THE COMPETITIVENESS EFFECTS OF ELECTRICITY GENERATION TAXES: A COMPUTABLE GENERAL EQUILIBRIUM ANALYSIS

by

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Summary

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Supervisors: Professor M Mabugu, Department of Economics
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The South African Government, in the Budget Review of 2008, proposed to impose a 2c/kWh tax on the sale of electricity generated from non-renewable sources, to be collected at source by the producers/generators of electricity. This tax will create distortions in the South African economy.

The research study aims to identify measures that can be taken to negate the negative competitiveness impact of the tax. In the first part of the study, we applied 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. GTAP is a multi-region CGE model designed for comparative-static analysis of trade policy issues. Various versions were constructed and the closure was changed to reflect the South African reality more accurately.

After the national as well as international economic and environmental impacts were analysed, we considered Border Tax Adjustments (BTAs) as a possible remedy to negate the negative competitiveness impact of the tax. Utilising theoretical Heckscher-Ohlin methodology, as well as the GTAP model, we showed that BTAs will not negate the adverse economic impact of an environmental tax. Instead, reversed BTAs, through gains of trade, could reverse the negative economic impact of an electricity generation tax, while enabling an economy to retain most of the environmental benefits of the tax.

We also considered the impact of an integrated approach, consisting of an electricity generation tax and a demand side policy, on the welfare of households. To analyse this, we used the University of Pretoria General Equilibrium Model (UPGEM). The model was extended to reflect Equivalent Variation values and we updated the database to include import tariffs. It was then shown that reversed BTAs could be used to offset the regressiveness of the electricity generation tax.

Policy implications from the study will be useful for macroeconomic policies, international trade negotiations and environmental policies to increase the welfare of society.

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Reyno Seymore, July 2011

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CHAPTER 1

INTRODUCTION

1.1 Background

In the 2008 Budget of the Minister of Finance, the South African Government proposed to impose a 2 cents/kilowatt-hour (c/kWh) tax on the sale of electricity generated from non-renewable sources; this tax is to be collected at source by the producers/generators of electricity. The intention of this measure is to serve a dual purpose of protecting the environment and helping to manage the current electricity supply shortages by reducing demand.

This study aims to answer some questions with regards to the implementation of the Electricity Generation Tax. What will the impact of the tax be on the South African economy? What will the impact of the tax be on the environment? What will the impact of the tax be on the competitiveness of the South African economy? Could multilateral taxes soften the competitiveness impact? Are border tax adjustments an effective instrument to counter the competitiveness impact? What is the role of demand side management? Are these policies regressive or progressive? Could this be changed?

These questions are addressed using theoretical models, such as Heckscher-Ohlin methodology as well as two computable general equilibrium (CGE) models, namely, the Global Trade Analysis Project (GTAP) model and the University of Pretoria General Equilibrium Model (UPGEM).

1.2 Chapter outline

This section provides a brief overview of the chapters.

1.2.1 Chapter 2: The impact of an environmental tax on electricity generation in South Africa

The objective of Chapter 2 is to evaluate the impact of the proposed Electricity Generation Tax in South Africa, on the South African, SACU and SADC economies. The chapter first considers the theoretical foundations of an electricity generation tax supported by international experiences in this regard. This section also contrasts the suitability of a permit with a tax system to achieve CO_2 emission reduction.

Subsequently the Global Trade Analysis Project (GTAP) model is used to evaluate the impact of an electricity generation tax on the South African, SACU and SADC economies. The proposed tax is simulated as a 10 percent increase in the output price of electricity. A closure rule that allows unskilled labour to move freely and a limited skilled workforce are assumed. As expected, the electricity generation tax will reduce demand. Due to the decrease in domestic demand, export volume increases and import volume decreases, this is despite a weaker terms of trade. It is also found that unemployment for unskilled labour increases and wages of skilled workers are expected to decrease. A unilateral electricity generation tax will benefit other SACU and SADC countries through an improvement in relative competitiveness, as shown by the improvement of the terms of trade for these regions. If, however, the benefits of pollution abatement are internalised, the electricity generation tax is expected to yield a positive effect on the South African economy.

1.2.2 Chapter 3: The competitiveness impact of a multilateral electricity generation tax

The primary objective of this chapter is to evaluate the impact of an electricity generation tax on the international competitiveness of South Africa. Specifically, different scenarios are assessed to establish whether the loss of competitiveness can be negated through an international, multilateral electricity generation tax.

The chapter first considers the impact of environmental taxation on the competitiveness of a country. It is shown that an electricity generation tax will indeed affect the competitiveness of South Africa in a negative way.

The Global Trade Analysis Project (GTAP) model is then applied to evaluate the impact of an electricity generation tax on the competitiveness of South Africa, given multilateral taxes on SACU, SADC and European Union economies. SACU and SADC wide implementation will marginally reinforce the negative competitiveness effects in South Africa. However, a multilateral electricity generation tax across SACU or SADC countries will result in emission reductions, but lower than in the case of a unilateral electricity generation tax.

In contrast, the cost to the South African economy could be limited, if the European Union would follow suit and implement an electricity generation tax. Therefore, one could argue in favour of global rules for environmental taxes, this will ensure minimum negative competitiveness effects on participating countries.

1.2.3 Chapter 4: The welfare effects of reversed border tax adjustments as a remedy under unilateral environmental taxation

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 chapter aims 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.

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

1.2.4 Chapter 5: Border tax adjustments to negate the economic impact of an electricity generation tax

The primary objective of this chapter is to evaluate the empirical effectiveness of border tax adjustments to negate the economic impact on competitiveness of such an electricity generation tax, without sacrificing the environmental benefits of the tax, in the case of South Africa.

The chapter 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 explore the possibility to reduce the economic impact of the electricity generation tax through 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. A reversed BTA approach is proposed, 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 reductions in import tariffs not only negate the negative GDP impact of the electricity generation tax, but the bulk of CO_2 abatement from the electricity generation tax is retained.

1.2.5 Chapter 6: An electricity generation tax and demand side management: the economic impact of simultaneously implemented policies

This chapter attempts to analyse the economic impact and household welfare effects of an electricity generation tax, as well as an effective electricity household demand side policy, if these two policies are simultaneously implemented, in South Africa.

The UPGEM model is used, and three scenarios are tested. Firstly, the electricity generation tax, implemented in 2009, of 2c per kWH (equivalent to a 10 percent price increase) is introduced to the model. Secondly, the Demand Side Management Policy of Eskom, aimed at reducing household demand for electricity by 10 percent, through a change in households' tastes and preferences is simulated. Lastly, both the first and second scenarios are run in the model simultaneously.

The impact of these shocks on the GDP, production structure, household demand, household welfare and the labour market are analysed. Overall, an electricity generation tax will lead to higher inflation, less production and lower employment while an effective demand side management policy will lead to lower inflation, higher economic growth and higher employment.

The equivalent variation values are calculated and it is shown that an electricity generation tax will be regressive with a negative impact on the utility of all households. An effective demand side policy will be progressive, with most households gaining in welfare, while simultaneous implementation will be regressive, moderated slightly by the progressiveness of an effective demand side policy.

1.2.6 Chapter 7: Reversing regressive electricity tax effects through reversed border tax adjustments

This chapter attempts, using reversed BTAs as developed in chapters 4 and 5, to offset the regressiveness of the simultaneous implementation of an electricity tax and a demand side policy as analysed in chapter 6. Equivalent variation as modelled in chapter 6 is used as a measure of household welfare.

The results from the simultaneous implementation of the two policies on household welfare are briefly reviewed and a short review of the concept reversed BTAs are presented. Thereafter, Heckscher-Ohlin methodology is used to explain theoretically why reversed BTAs, rather than BTAs are the tool that should be used to offset the welfare losses of a representative household.

Using SARS data to calculate applied average weighted tariffs, import tariffs are introduced to the UPGEM model. The results show that gains from trade through reversed BTAs would not only be sufficient to offset the welfare losses of the integrated approach, but would be welfare enhancing.

The policy implication, contrary to arguments made in literature (as explored in chapters 3 and 4) is that liberalisation though reversed BTAs, could be used to offset the adverse household welfare impact of an integrated approach.

1.2.7 Chapter 8: Conclusion and policy implications

Chapter 8 concludes with a short summary as well as the policy implications of the study.

CHAPTER 2

THE IMPACT OF AN ENVIRONMENTAL TAX ON ELECTRICITY GENERATION IN SOUTH AFRICA[1]

2.1 BACKGROUND[2]

The South African government has proposed the imposition of a 2 cents/kilowatt-hour (c/kWh) tax on the sale of electricity generated from non-renewable sources. This tax is to be collected at source by the producers/generators of electricity. The intention of this intervention is to reduce South Africa's carbon dioxide emission load and to help manage the current electricity supply shortages by reducing demand (Republic of South Africa 2008).

The world produced approximately 49,000 million ton (Mt) CO_2-equivalent in 2004, mainly from deforestation and energy generation. South Africa's share is about 1% of the global figure, or 440Mt. The emissions per capita in South Africa are very high, i.e. 9.5tCO_2-eq., compared to averages of 5.0tCO_2-eq. for developing countries and 6.8tCO_2-eq. for the world. Emissions per capita of Brazil are 13.1t CO_2-eq., China 3.9t CO_2-eq. and India 1.8t CO_2-eq. per person. African and developing countries emit less CO_2 for a unit of GDP than the world average, but South Africa is the exception and emits more than OECD countries. South Africa's emissions per GDP, or its emission intensity, is 0.75kg/$, whereas the world average is 0.56kg/$ (Winkler 2007).

Table 2.1: South Africa's electricity capacity – 2004

ENERGY SOURCE	CAPACITY (MW)	PERCENT OF TOTAL
Coal	38 209	88.8
Nuclear	1 800	4.2
Bagasse	105	0.2
Hydro	668	1.6
Gas turbines	660	1.5
Pumped storage	1 580	3.7
Total	43 022	100

Source: Republic of South Africa 2006

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[1] This Chapter appeared as an article in the Journal for studies in economics and econometrics, 34(2):1-18.

[2] The authors would like to thank an anonymous referee of Economic Research South Africa (ERSA) for the comments and suggestions. The author acknowledges financial support from ERSA.

Eskom dominates the electricity industry in South Africa and generates approximately 95 percent of electricity in South Africa (Eskom Holdings Limited 2009). As shown in Table 2.1, coal-fired power stations contribute approximately 89 percent of electricity generation capacity in South Africa. Eskom owns 96 percent of all generation capacity in South Africa and 100 percent of the national transmission grid. 60 percent of electricity is distributed directly to end-use customers and the remaining 40 percent is distributed through municipal distributors (Republic of South Africa 2007). However, the electricity distribution industry is currently in a process of restructuring. In March 1997 the South African Cabinet approved consolidation of the electricity distribution industry into six Regional Electricity Distributors (REDs). Since then, the establishment of REDs has been met with limited success. On 25 October 2005, in an attempt to address the challenges that the distribution sector faces, Cabinet approved the creation of six "wall-to-wall" REDs. These REDs should be created as public entities and the Department of Minerals and Energy, through Energy Distribution Industry (EDI) Holdings, should oversee and control their establishment (Republic of South Africa 2007).

