2 abatement from the electricity generation tax was retained.

GTAP as a multi-country model focuses on the interaction between countries arising from the flow of goods and services. The representation of investment and savings leakages is relatively weak and it does not record the possible inter-country shifts of physical and financial assets that may arise from the electricity generation tax. Also, the entire demand system is treated as the demand system of a representative household. There is effectively only one household, and it is not possible to analyse the welfare effects of the electricity tax on different households.

The GTAP version used in this paper is not dynamic, but rather a static model. Thus, there is no allowance for inter-temporal linkages between savings and consumption, and investment and capital. The model is able to project likely capital changes by region and industry associated with the tax, but there are no endogenous mechanisms that allow projections of the time-pattern of investment changes which lead to the projected capital changes. Also, short-term and long-term adjustment costs associated with the tax cannot be properly analysed in a static framework.

The emergence of new industries, such as nuclear or coal generation with carbon capture are not endogenously allowed for in the model. The model user must therefore exogenously introduce new industries, with the timing and size of the new industries specified by the modeller. In this paper, it is assumed that no new industries emerge as result of the 2c/kWh electricity tax. Thus, the impact analysis is a relatively short to medium term analysis.

No attempt is made in these simulations to include the possible effect of climate change in the base case. There are no assumptions made about the possible costs under “business as usual” resulting from climate change. For example, we do not assume an increase in the demand for electricity resulting from desertification leading to an increased need for irrigation. Not allowing for climate change implies that we also do not account for any of the possible economic benefits arising from abatement achieved by the electricity generation tax.

Although this paper attempted to evaluate the effectiveness of BTAs to negate the competitiveness and economic impacts of an electricity generation tax, given the limitations above, it might be useful to extend this analysis to a dynamic CGE model, or to allow the emergence of new industries due to the electricity generation tax.

APPENDIX

Table A1: Sectoral aggregation of GTAP

Identifier	**Sectors in Region**
1. Electricity	Electricity
2. GrainsCrops	Paddy rice Wheat Cereal grains nec Vegetables, fruit, nuts Oil seeds Sugar cane, sugar beet Processed rice
3. MeatLstk	Cattle, sheep, goats, horses Animal products nec Raw milk Wool, silk-worm cocoons Meat: cattle, sheep, goats, horse Meat products nec
4. Extraction	Forestry and fishing Coal Oil and gas Mineral nc
5. ProcFood	Vegetable oils and fats Dairy products Sugar Food products nec Beverages and tobacco products
6. TextWapp	Textiles Wearing apparel
7. LightMnfc	Leather products Wood products Paper products, publishing Metal products Motor vehicles and parts Transport equipment nec Manufactures nec
8. HeavyMnfc	Petroleum, coal products Chemical, rubber, plasticprods Mineral products nec Ferrous metals Metals nec Electronic equipment Machinery and equipment nec
9. Util_cons	Gas manufacture, distribution Water Construction
10. TransComm	Trade Transport nec Sea transport Air transport Communication
11. OthServices	Financial services nec Insurance Business services nec Recreation and other services Public Admin, defence, health, education Dwellings

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