Table 2.2: Electricity consumption by industry

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

Source: GTAP database, Preliminary version 7

The South African electricity usage is characterised by a few energy intensive industries as shown in Table 2.2. The Mining and Extraction Industry consumes more than 50 percent of electricity, but contributes only 3 percent to domestic production at market prices and 14.58 percent to exports at market prices. Similarly, 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.

South Africa is a member of the Southern African Power Pool (SAPP) which facilitates electricity distribution within SADC. As shown in Table 2.3, South Africa recorded a trade surplus in electricity from 2003 to 2008 of between 3 000 GWh and 4 500 GWh.

Table 2.3: South African international trade in electricity

	IMPORTS GWH	EXPORTS GWH	NET EXPORTS
2000	4719	4007	-712
2001	7247	6519	-728
2002	7873	6950	-923
2003	6739	10136	3397
2004	8026	12453	4427
2005	9199	12884	3685
2006	9782	13766	3984
2007	11348	14496	3148
2008[3]	9492	12968	3476

Source: Republic of South Africa 2009

The primary objective of this chapter is to evaluate the impact of an electricity generation tax on the South African, SACU and SADC economies. The next section considers the theoretical foundations of an electricity generation tax and examines some evidence put forth by similar studies. In the third section, the Global Trade Analysis Project (GTAP) model and data are discussed. This is followed by an analysis of the results. The last section contains the conclusion, as well as the limitations of the model.

2.2 LITERATURE REVIEW[4]

2.2.1 Introduction

In this section we refer to results obtained from simulating taxes on electricity by making use of national models of South Africa. We start by summarising the conventional wisdom on economic instruments for curbing pollution, and then motivate the choice of taxing electricity in South Africa for this purpose.

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[3] The data for 2008 is only for the first 11 months.

[4] This part of the paper is commissioned research for The National Treasury (South Africa) and funded by AUSAid. The authors would like to thank ASSET Research and CoPS for facilitating the project.

2.2.2 Permits or taxes?

Economic measures use the price mechanism to internalise the negative externalities associated with fossil fuel use. These measures could be used, at lowest cost to the economy, to achieve environmental targets. If marginal abatement costs could be equalised across all agents, action will be taken at the points in production that will result in the most efficient and cheapest abatement (UP 2007). UP (2007) identified tradable emissions schemes and taxes on emissions (or proxies of emissions) as the two most important economic measures in the context of emissions reductions.

Taxes on emissions, also called Pigouvian taxes, require that the total value of damage caused by an extra unit of emissions is equal to the tax levied per unit of emissions (Norregaard & Reppelin-Hill 2000). The result of this tax is to signal the true social cost of pollution to the emitter, who then has the financial incentive to reduce emissions to the point where the financial implication of one unit reduction to the emitter, is equal to the social damage involved.

On the other hand, in a system of marketable permits, permits are allocated by the regulatory authority that is equal to the aggregate quantity of emissions. This allocation could, for example, be through an auction (Norregaard and Reppelin-Hill 2000). In line with the Coase theorem, Perkins *et al* (2006) argued that the creation of a marketable permit system can achieve an efficient outcome with minimal government intervention. Although these permits may be the most-efficient way to reduce pollution, the requirements to function optimally are stringent and not often met in practice (Perkins *et al* 2006).

According to McKibben and Wilcoxen (2002), especially under uncertainty, taxes on emissions tend to be more efficient than a permit system. Furthermore, Rosen (1999) remarks that the relevant issue is not whether the perfect method of dealing with externalities is taxing emissions, but rather, whether or not they are likely to be better than other alternatives.

2.2.3 The tax base

Van Heerden et al (2006) used a national CGE model of South Africa (UPGEM) to simulate various environmental taxes, and found three main effects on an economy:

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

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

The use of fossil fuels in production can be taxed at different stages of production. As shown in Table 2.4, environmental taxes and charges can take different forms. Taxes can be raised on the outputs themselves at the consumption stage; the production of fossil fuels; their use as inputs; or governments can choose to tax the actual emissions of greenhouse gasses.

The choice of where to tax fossil fuel use has several effects. Firstly, there is an effect on the emission reduction incentives. Generally, the closer the tax incidence is to the source of emissions, the more effective the tax. Secondly, taxing end-consumption has a smaller effect on the competitiveness of the country, than taxing production (UP 2007). Thirdly, regardless of the placement of the statutory tax incidence, the economic incidence affects the distribution of income in the economy. Lastly, the administration costs and feasibility of the tax are determined by the point in the production where the tax is levied (UP 2007).

Table 2.4: Environmental taxes and charges

<table>
<tr><td colspan="2">Environmental taxes and charges can be classified in a number of ways. An environmental tax is defined by the OECD as “tax whose tax base is a physical unit (or proxy of it) that has proven specific negative impact on the environment”.

The National Treasury noted that classification of environmental taxes according to the tax base and not the intent of the tax is important for the following reasons:
• It is in line with international practices and facilitates cross-country comparisons;
• Unintended environmental outcomes are captured; and
• It provides a consistent framework to evaluate the impact of a particular tax instrument over time irrespective of the original intent.</td></tr>
<tr><td>Tax</td><td>A tax is a compulsory unrequited payment not proportional to the good or service received in return for that payment. Important characteristics of a tax include: beneficiaries constitute distinct groups of agents; no direct benefits accrue to individuals in exchange for payments; payments are enforced in terms of legislation; and government or organs of the state direct the use of tax revenues.</td></tr>
<tr><td>User Charge</td><td>A user charge is a requited payment for a specific service rendered. These payments are based on the individual benefit principle and attempt to link the amount paid to the benefit received by a specific individual. Important characteristics of a user charge include: a marketable service is provided to individual beneficiaries; direct benefits accrue to beneficiaries in exchange for payments; and transactions take place in a willing buyer willing seller market. As a guiding rule, user charges should not exceed the average cost of providing the service. In some instances, user charges might be set below average cost to ensure affordability.</td></tr>
<tr><td>Levy</td><td>A statutory levy is a compulsory payment and is, therefore, a tax.</td></tr>
<tr><td>Earmarked Tax</td><td>An earmarked tax is a tax, the revenues from which are used to finance a specific activity or programme.</td></tr>
</table>

Source: Republic of South Africa 2006

However, the goal of environmental taxation is to reduce emissions through redirecting behaviour away from actions that are detrimental to the economy. According to conventional tax wisdom, environmental taxation will be most effective in influencing behaviour, if the activity causing the pollution is taxed directly (OECD 2001). Therefore, where there is a clear environmental objective, the tax should be targeted as directly as possible. The preferred situation is a direct link between the tax and the environmental issue. If this is the case, incentives to change behaviour are likely to be stronger and unintended effects will be minimised

(Republic of South Africa 2006). The implication for CO_2 emissions is to tax the actual emissions directly. Unfortunately, this is usually not a feasible option due to the high administration cost associated with such a tax. As a result, no country has ever imposed a direct tax on actual emissions (UP 2007). The closest proxy for actual emissions taxes is an input tax on fossil fuels that discriminates based on the carbon content of different fuels used in the production process (UP 2007).

It should be noted that the direct effects of energy taxes are usually found to be regressive, due to the relatively high proportion of income spent on energy by poorer households. However, these regressive effects tend to be smaller when indirect effects, such as the increase in the relative prices of electricity intensive products, are taken into consideration (UP 2007).

2.2.4 Electricity generation tax: Some evidence

In 2008 the South African government announced the intention to levy a tax on electricity generation in South Africa. As discussed in the introduction, the aim of this tax is to reduce the country's emission intensity through providing an incentive to producers to switch away from processes associated with high levels of emissions. Since this tax will create a change in the economy, the economic welfare losses of rising energy prices have to be compared to the social welfare gains of reduced emissions.

The Scenario Building Team (SBT) at the Department of Environmental Affairs and Tourism in South Africa (Republic of South Africa 2007) showed that any level of taxation induces switching away from coal-fired electricity plants and coal-based technologies. Despite the costs associated with the switching, increased tax levels provide the incentive for switching away from coal-based processes, and this is a desirable outcome from an environmental perspective, as well as being the principle objective of the environmental tax. It is also reported that at levels beyond 208.3 cents per kWh the net economic impact will be negative. Results from the computable general equilibrium model used by the SBT (Republic of South Africa 2007), showed at high levels of taxation overall production and employment levels are likely to decline. GDP may decrease by between 2 and 7 per cent for a tax of 208.3 cent per kWh, and decrease by between 9 and 17 per cent for a tax of 625 cent per kWh.

As noted earlier, tradable emissions schemes and taxes on emissions (or proxies of emissions) are the two most important economic instruments in the context of emissions reductions. Due to the monopolistic character of the energy industry in South Africa (see Section 1), a tradable permit system would in effect become a command-and-control system. This would be the same as a direct quota to Eskom and does not seem to make much sense (UP 2007).

However, the impact of an environmental tax on incentives to abate emissions cannot be analysed in isolation. The market structure and price elasticities of demand are both vital in determining who bears the brunt of the tax incidence and how behaviour will change as a result of the tax.

Given the monopolistic nature of the South African electricity generation industry, passing through the increased prices of fossil fuel to consumers should be relatively easy. This will serve to limit the incentives to shift to lower-carbon fuels and as a result, the output-demand effect could be more important than the input-substitution effect (UP 2007).

The price elasticities of electricity demand, as well as government price setting regulations, will also influence the extent to which the tax burden can be shifted to end-consumers. Blignaut and De Wet (2001) calculated the arc price elasticity of electricity demand to investigate the effect of a change in the price of electricity on the consumption of energy over a twenty-year time period in South Africa. They reported that the manufacturing sector is relatively price inelastic in its decision making process. As a result, the price of electricity is a weak instrument to bring about behavioural changes in the manufacturing sector of South Africa. Furthermore, since electricity exhibits the characteristics of a consumable, essential as well as non-luxury commodity, it can be expected that the demand for electricity will reflect the same inelastic price elasticity globally.

An electricity generation tax can be effective in the reduction of emissions, despite the inelasticity of electricity, the monopolistic nature of the market and price regulation. Van Heerden et al. (2006) showed the almost one-to-one relationship between coal combustion and electricity. An electricity tax will increase the price of electricity. This increase will bring about a relatively small change in consumption. However, this reduction in consumption will reduce emissions almost on a one-to-one basis (Van Heerden et al 2006).

Van Heerden, Blignaut and Jordaan (2008) modelled a 10 percent tax increase on the price of electricity to determine the effect of such an increase on the consumer price index. The model used in their study, UPGEM, was developed as a computable general equilibrium model of the Department of Economics at the University of Pretoria. The model database was based on the official 1998 Social Accounting Matrix of South Africa, which divided households into 48 groups and distinguished 27 sectors. Also, the model's closure rules reflected a short-run time horizon. They found the direct impacts of an increase in electricity prices were mostly negative on the economy as industry production as well as GDP decreased.

The model presented in this chapter simulates an equivalent increase in electricity prices, but goes a step further by looking not only at the South African economy, but also the impact on other SACU and SADC countries. Furthermore, the model gives a detailed breakdown on industry level and distinguishes between skilled and unskilled labour. This should enable policy makers to fully assess the impact of the proposed electricity generation tax, not only on a national and international level, but also on an industry level.

Kerkela (2004) also used the GTAP model to simulate electricity price increases in Russia, where consumers are subsidized for the consumption of electricity. Our results compare very well with that of Kerkela, but as pointed out below, the results are not exactly the same as those of the national models mentioned above.

2.2.5 Double dividend: fact or fiction?

If the revenue generated from the environmental tax is recycled in a manner that addresses the current distortions in the economy, a second dividend becomes possible. UP (2007) defined the first dividend as the improvement in the environment due to the pollution abatement effect and the second dividend as possible improvement in the efficiency of the economy. This second dividend could be achieved, and the economy could move closer to the optimal situation, if the revenues are used to reduce existing distortions caused by taxes on labour and capital.

The potential of a second dividend depends on the initial state of the tax system. Where there are initial taxes, environmental taxes distort choices concerning labour supply and demand as well as investment. According to UP (2007), this tax interaction effect may dominate the positive effects of reducing other taxes. In other words, a double dividend is not automatic, but depends on the initial tax system and the initial distortions created. According to Van Heerden et al. (2006) a reduction of the energy demand through increased energy taxes will not lead to a reduction of tax revenues in South Africa due to the virtual absence of initial energy taxes. Thus, the loss of public funds is limited if there is a shift in taxes towards energy, which makes a double dividend more probable.

2.3 MODEL AND DATA

2.3.1 Introduction

This chapter 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.

2.3.2 The GTAP model

GTAP is a multi-region CGE model designed for comparative-static analysis of trade policy issues. All GTAP datasets are defined in terms of three primary sets: the set of countries and regions, the set of sectors and produced commodities, and the set of primary factors (Rutherford and Paltsev 2000). The aggregation of the model used in this chapter distinguishes four regions, namely South Africa, SACU countries excluding South Africa, SADC countries excluding SACU and the Rest of the World. The 57 GTAP sectors have been aggregated into 11 sectors shown in Table 2.A1 in the Appendix. In addition to the 11 sectors, there are three other agents in each region: a capital creator, a representative household and the government.

The GTAP model features explicit modelling of international transport margins, a global bank designed to mediate between world savings and investment, and a consumer demand system designed to capture differential price and income responsiveness across countries (Hertel and Will 1999). Macroeconomic data is used in GTAP to update the regional input-output tables to a common base year - 2004 for the GTAP 7 database used in this chapter. All the coefficients in the regional input-output models, initially in national currency units, are scaled-up to external GDP data in 2004 US dollars. Thereafter, private consumption, gross capital formation and government consumption are used to update the values of these aggregates in the regional input-output tables (Hertel 1997).

The GTAP model optimises the behaviour of agents in competitive markets to determine regional supply and demand of goods and services. Optimising the behaviour also determines sector demands for primary factors, i.e. labour, land, capital and natural resources. In each region there are two types of labour (skilled and unskilled) and a single, homogenous capital good. In standard comparative static applications of the model total supplies of all endowment factors (capital, labour, land and natural resources) are fixed for each region (in other words; South Africa, SACU excluding South Africa, SADC excluding SACU, and the rest of the world). 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 high structural unemployment in the unskilled labour market and a limited supply of skilled labour in the skilled labour market.

Other key assumptions are:

- Public and private consumption expenditures as well as nominal savings in each region are assumed to move with regional income. National investment is modelled as being responsive to changes in rates of return on capital. Global investment is assumed to be fixed. Therefore a region which benefits more from an exogenous shock will increase its share of global investment at the expense of other regions.
- We assume that the exogenously imposed shocks in each scenario have no effect on rates of commodity taxes, other than those used to impose the shocks.
- Here we assume that all technology variables are unchanged. For example, an increase in the price of electricity has no impact on the technology used in the production of electricity-intensive industries such as mining.
- Capital stocks are fixed, while rates of return are allowed to vary to accommodate the unchanged capital.

The GTAP model is a multi-country model focussing on the interaction among countries arising from the flows of goods and services. Its representation of savings and investment linkages is relatively weak, and so it does not pick up the possible inter-country shifts in assets (financial and physical) that may arise from the imposition of an electricity generation tax. Furthermore, the entire final demand system is treated as the demand system of a representative household. It is therefore not possible to analyse the welfare effects of the tax on different households as there is effectively only one household in the model.

The model does not endogenously predict the emergence of new industries, such as coal generation with carbon capture and storage or nuclear. New industries must be exogenously introduced, with the size and timing of the new industries specified by the model user. In the modelling conducted for this study it is assumed that no new industries emerge as a result of an electricity generation tax. However, this is a realistic assumption in South Africa in the short run. As discussed in the introduction, Eskom is investing in expanding the electricity generation capacity in the long run.

The version of GTAP used in this chapter is static, not dynamic. Accordingly, there is no allowance for the inter-temporal linkages between investment and capital, and between savings and consumption. While the model is able to project the likely changes in capital by industry and region associated with an electricity tax, there are no endogenous mechanisms that allow it to project the time-pattern of investment changes that bring about the projected changes in capital. A comparative-static framework also prevents a proper analysis of the adjustment costs (short-term and long-term) associated with an electricity tax.

For the simulations discussed in this chapter, no attempt was made to include the possible effects of climate change in the base case. That is, there are no assumptions made about the possible costs under 'business as usual', as a result of climate change. Neither do we include other more serious predictions of climate scientists, such as the flooding of low-lying urban areas or increased forest fire activity. Not allowing for the possible effects of climate change means that we do not account for any of the possible direct economic benefits arising from abatement achieved by an electricity tax. Also note that limited welfare analysis is possible, as there is only one household defined in the model.

2.3.3 The GTAP database

The GTAP database comprises of 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. The simulations reported in this study are based on a preliminary release of Version 7 of the database. 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.

2.3.4 Simulation design

The version described in the previous section is used to simulate a 2c/kWh tax on electricity generation. It should be noted that 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% (Blignaut, Chitiga-Mabugu and Mabugu 2005).

The shocks 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. Thus, a simulation of a 10 percent increase in the output tax of electricity was imposed.

2.4 RESULTS

The effect of a unilateral 2c/kWh electricity generation tax in South Africa is shown in Table 2.5. Note that revenue neutrality was also simulated and the results reflected no statistically significant differences from the results reported below.

Before these results are disaggregated, aggregated results will be briefly discussed using in part a stylised model proposed by Adams (2003).

If $A = B + C$, and a is the percent change in A, b is the percent change in B and c is the percent change in C, then it is approximately true that:

$$A * a = B * b + C * c$$

So that:

$$a = B/(B + C) * b + C/(B + C) * c$$
$$a = S_B * b + S_c * c$$

With a, b and c the percent changes in A, B and C respectively, and S_B and S_C the shares of B and C in A, respectively (Adams 2003).

If we then consider the following Keynesian macroeconomic identity:

$$Y = C + I + G + X - M$$

And apply the rule of:

$$a = S_B * b + S_C * c$$

The Keynesian macroeconomic identity could be approximated by:

$$y = S_c * c + S_I * i + S_G * g + S_X * x - S_M * m$$

Where y, c, i, g, x and m are the percent changes in Y, C, I, G, X and M respectively and S_C, S_I, S_G, S_X and S_M are the shares of the respective macroeconomic entities of total GDP.

Table 2.5: Effects of an electricity generation tax in South Africa

(Percentage deviations from no-tax case)

	SOUTH AFRICA	SACUEXCSA[5]	SADCEXCSA	ROW
Real GDP	-0.28	0.01	0.01	0.00
Real private consumption	-0.40	0.06	0.02	0.00
Real public consumption	-0.17	0.03	0.01	0.00
Real investment	-2.29	0.12	0.07	0.01
Real import volume	-0.69	0.13	0.04	0.00
Real export volume	0.70	0.02	0.00	-0.01
Terms of Trade	-0.15	0.60	0.02	0.00
Unskilled employment	-0.77	0.07	0.01	0.00
Skilled employment wage	-0.63	0.07	0.04	0.00
Industry production				
Electricity	-4.29	1.47	0.45	0.02
Grains and crops	0.31	-0.07	-0.02	0.00
Livestock and meat products	-0.08	-0.05	0.00	0.00
Mining and extraction	-0.35	0.00	0.00	0.00
Processed food	0.01	-0.06	-0.02	0.00
Textiles and clothing	0.34	0.15	-0.02	0.00
Light Manufacturing	0.12	-0.29	-0.14	0.00
Heavy Manufacturing	-0.18	0.01	-0.09	0.00
Utilities and construction	-1.84	0.10	0.06	0.01
Transport and communication	0.01	0.00	0.00	0.00
Other services	-0.19	0.04	0.01	0.00

As shown in Table 2.5, an electricity generation tax is expected to lower real GDP in South Africa by 0.28 percent. Since real private consumption constitutes 0.59 percent of real GDP[6] and

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[5] Where SACUEXCSA is SACU countries excluding South Africa, SADCEXCSA is SADC countries excluding SACU countries and ROW is the rest of the world.

[6] GTAP database Version 6

is expected to decrease by 0.40 percent, around 0.24 percent of the 0.28 percent decrease in real GDP could be explained by the change in real private consumption.

All the macroeconomic variables reported in Table 2.5, (with the exception of the real export volume) decrease for South Africa when simulating a unilateral implementation of an electricity generation tax. This tax drives a wedge between the price received by producers and the price paid in the market. As discussed in section 2, due to the inelastic nature of the demand for electricity, the price of electricity can be expected to increase by around ten percent. Since electricity is an input in most production processes, an increase in the electricity tariff will lead to an increase in production cost and thus suppress economic activity. This explains the 0.28 percent contraction of the real South African GDP. As the real GDP contracts, national income will decrease with a resulting decrease in real private consumption, real public consumption and real investment.

Table 2.5 shows that despite higher production costs as a result of more expensive electricity, the terms of trade weaken for South Africa. This is because the domestic demand decrease outweighs the decrease in domestic production, thereby reducing the domestic price level. Therefore, contrary to the expected outcome, despite the higher production costs real export volumes increase by 0.7 percent and the real import volume decreases by 0.69 percent. The effect of the decrease in domestic household and government demand can be seen in Table 2.6. Domestic prices will decrease in all the sectors. This is similar to a leftward shift of the demand curve in a static partial equilibrium analysis.

Table 2.6: Demand and market price percentage changes: South Africa

	HOUSEHOLD DEMAND	GOVERNMENT DEMAND	MARKET PRICE
Electricity	-3.37	-9.24	10.00
Grains and crops	-0.29	-0.51	-0.26
Livestock and meat products	-0.32	-0.51	-0.32
Mining and extraction	-0.50	-0.71	-0.03
Processed food	-0.30	-0.37	-0.41
Textiles and clothing	-0.35	-0.45	-0.34
Light Manufacturing	-0.43	-0.59	-0.27
Heavy Manufacturing	-0.49	-0.70	-0.06
Utilities and construction	-0.36	-0.49	-0.28
Transport and communication	-0.38	-0.33	-0.42
Other services	-0.37	-0.17	-0.57

The reduction in production will also translate into job losses, with unskilled employment shedding 0.77 percent. For skilled employment, wages will decrease by -0.63 percent, also due to the decline in real GDP. This is a major contributing factor towards the economy-wide decrease in demand by households and the government.

A more detailed picture arises from a breakdown by industry production. Despite lower domestic prices, three sectors will benefit from the electricity generation tax, namely: 'Grains and crops'; 'Textile and clothing'; as well as 'Light manufacturing'. These results are in line with expectations as these industries are non-energy intensive industries (see Table 2.2) and should benefit from the movement of factors of production away from energy intensive sectors. They also benefit from reduced input prices since domestic prices have fallen.

The "Processed food" as well as "Transport and communication" industries will experience an insignificant impact on domestic production. The other industries are all set to cut production, with the "Electricity" industry at -4.29 percent and the "Utility and construction" industry at -1.84 percent being hit hardest. The "Mining and extraction", "Heavy manufacturing" and "Other services" industries also record relatively high negative growth, as they use relatively more electricity than other sectors.

SACU countries, excluding South Africa will benefit from the unilateral electricity generation tax. South Africa is the dominant economic power in the region and the tax will improve the relative competitiveness of the other SACU countries, specifically in the production of electricity. However, it can be expected that these increases in the production of electricity will mainly be through coal-fired power stations, implying possible carbon leakage. As shown in Table 2.7, South Africa will reduce electricity production by 4.29 percent and increase electricity imports by 26.53 percent, while SACU excluding South Africa will increase domestic production by 1.47 percent and increase electricity exports by 1.44 percent. SADC excluding SACU is set to increase domestic production of electricity by 0.45 percent and increase exports by 0.58 percent. The impact on the rest of the world as a macro region will be insignificant as shown in the last column in table 2.5, in line with the fact that South Africa is considered a small country in global trade.

Table 2.7: Electricity flows (percentage changes)

	SOUTH AFRICA	SACUEXCSA	SADCEXCSA
Production	-4.29	1.47	0.45
Exports	-35.01	1.44	2.09
Imports	26.53	-1.55	-0.58

From Tables 2.5-2.7 we conclude that the economic incidence of higher electricity prices in South Africa falls on the domestic consumers, who lose their jobs and who have to pay more for electricity. Our competitors in SACU and SADC would be the main beneficiaries of this suggested policy implementation.

The CO_2 abatement 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 Emission Reduction certificate. As reflected in Table 2.8, the reduction in CO_2 emissions in the electricity sector will be worth R949 million, and pollution abatement across the economy will yield a benefit of R970 million.

Table 2.8: CO_2 abatement benefit: South Africa

	CHANGE IN CO_2 EMISSIONS (MT)	BENEFIT (R MILLION'S)	CHANGE IN INDUSTRY OUTPUT R MILLION'S)
Electricity	-9.487	948.68	-309.61
Grains and crops	0.024	-2.44	23.19
Livestock and meat products	-0.001	0.14	-8.58
Mining and extraction	-0.028	2.75	-50.9
Processed food	0.000	0.00	2.66
Textiles and clothing	0.000	0.00	35.3
Light Manufacturing	0.019	-1.94	60.78
Heavy Manufacturing	-0.184	18.41	-153.03
Utilities and construction	-0.048	4.82	-403.78
Transport and communication	0.005	-0.45	4.9
Other services	-0.005	0.50	-293.33

A sensitivity analysis has been conducted on the price elasticity of demand for electricity in the South African economy (0.47) and the elasticity has been found to be robust at a 10 percent variation using the Stroud quadrature and solving the model 22 times.

2.5 CONCLUSION

The South African government has proposed the imposition of a 2c/kWh tax on the sale of electricity generated from non-renewable sources; this tax is to be collected at source by the producers/generators of electricity. The intention of this measure is to serve a dual purpose of protecting the environment and helping to manage the current electricity supply shortages (Republic of South Africa 2008).

In South Africa, due to the structure of the market, an electricity generation tax is preferred to a permit system. Despite the inelastic demand for electricity, literature suggests that such a tax has the potential to reduce emissions.

The results from the simulation showed that the electricity generation tax would create distortions in the economy. The real GDP, real private consumption, real public consumption and real investment would decrease. Due to the decrease in domestic demand, export volume is expected to increase and import volume to decrease, despite a weaker terms of trade. These results are in line with the findings of Van Heerden, Blignaut and Jordaan (2008), who found that the direct effects of a 10 percent tax on the price of electricity are mostly negative. This chapter allowed unskilled workers to migrate, but assumed a limited skilled workforce, and found that unemployment for unskilled workers is expected to increase and wages of skilled workers are expected to decrease.

It is clear that an electricity generation tax will impose a cost on the South African economy, in terms of a reduction in the Gross Domestic Product of South Africa. However, the electricity generation tax is also expected to yield a positive effect on the South African economy, in terms of the benefits derived from pollution abatement. Ultimately, the government will achieve the objective of the electricity generation tax, namely the reduction of CO_2 emissions, at the expense of a slight reduction in output.

A unilateral electricity generation tax will benefit other SACU and SADC countries through an improvement in relative competitiveness, as shown by the improvement of the terms of trade for these regions.

APPENDIX

Table 2.A1: Sectoral composition of GTAP

IDENTIFIER	SECTORS IN REGION
Electricity	Electricity
Grains and crops	Paddy rice
	Wheat
	Cereal grains nec
	Vegetables, fruit, nuts
	Oil seeds
	Sugar cane, sugar beet
	Processed rice
Livestock and meat products	Cattle, sheep, goats, horses
	Animal products nec
	Raw milk
	Wool, silk-worm cocoons
	Meat: cattle, sheep, goats, horse
	Meat products nec
Mining and extraction	Forestry and fishing
	Coal
	Oil and gas
	Mineral nc
Processed food	Vegetable oils and fats
	Dairy products
	Sugar
	Food products nec
	Beverages and tobacco products
Textiles and clothing	Textiles
	Wearing apparel
Light Manufacturing	Leather products
	Wood products
	Paper products, publishing
	Metal products
	Motor vehicles and parts
	Transport equipment nec
	Manufactures nec
Heavy Manufacturing	Petroleum, coal products
	Chemical, rubber, plasticprods
	Mineral products nec
	Ferrous metals
	Metals nec
	Electronic equipment
	Machinery and equipment nec
Utilities and construction	Gas manufacture, distribution
	Water
	Construction
Transport and communication	Trade
	Transport nec
	Sea transport
	Air transport
	Communication
Other services	Financial services nec
	Insurance
	Business services nec
	Recreation and other services
	Public Admin, defence, health, education
	Dwellings

CHAPTER 3

THE COMPETITIVENESS IMPACT OF A MULTILATERAL ELECTRICITY GENERATION TAX

3.1. INTRODUCTION

A tax on electricity generation in South Africa will affect not only the South African economy, but also SACU, SADC, EU and the rest of the world, via changes in South Africa's export and import volumes.

Bilateral import shares for the regions under consideration are shown in Table 3.1. South Africa, despite bordering the rest of the SACU countries, only imports 7.1 percent of total imports from the rest of SACU countries and 6.3 percent from the rest of SADC countries. On the other hand, South Africa imports 35.7 percent of total imports from the European Union, South Africa's largest trading partner.

Table 3.1: Bilateral import shares

	SOUTHAFRICA	**SACUEXCLSA**	**SADCEXCLSACU**	**EU_25**
to South Africa	0.0	7.1	6.3	35.7
to SACU (exclSA)	6.9	0.1	1.9	55.4
to SADC (exclSACU)	6.1	0.7	5.1	42.4
to EU_25	0.6	0.0	0.1	59.9

Source: GTAP database

The rest of SACU countries import 6.9 percent of total imports from South Africa, but 55.4 percent from the European Union. Similarly, the rest of SADC countries import 6.1 percent of total imports from South Africa, but 42.4 percent from the European Union.

Table 3.2: Bilateral exports shares

	SOUTHAFRICA	**SACUEXCLSA**	**SADCEXCLSACU**	**EU_25**
from South Africa	0.0	7.5	5.5	36.2
from SACU (exclSA)	7.1	0.1	1.7	55.0
from SADC (exclSACU)	6.3	0.7	4.9	41.5
from EU_25	0.5	0.0	0.1	61.2

Source: GTAP database

As shown in table 3.2, exports exhibit similar shares, with the European Union being the dominating trade partner for South Africa, the rest of SACU countries and the rest of SADC countries.

The primary objective of this chapter is to evaluate the impact of an electricity generation tax on the international competitiveness of South Africa. Also, different scenarios are assessed to establish whether the loss of competitiveness can be negated through an international, multilateral electricity generation tax.

The next section considers the relationship between environmental taxation and pollution, as well as the effect of environmental taxation on competitiveness. In the third section, the model, data and simulation design are discussed. This is followed by an analysis of the results. The fourth section presents a conclusion and discussion of the limitations of the model.

3.2. LITERATURE REVIEW

3.2.1 Introduction

This section of the chapter considers the impact of environmental taxation on the competitiveness of a country. The fear of loss of competitiveness and the fear of negative distributional impacts are currently the main obstacles to the implementation of environmental taxation (OECD 2001).

3.2.2 Defining environmental taxes

The idea behind environmental taxation is to internalise the externalities caused by polluting industries, which should then fully reflect the negative impact of production on the environment (OECD 2001).

"Putting an appropriate price on carbon, explicitly through a tax or trading, or implicitly through regulation, means that people are faced with the full social cost of their actions. This will lead individuals and businesses to switch away from high-carbon goods and services, and to invest in low-carbon alternatives." (Stern & The Great Britain Treasury 2006 p xviii)

Environmental taxes were defined by De Kam (2002 p2) as "Any compulsory, unrequited payment to general government levied on a tax base deemed to be of particular environmental relevance". Environmental taxes are unrequited since the payments by taxpayers are normally not in proportion to the benefits they receive from government.

Given the definition above, environmental taxes can only be successfully implemented if the following two principles of taxation are considered (De Kam 2002):

- A tax will, as long as it affects the incentives of economic agents, creates distortions in the economy that will lead to a reduction of economic efficiency. However, these distortions might be introduced into the system to correct market failures and thereby enhance welfare. Also, where the price elasticity of demand is relatively inelastic, there will be substantial revenue gains; this might be used to offset distortions caused by other taxes. In such a situation, a double dividend becomes possible.
- The direct effect of the tax should be assessed as it will impact on the distribution of income and create questions about fairness. According to De Kam (2002), this issue of redistribution should be awarded substantial weight even if it lowers economic efficiency.

Over the past couple of decades the OECD (2001) found, that environmental taxes could be effective and efficient instruments for environmental policy to reduce pollution. These measures, through their price signals to the economy, ensure that polluters take into account the detrimental impact of their production and consumption decisions on the environment (OECD 2001). Environmental improvements are achieved through price increases of environmentally harmful products. These price increases reduce the quantity demanded of the product. The idea is that the most efficient and cheapest abatement could be achieved if marginal abatement costs are equalised across all agents (UP) 2007).

However, most stakeholders will agree that the optimal environmental effectiveness and economic efficiency of environmentally related taxes have not been achieved due to existing exemptions and other special provisions. In the context of this study, optimal environmental effectiveness is when the environmental tax has the ability to fully internalise the externalities caused by the polluting industries and economic efficiency refers to the actual internalisation process. Two main political concerns hamper the scaling back of these obstacles, namely, the fear of loss of competitiveness and the fear of negative distributional impacts (OECD 2001). As a result, the negative environmental impacts caused by production and consumption are not fully reflected in the economy.

3.2.3 The effect of environmental taxes on competitiveness

International competitiveness

The definition of "international competitiveness" is not clear in the literature. Krugman (1994) claims that competitiveness is a dangerous obsession when applied to countries, as opposed to companies. International trade is not a zero-sum game, and countries do not compete directly in the same way as companies (Krugman 1994). Golub (2000 p8) defined competitiveness as a "favourable business climate, sometimes measured by a composite score of a series of indicators: structural and macroeconomic policies, basic infrastructure, education, labour market rigidities, etc.". This definition is in line with the approach of the competitiveness rankings of the World Economic Forum.

The concept of competitiveness has several different levels (UP 2007). It is therefore important to distinguish between the competitiveness of an entire country and the competitiveness of individual firms and sectors. As long as a company or sector is able to compete in international markets, and earn an adequate rate of return; the company or sector could be seen as competitive. On the other hand, competitiveness for an entire country is more complex to define. Environmental taxes are intended to correct market failures. If this is achieved, overall economic efficiency in the economy increases. However, certain sectors will face higher production costs and will therefore be adversely affected. If there is a revenue recycling scheme in place and recycling takes place through a reduction in labour taxes, labour intensive industries will tend to gain at the expense of energy intensive sectors (De Kam 2002). The different dimensions of competitiveness are described in Table 3.3.

Table 3.3: The different dimensions of competitiveness

	INDIVIDUAL FIRM	COUNTRY
Definition	Able to compete in international markets, with an adequate rate of return.	Favourable business climate, while correcting for market failures, resulting in an improvement in the overall economic outcome.
Relative Performance	If uncompetitive, risk losing market share and eventually close down.	If uncompetitive, grow more slowly and enjoy fewer opportunities than more competitive countries.
Environmental Tax	Impact on the bottom-line.	Impact on the overall performance of the economy

Source: Republic of South Africa 2008

The second dimension of competitiveness is relative performance, in terms of individual firms and countries. An uncompetitive firm is at risk to lose market share, or to close down. However, a country cannot close down. But countries with low competitiveness could experience slower than optimal economic growth, with lower real wage growth and fewer economic opportunities than more competitive countries (Stern 2006). On a country level, improving competitiveness would entail new policies and revamping institutions to enable the economy to adapt more freely to changing environments and exploiting new opportunities. This should include measures to improve national productivity. National competitiveness could further be enhanced through environmental measures that encourage emission mitigation, if these measures are carefully designed and if these measures provide incentives to innovate. Therefore, innovation associated with countering climate change could stimulate global economic growth (Stern 2006).

Environmental taxes and competitiveness

When implementing environmental taxes, the objectives of these taxes should be clearly stated at the onset (OECD 2001). An environmental tax will have an impact on the competitiveness of certain industries, especially energy intensive industries. According to the OECD (2001), due to the influence and large interests of industry, energy taxes cannot be introduced without significant exemptions and other special provisions to reduce the burden on at least the worst hit sectors. Exemptions and other special provisions could be inefficient if the unilateral imposition of environmental taxes creates a possibility for leakage. Also, exemptions and special provisions differ in the way in which they affect the original emission reduction incentives of the tax. The most efficient emission reduction could be achieved if equal tax rates are levied on all agents and then compensate the worst hit sectors separately. If this is not possible, low tax rates that are raised slowly over time could be levied in these sectors as opposed to complete exemptions or zero-rates (UP 2007).

However, exemptions create inefficiencies in pollution abatement and run contrary to the objective of environmental taxes, that is, the polluter should pay principle.

Potential loss of competitiveness

Popular view dictates that trade liberalisation will shift power from governments to firms, thus making it easier for firms to resist costly environmental regulation. This becomes possible if firms refer to their need to stay competitive. However, the argument will only hold if environmental measures decrease the competitiveness of firms and governments respond by setting less stringent environmental policies (Greaker 2004).

De Kam (2002) reported that environmental taxes imposed in OECD countries did not reduce the competitiveness of industries within these countries. This might be due to partial exemption provided to energy intensive industries in these countries. In fact, it is clear from the OECD/EU database that environmentally-related taxes are almost exclusively levied on households and the transport sector (De Kam 2002).

However, the OECD (2001) indicated that economic instruments, used for pollution abatement purposes are likely to have detrimental effects on the international competitiveness of certain industries, especially if these instruments are implemented through a unilateral policy decision. This is because a unilateral environmental tax will increase the production cost in the country imposing the tax, thus forcing the prices of domestically produced products traded in the international market to higher levels. As a result, exports will become less attractive and imports more so. This will lead in the short run to lower domestic production, potential job losses and other adjustments caused by the tax in the economy (De Kam 2002).

Competitiveness concerns are expected to be the strongest if the environmentally-related tax is imposed on internationally traded goods or key factors of production, and these goods or factors are freely traded with no border tax adjustment in place. Another critical factor is substitution possibilities. If there is limited scope for the identification and financing of cleaner production processes and technologies, the inability to substitute away from environmental taxes will adversely impact on the competitiveness of affected industries (De Kam 2002). On the other hand, competitiveness effects are not likely to be a major concern if the environmental tax is levied on the production of a product that cannot be readily imported or exported, and substitution is possible as well as relatively cheap.

According to Stern (2006), in the case of a unilateral tax, the potential impact on a small number of industries is such that leakage becomes possible. In other words, even if these sectors are not characterised by high trade intensity, there are incentives for import substitution and to relocate production to countries with less stringent environmental regulation. Therefore, some sectors (for example, steel and cement or even electricity for more inter-connected countries) might be more vulnerable where countries border other countries with less stringent mitigation regulation (Stern 2006).

Potential gain of competitiveness

There is also some evidence in the literature that suggests that environmentally-related taxes could increase the competitiveness of a country imposing the tax. For example, the Porter-hypothesis states: "Governments can tighten their level of environmental regulation, and firms will find that they become more competitive, not less" (Porter 1991). This hypothesis could be interpreted in at least two different ways. Firstly, emissions can be seen as a wasteful use of scarce resources. Scarce resources are transformed to pollution as a by-product of production. According to Porter and Von der Linde (1995) this could be seen as a sign that these resources are used in an incomplete, inefficient or ineffective manner. If these emissions are removed from the system, efficiency gains will be made as less scarce resources will be needed to produce final goods (Porter and Von der Linde 1995). Secondly, if stringent regulation is implemented in the correct manner, firms in tax paying countries could become more competitive than firms in countries without the same type of taxation. In other words, a tough environmental policy makes firms more internationally competitive than a weak environmental policy (Porter 1991).

Greaker (2003) referred to the scale advantages of abatement technology when he stated that emissions may be an inferior input in production. He also provided evidence that governments could exploit this in the international market place through setting a high emissions tax.

In 2004, Greaker supported the Porter-hypothesis by illustrating the possibility of improved downstream competitiveness due to tough environmental policies. Entry into the abatement services industry is expected to increase under tough environmental policies. This is expected to lead to a lower price on pollution abatement and consequently a more competitive polluting industry. Thus, Greaker (2004) proposed that governments should set an especially stringent environmental policy. However, this argument is only valid if the environmental policy is unilateral in nature. In other words, this incentive to set a stringent environmental policy will disappear if there is a global market for pollution abatement services.

Along the same line of argument, stringent environmental taxes could also increase firm competitiveness, since higher emission taxes lead to a reduction of marginal costs. This would be the case if emissions per unit of output decrease due to increased spending on research and development and if this effect dominates the direct effect of the environmental tax (Ulph 1994).It remains ambiguous to which extent governments should set a high emissions tax to exploit this relationship.

Computable General Equilibrium model results for South Africa

Van Heerden, Blignaut and Jordaan (2008) modelled a 10 percent increase in the price of electricity in South Africa. The aim was to determine the effect of such an increase on the consumer price index. A computable general equilibrium model of the Department of Economics at the University of Pretoria, UPGEM, was used in the study. The official 1998 Social Accounting Matrix of South Africa, which divided households into 48 groups and recorded 27 sectors, was used in the database. The UPGEM model's closure reflected a short-run time horizon. They found the direct impacts of an electricity generation tax on the economy to be mostly negative.

The model presented in this study simulates an equivalent increase in electricity prices, but looks not only at the South African economy, but also SACU, SADC and the European Union. Furthermore, a unilateral and multilateral tax is simulated to examine the possibility of negating the adverse competitiveness effects through multilateral tax implementation. The model also provides a detailed breakdown on industry level, and distinguishes between unskilled and skilled labour. This analysis should enable policy makers to assess the impact of the proposed electricity generation tax, whether unilateral or multilateral, on an international, national and industry level.

3.3. MODEL AND DATA

3.3.1 The GTAP model

A description of the GTAP model, as well as the assumptions, limitations and closure has been provided in Chapter 2. The version of the model used in this chapter distinguishes five regions, shown in Table 3.4, and the 57 GTAP sectors has been aggregated into 11 sectors shown in Table 2.A1 in the Appendix of Chapter 2. In addition to the 11 sectors, there are three other agents in each region: a capital creator, a household and the government.

Table 3.4: Regional aggregation of GTAP

IDENTIFIER	COUNTRIES IN REGION
South Africa	South Africa
SACU (exclSA)	Lesotho, Swaziland, Namibia and Botswana
SADC (excl SACU)	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
Rest of world	The rest of the world

3.3.2 Simulation design

The version described in the previous section is used to model different 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 weighed average of 10 percent (Blignaut, Chitiga-Mabugu and Mabugu 2005). The second and third scenarios model the effects of a 10 percent electricity generation tax in SACU and SADC respectively. The fourth scenario models a 10 percent electricity generation tax in South Africa and the European Union. The reason for the last three simulations is to investigate to the possibility that the negative competitiveness impact of environmental taxes could be negated through multilateral implementation instead of unilateral implementation.

Since an output tax drives a wedge between the price received by producers and the price paid in the market, we imposed the shocks via changes to output taxes in the production of electricity.

3.4. RESULTS

This chapter considers the impact of unilateral and multilateral electricity generation taxes of 2c/kWh on competitiveness, under the four scenarios discussed in the previous section. Note that revenue neutrality was also simulated and the results reflected no significant differences from the results reported below.

Table 3.5: Results of Scenario 1

	South Africa	SACU (excl SA)	SADC (excl SACU)	EU_25	Rest of world
Real GDP	-0.28	0.01	0.01	0.00	0.00
Real private consumption	-0.40	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 wages	-0.63	0.07	0.04	0.00	0.00

Under the first scenario, South Africa imposed a unilateral 2c/kWh tax on electricity generation. The results of this simulation have been discussed in Chapter 2, and are summarised in Table 3.5.

Higher production costs will result in terms of trade deterioration of 0.15 percent for South Africa. However, the decrease in domestic demand will outweigh the decrease in domestic production. Therefore, contrary to the expected outcome and despite the higher production costs and weaker terms of trade, the real export volume increases by 0.7 percent and the real import volume decreases by 0.69 percent. The industry breakdown is presented in Appendix 3.A2.

The second scenario modelled the effects of a 10 percent electricity generation tax in South Africa and the rest of SACU. The macroeconomic results for South Africa remained the same, except for a marginal greater decrease in real public consumption, real investment and real import volume. Real investment decreased by 2.3 percent in stead of 2.29 percent. South Africa is seen as the gateway to Africa for many multinational organisations. A decrease in the real

GDP of other SACU countries might deter real investment in South Africa. In fact, a multilateral tax as modelled in scenario 2 will result in a 0.09 percent decrease in the real GDP of other SACU nations.

Table 3.6: Results of Scenario 2

	SouthAfrica	**SACUexclSA**	**SADCexclSACU**	**EU_25**	**restofworld**
Real GDP	-0.28	-0.09	0.01	0.00	0.00
Real private consumption	-0.40	-0.09	0.03	0.00	0.00
Real public consumption	-0.18	-0.08	0.01	0.00	0.00
Real investment	-2.30	-0.35	0.09	0.01	0.01
Real import volume	-0.70	0.13	0.06	0.00	0.00
Real export volume	0.70	0.21	-0.01	0.00	-0.01
Terms of Trade	-0.15	0.04	0.03	0.00	0.00
Unskilled employment	-0.77	-0.25	0.02	0.00	0.00
Skilled employment wages	-0.63	-0.22	0.05	0.00	0.00

For the rest of SACU, the multilateral tax under scenario 2 will adversely affect all the macroeconomic variables, except international trade. The terms of trade, calculated as the ratio between export prices and import prices, are expected to improve by 0.04 percent, and as a result, exports are expected to increase 0.21 percent and imports to increase 0.13 percent. The terms of trade for the rest of SACU can be expected to improve. The reason for this is the prominent role that South Africa plays in trade with these countries (see section 2). Since the adverse effects of electricity generation taxes are greater in South Africa than in the rest of SACU (Table 3.6), the relative trade position of the rest of SACU is expected to improve.

As expected, the impact on the European Union and the rest of the world is insignificant but the effect on the rest of SADC is mostly positive. The only macroeconomic variable decrease experienced by the rest of SADC is a 0.01 percent decrease in real export volume. This is due to the greater relative improvement of the rest of SACU's terms of trade (0.04 percent) compared to 0.03 percent in the rest of SADC.

Table 3.7: Results of Scenario 3

	SouthAfrica	**SACUexclSA**	**SADCexclSACU**	**EU_25**	**restofworld**
Real GDP	-0.28	-0.10	-0.54	0.00	0.00
Real private consumption	-0.41	-0.11	-0.74	0.00	0.00
Real public consumption	-0.18	-0.10	-0.16	0.00	0.00
Real investment	-2.33	-0.37	-3.13	0.01	0.01
Real import volume	-0.74	0.08	-1.22	0.00	0.00
Real export volume	0.69	0.18	0.13	-0.01	-0.01
Terms of Trade	-0.16	0.02	-0.11	0.00	0.00
Unskilled employment	-0.78	-0.28	-1.03	0.00	0.00
Skilled employment wages	-0.63	-0.24	-0.11	0.00	0.00

The results of scenario 3 are presented in Table 3.7. A multilateral tax in all SACU and SADC countries will affect South Africa more negatively than a unilateral tax in South Africa only. The South African deterioration in terms of trade (-0.16 percent) and the weaker demand in the rest of SACU (-0.11 percent decrease in real private consumption and -0.1 percent decrease in public consumption) and the rest of SADC (-0.74 percent decrease in real private consumption and -0.16 percent decrease in public consumption) will result in a decrease of 0.74 percent in the real import volume. Exports will increase by 0.69 percent compared to 0.7 percent under scenario 1. Also, real investment decreases by 2.33 percent and unskilled employment by 0.78 percent.

Table 3.8: Results of Scenario 4

	SouthAfrica	**SACUexclSA**	**SADCexclSACU**	**EU_25**	**restofworld**
Real GDP	-0.26	0.02	0.02	-0.37	0.02
Real private consumption	-0.38	0.03	0.06	-0.50	0.04
Real public consumption	0.16	0.00	0.01	-0.24	0.03
Real investment	-1.67	0.37	0.62	-1.09	0.40
Real import volume	-0.61	0.12	0.18	-0.55	0.17
Real export volume	0.42	-0.05	-0.15	0.05	-0.25
Terms of Trade	-0.13	-0.01	0.07	-0.06	0.04
Unskilled employment	-0.74	0.08	0.02	-0.91	0.06
Skilled employment wages	-0.61	0.03	0.13	-0.72	0.04

Furthermore, all other SACU and SADC countries will be adversely affected with the exception of the rest of SACU and the rest of SADC's international trade position. Again, this improvement is due to the relative position of the rest of SACU and the rest of SADC countries to South Africa. Thus, contrary to the idea that multilateral taxation will negate the effect of an electricity generation tax in South Africa, multilateral taxation will reinforce the negative effects of a unilateral electricity generation tax on the South African economy.

Scenario 4 modelled a multilateral electricity generation tax of 10 percent in South Africa and the European Union. From the results in Table 3.8, it can be seen that a simultaneous tax in both regions will have a smaller negative effect on the South African economy, compared to a unilateral tax in South Africa only (Table 3.6). This is in line with expectations as the European Union is the largest trading partner of South Africa, and the loss of competitiveness to the European Union, will under this scenario, be negated. However, the cost to the European Union will be significant.

CO_2 abatement benefit: South Africa

The CO_2 abatement has been calculated, using the greenhouse gas emissions inventory as developed by Blignaut, Chitiga-Mabugu and Mabugu (2005). Economic benefit accruing to CO_2 abatement was calculated at R100 per ton, based on a low estimate of approximately Euro 8 for a Certifiable Emission Reduction certificate. As reflected in Table 3.9, the imposition of a unilateral electricity generation tax will lead to a reduction in CO_2 emissions worth R970 million. If the electricity generation tax is imposed multilaterally across all SACU or all SADC countries, the benefit of a reduction in emissions will be reduced to R962 million and R933 million respectively. Furthermore, if the electricity tax is levied in South Africa and the European Union, emission reduction will be worth R626 million.

Table 3.9: CO_2 abatement benefit: South Africa

	SCENARIO 1		SCENARIO 2		SCENARIO 3		SCENARIO 4	
	CO_2	Benefit (R million's)	CO_2	Benefit (R million's)	CO_2	Benefit (R million's)	CO_2	Benefit (R million's)
Electricity	-9.49	948.68	-9.40	939.84	-9.11	911.09	-5.97	597.07
Grains and crops	0.02	-2.44	0.02	-2.44	0.02	-2.12	0.02	-1.57
Livestock and meat products	0.00	0.14	0.00	0.16	0.00	0.17	0.00	0.21
Mining and extraction	-0.03	2.75	-0.03	2.75	-0.03	2.67	-0.04	3.54
Processed food	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Textiles and clothing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light Manufacturing	0.02	-1.94	0.02	-1.78	0.01	-1.46	0.01	-0.81
Heavy Manufacturing	-0.18	18.41	-0.18	18.41	-0.17	17.39	-0.20	20.45
Utilities and construction	-0.05	4.82	-0.05	4.85	-0.05	4.90	-0.04	3.57
Transport and communication	0.00	-0.45	0.00	0.00	0.00	0.00	-0.03	3.15
Other services	0.00	0.50	-0.01	0.52	-0.01	0.52	-0.01	0.55
Total	-9.70	970.48	-9.62	962.31	-9.33	933.17	-6.26	626.16

A multilateral electricity generation tax across SACU or SADC countries will not only have a marginal negative effect on the South African economy, but also result in emission reductions lower than in the case of a unilateral electricity generation tax. As expected, a multilateral electricity generation tax in South Africa and the European Union will not only have a smaller negative effect on the competitiveness of South Africa, but also lead to lower emission reductions than under a unilateral electricity generation tax. Since the multilateral electricity generation tax limits the negative competitiveness effect on the South African economy, production decreases are smaller than under a unilateral tax, leading to lower emission reductions.

A sensitivity analysis has been conducted on the price elasticity of demand for electricity in the South African economy, the rest of SACU, the rest of SADC, the European Union and the Rest of the World. The elasticities have been found to be robust at a 10 percent variation using the Stroud quadrature method.

3.5. CONCLUSION

An electricity generation tax would affect the competitiveness of South Africa negatively. Furthermore, SACU and SADC wide implementation would marginally reinforce these negative effects. However, a multilateral electricity generation tax across SACU or SADC countries could result in emission reductions, but lower than in the case of a unilateral electricity generation tax.

In contrast, the cost to the South African economy could be limited if the European Union would follow suit and implement an electricity generation tax. As expected, a multilateral electricity generation tax in South Africa and the European Union would have a smaller negative effect on the competitiveness of South Africa. But, on the other hand, also lead to lower emission reductions than under a unilateral electricity generation tax. Therefore, one could argue in favour of global rules for environmental taxes since this would ensure minimum negative competitiveness effects on participating countries.

APPENDIX

Tables 3.A1 – 3.A4 shows the impact of the various scenarios on the output of industries in the 5 regions. In all the scenarios, electricity output would be lower due to the environmental tax. As more countries levy a similar environmental tax, the impact on South African electricity output would be smaller, but remain negative. In scenario 4, if the EU and South Africa implements a multilateral environmental tax, electricity output in South Africa would only decrease by 2.7 percent compared to a 4.29 percent reduction under a unilateral environmental tax. It is also clear that the economy would change structurally, away from electricity intensive industries, if an environmental tax is levied.

Table 3.A1: Scenario 1 industry results

	SouthAfrica	SACUexclSA	SADCexclSACU	EU_25	restofworld
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

Table 3.A2: Scenario 2 industry results

	SouthAfrica	SACUexclSA	SADCexclSACU	EU_25	restofworld
Electricity	-4.25	-7.70	0.66	0.04	0.01
Grains and crops	0.31	-0.02	-0.02	-0.01	0.00
Livestock and meat products	-0.09	0.00	0.00	0.00	0.00
Mining and extraction	-0.35	0.16	-0.01	0.00	0.00
Processed food	0.01	-0.01	-0.03	0.00	0.00
Textiles and clothing	0.34	0.21	-0.05	0.00	-0.01
Light Manufacturing	0.11	-0.29	-0.16	0.00	0.00
Heavy Manufacturing	-0.18	0.08	-0.12	0.00	0.00
Utilities and construction	-1.85	-0.31	0.07	0.01	0.01
Transport and communication	0.00	-0.05	0.00	0.00	0.00
Other services	-0.2	-0.05	0.00	0.00	0.00

Table 3.A3: Scenario 3 industry results

	SouthAfrica	SACUexclSA	SADCexclSACU	EU_25	restofworld
Electricity	-4.12	-6.02	-9.77	0.06	0.02
Grains and crops	0.27	-0.07	0.41	-0.01	-0.01
Livestock and meat products	-0.10	-0.02	-0.30	0.00	0.00
Mining and extraction	-0.34	0.16	0.37	0.00	0.00
Processed food	-0.02	-0.06	0.35	-0.01	0.00
Textiles and clothing	0.34	0.19	3.49	-0.01	-0.01
Light Manufacturing	0.09	-0.33	-0.12	0.00	0.00
Heavy Manufacturing	-0.17	0.03	-4.26	0.00	0.00
Utilities and construction	-1.87	-0.32	-2.32	0.01	0.01
Transport and communication	0.00	-0.08	-0.06	0.00	0.00
Other services	-0.20	-0.07	0.10	0.00	0.00

Table 3.A4: Scenario 4 industry results

	SouthAfrica	SACUexclSA	SADCexclSACU	EU_25	restofworld
Electricity	-2.70	3.78	4.00	-3.41	0.46
Grains and crops	0.20	-0.08	-0.11	-0.08	-0.02
Livestock and meat products	-0.12	-0.10	-0.03	-0.21	-0.01
Mining and extraction	-0.45	-0.11	-0.10	0.01	-0.06
Processed food	-0.04	-0.16	-0.20	-0.23	-0.03
Textiles and clothing	0.25	0.35	-0.66	-0.01	-0.19
Light Manufacturing	0.05	-0.13	-0.34	-0.26	-0.03
Heavy Manufacturing	-0.20	0.33	-0.46	-0.34	0.03
Utilities and construction	-1.36	0.29	0.44	-0.84	0.31
Transport and communication	-0.07	0.03	-0.13	-0.22	0.00
Other services	-0.21	-0.05	-0.12	-0.21	-0.01

CHAPTER 4

THE WELFARE EFFECTS OF REVERSED BORDER TAX ADJUSTMENTS AS A REMEDY UNDER UNILATERAL ENVIRONMENTAL TAXATION

4.1 Introduction

Economic measures, such as environmental taxes, work through the price mechanism to internalise the externalities of fossil fuel use and have the potential to reach environmental targets at lowest 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 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, 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.

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 chapter aims to provide a theoretical general equilibrium 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.

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.

4.2 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).

4.3 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).

The world currently faces unequal carbon prices across various countries because different countries levy different tax rates and use different instruments (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 rationale 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, limits 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).

4.4 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, 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.

Contrary to popular belief, if the neutrality concept holds, BTAs will not offset the competitiveness effects of environmental policies (Lockwood and Whalley 2008).

4.5 BTAs: A Heckscher-Ohlin Approach

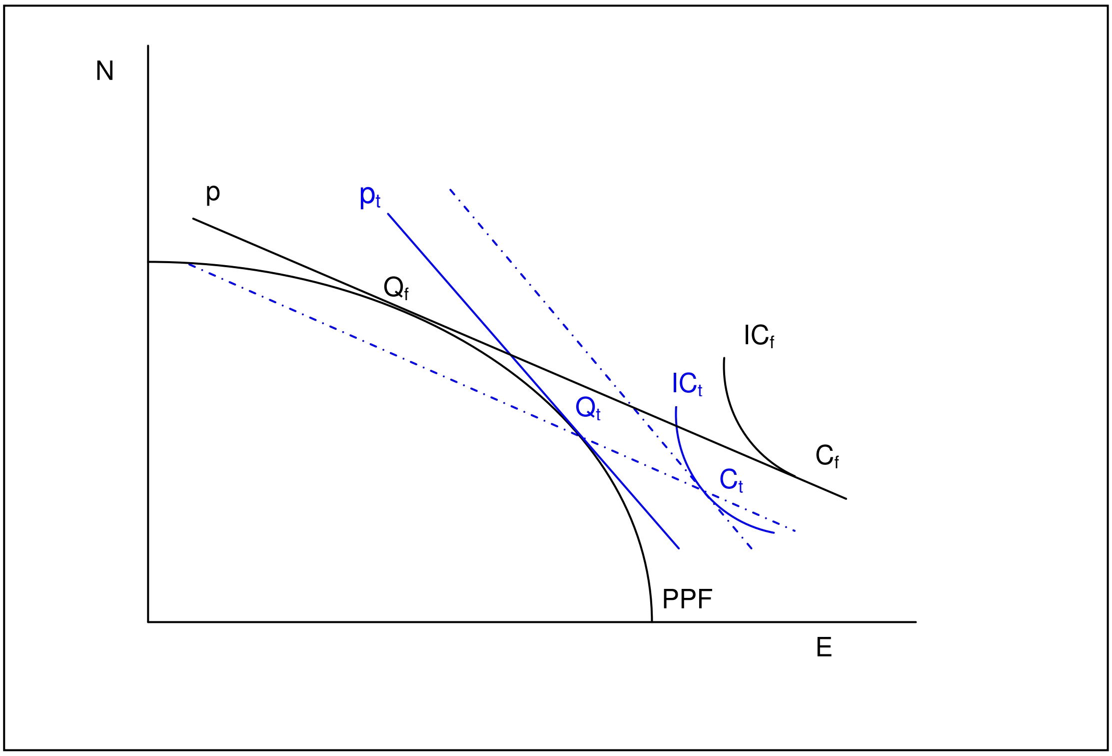
As discussed in the previous section, the neutrality proposition implies that complete BTAs will have no effect on the real domestic economy. However, BTAs are seldom complete and might therefore have an impact on the real domestic economy. In this section we consider the case where there is an import 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).

Figure 4.1: The effect of a tariff on energy intensive products



Source: Adapted from Salvatore (1998)

Free trade consumption equilibrium is illustrated in Figure 4.1 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, 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 $p_t > p$.

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-electricity intensive products at Q_t.

Introducing an environmental tax

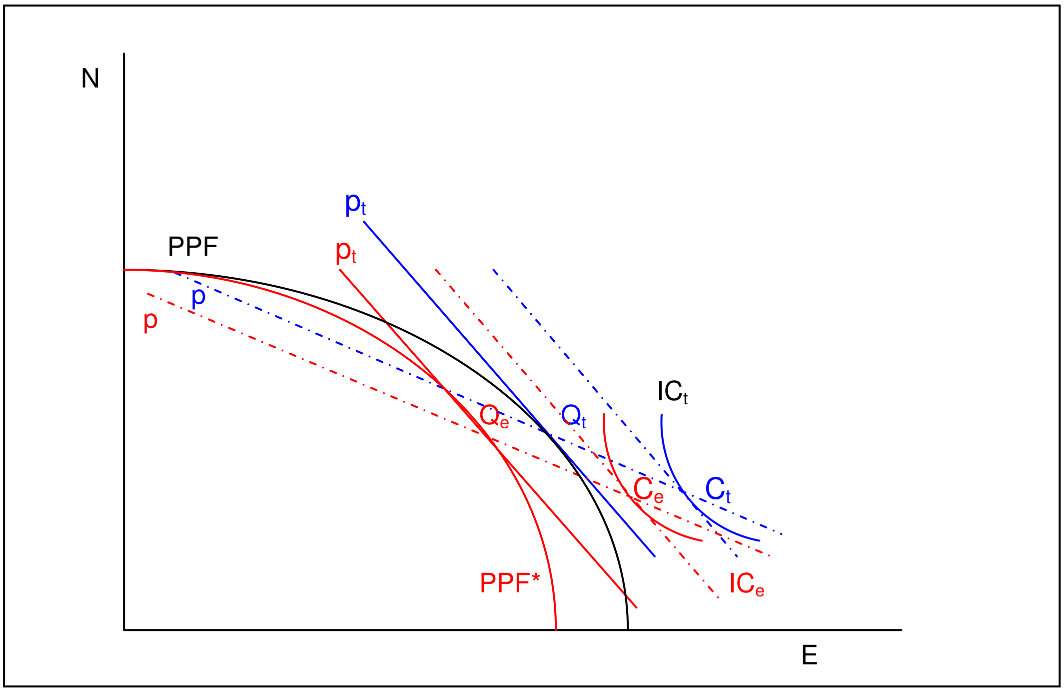
A distortion, to represent a unilateral environmental tax, in the form of a tax on energy intensive production based on carbon content, is introduced in Figure 4.2, the tax shifts the production possibility frontier inwards from PPF to PPF*. This distortion affects the production potential of energy 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 4.2: An energy intensive biased negative distortion to production potential



Source: Own compilation

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 reversed border tax adjustments

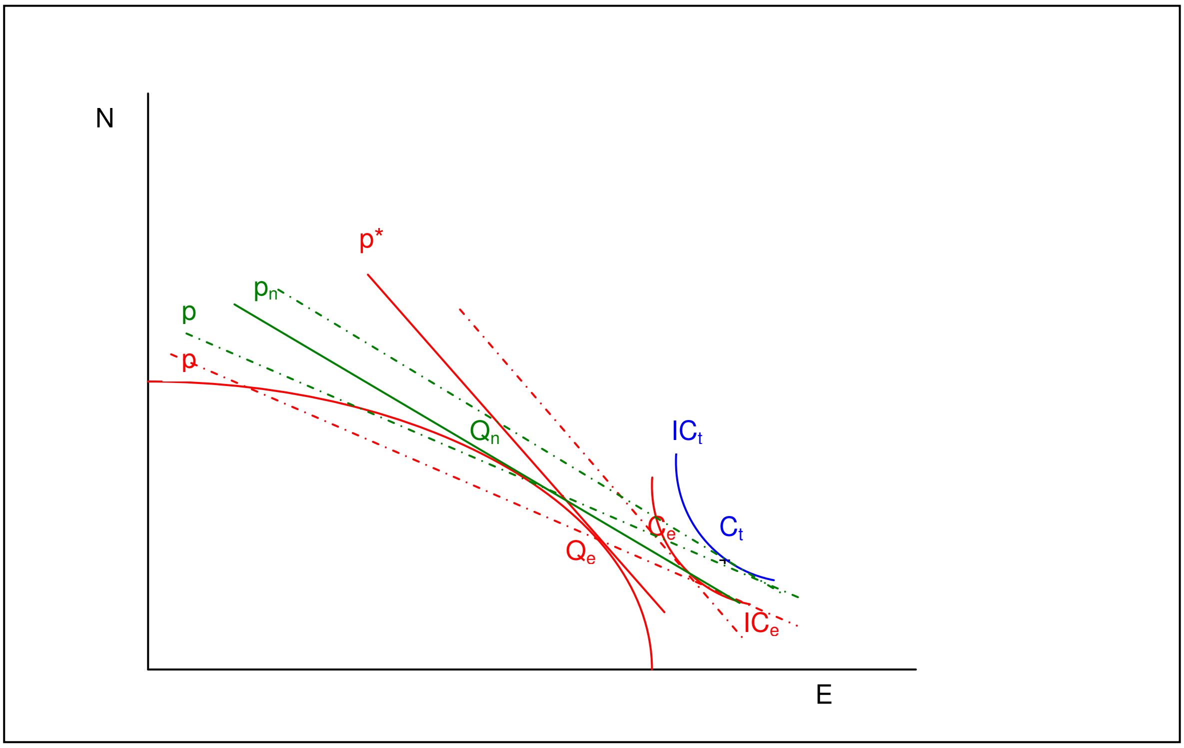
Conventional BTAs will in this case entail an import tax on energy intensive products, based on the carbon content. In the small country case, the international price ratio will still be p, but the domestic price ratio (p_t) will change. The new domestic price ratio (p_{bta}) will then be $p_{bta} = p(1+t+bta)$ 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 4.3, 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 4.3: Reversing the impact of the distortion



Source: Own compilation

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.

4.6 Conclusion

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 chapter 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 chapter, by considering a big country case, as well as multilateral implementation of environmental taxes.

CHAPTER 5

BORDER TAX ADJUSTMENTS TO NEGATE THE ECONOMIC IMPACT OF AN ELECTRICITY GENERATION TAX

5.1 INTRODUCTION

As discussed in Chapter 2, in the 2008 Budget Review, the South African Government announced its intention to levy a 2c/kWh tax on the sale of electricity generated from non-renewable sources.

Since the electricity generation tax is set to have an impact on the economy, in particular its competitiveness, measures to counter the negative effects while retaining pollution abatement benefits ought to be investigated. Several instruments have been proposed in the literature, one of which is border tax adjustments (BTAs).

This chapter evaluates the effectiveness, for the South African case, of border tax adjustments (BTAs) in counteracting the negative impact of an electricity generation tax on competitiveness. The remedial effects of the BTAs are assessed in the light of their ability to maintain the environmental benefits of the electricity generation tax. If traditional BTAs are unable to achieve this, we will propose a new approach, which we refer to as “reversed BTAs”. With this approach, gains from trade could be used to negate the negative effects of an electricity generation tax, while the environmental benefits associated with the electricity generation tax are retained.

The next section provides an economic rationale for an electricity generation tax and examines the instruments available to reduce or eliminate the negative economic effects of such a tax. Section 3 provides an overview of the South African industries with regards to electricity needs, domestic production and export shares. Also, the average weighted tariffs as applied to the different products and regions are discussed. In the fourth section, the model and data are discussed. This is followed by an analysis of the results in section five. Section six concludes.

5.2 LITERATURE REVIEW[7]

5.2.1 Electricity generation tax: a brief overview

The economic rational of electricity generation taxes has been discussed in Chapters 2 and 3. This section briefly summarise the main ideas within the context of BTAs.

Fossil fuel use creates negative externalities, such as CO_2 emissions. These externalities can be internalised through the price mechanism with the use of certain economic measures. This has the potential to achieve, at the least cost to the economy, environmental targets. The goal is equalised marginal abatement costs across all agents, ensuring that action is taken where it is the cheapest and most efficient (UP 2007). The two most prevalent economic measures in this context are taxes on emissions (or proxies of emissions) and tradable emission permits schemes (UP 2007).

According to McKibben and Wilcoxen (2002), a tax on emissions is more efficient than a permit system, especially under uncertainty. Furthermore, Rosen (1999) noted that the relevant issue is whether the measure employed is better than other alternatives, rather than whether or not it is a perfect measure to deal with externalities.

Environmental improvements are realised through price increases in environmentally harmful products. These price increases will result in a reduced demand for the products, reducing the quantity supplied and the associated emissions. However, existing exemptions and other special provisions aimed at protecting economies against the negative impacts of environmental taxes, restrict the environmental effectiveness and economic efficiency of environmental taxes. Removing these restrictions could create conflict with two main political concerns that currently impede the wider use of environmentally related taxes, namely the potential negative distributional effects and the potential loss of competitiveness (OECD 2001).

Regarding the competitiveness impacts, the authorities are responsible for stating clearly the objectives of the environmentally related taxes from the outset (OECD 2001). Due to vested interests within industry, energy taxes cannot be implemented without significant measures to reduce the impact on, at least, the worst-hit sectors (OECD 2001). This applies in particular if

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[7] This part of the paper is the product of commissioned research for The National Treasury (South Africa) which was funded by AUSAid. The authors would like to thank ASSET Research and CoPS for facilitating the project.

the tax is implemented in a unilateral fashion. Where non-global environmental taxes increase prices of internationally traded goods, imports will become more attractive and exports less so in the taxing country. Therefore, domestic production is expected to decline, at least in the short run, leading to adjustments in the national economy, as well as job losses (De Kam 2002).

The competitiveness impact is likely to be significant if the products or factors of production affected by the environmentally related taxes are traded widely, without significant import protection or other BTAs. It is therefore also likely that the competitiveness concerns are strongest if an environmentally related tax affects these products or factors of production. Another critical factor is substitution possibilities, since limited scope to identify and finance cleaner production technologies implies limitations on the ability to substitute away from environmental taxes (De Kam 2002). On the other hand, if an environmentally related tax is levied on products or factors of production that are not widely traded, with limited import and export possibilities and that are easily substituted with cleaner technologies, competitiveness concerns are likely to be less pressing.

A world-wide characteristic of existing environmental taxes is the presence of tax relief and exemptions for certain sectors, specifically in the manufacturing sector (Ekins and Speck 1999). However, preserving competitiveness goes beyond the implementation of proper compensation measures; indeed, competitiveness concerns ought to be incorporated during the design phase of the environmental tax. Although it is common practice in energy taxation to offer tax relief or exemptions to internationally exposed, energy-intensive sectors, this practice could be criticised. The tax relief and exemptions are counterintuitive as they distort the goal of environmental taxes, which is to equalise marginal abatement costs across the economy. It should be noted that this goal is one of the main reasons why economic measures are seen to be more efficient than command-and-control measures (UP 2007).

5.2.2 Instruments to limit the impact of environmental taxes on competitiveness

If an environmentally related tax is imposed unilaterally, instead of multilaterally, significantly larger decreases may realise in production of the country and sectors concerned. The larger the group of countries that impose the environmental tax, the more limited the impacts on sectoral and individual country competitiveness (OECD 2001).

The OECD (2001) proposes several options to protect the competitiveness of a country when implementing environmentally related taxes:

- Environmentally motivated reforms should be integrated with broader fiscal reforms.
- The introduction of new taxes or rate increases should be announced well in advance.
- If exemptions and rebates are given for competitiveness reasons in certain industries, impose the full tax rate, but channel part of the tax revenue back to the industry in such a way that marginal abatement incentives are maintained.
- Ensure that firms, who benefit from exemptions and reductions, sign up to stringent mitigation measures. This should limit the negative environmental effects of the exemptions and reductions.
- A two-tier rate structure, with lower rates for internationally exposed sectors, is a more effective and efficient option than full exemptions for some sectors.

According to Stern (2006), the dynamic impacts of the transformation to a low-GHG economy should be relatively small. Relative prices will change as the social cost of carbon is incorporated into production activities. However, these changes are well within the normal range of variation in prices as experienced in an open economy. The short-run primary cost increases from an environmental tax that reflects the damage from emissions, is likely to be far smaller than input-cost variations from fluctuations in, for example, the world oil price or the exchange rate.

Barde and Braathen (2002) suggest that countries can adopt two strategies in addressing competitiveness concerns. The first strategy is to wait for other countries to take the initiative. However, if no country is willing to take the lead, no action will be taken, even if all countries are convinced that environmental taxes are the best method to reduce emissions. The second strategy is to introduce environmental taxes unilaterally, but with special provisions to protect internationally exposed sectors and thereby protecting the country's competitiveness. 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):

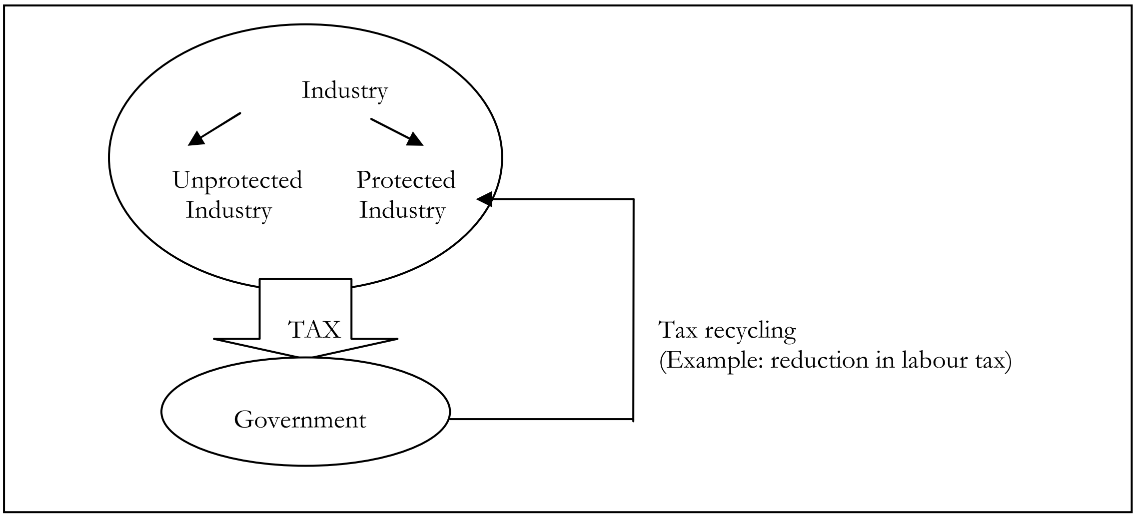
- revenue recycling,
- exemptions for specific activities, sectors or products,
- reduced tax rates for certain sectors, products or inputs, or
- border tax adjustments.

These instruments will now be discussed in more detail.

- *Revenue recycling*

The OECD (2001) looks at different approaches that could maintain abatement benefits of environmental taxes, while at the same time limiting the burden on affected firms and industries. The first option is to recycle a part of the tax revenue back to the affected firms. This approach is illustrated in Figure 5.1.

Figure 5.1: Revenue recycling



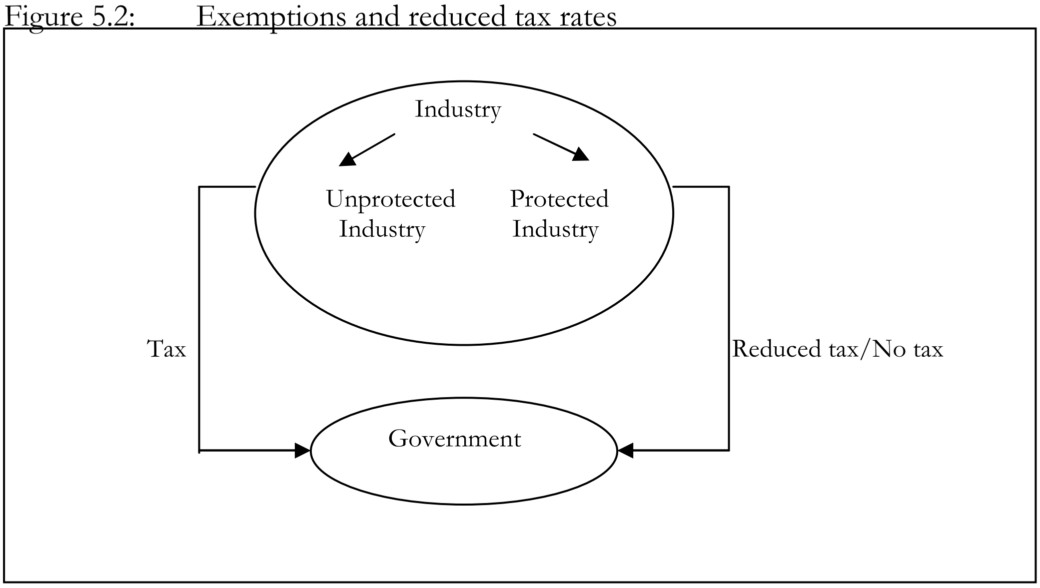
Source: Republic of South Africa 2008

A number of governments have implemented environmental taxes in such a way that revenues are recycled fully back to the taxpayer. The environmental effectiveness of tax reform will be greater if the revenue recycling is based on factors that are independent from environmental damage, rather than exemptions and reduced rates for affected sectors. This independent recycling will maintain the abatement incentives, since the price signal to polluters is not diluted. In other words, the tax burden increases with the environmental damage done (De Kam 2002). For example, revenue recycling through a reduction in labour taxes might lead to an overall efficiency in the tax system, as long as labour is over-taxed compared to other factors of production (UP 2007). However, earmarking the tax revenue fixes the use of the revenue, which creates an obstacle for the re-evaluation and modification of the tax and spending programmes. In the case of earmarking, policymakers should evaluate the economic and environmental rationale regularly to avoid inefficient spending (OECD 2001).

- *Exemptions and reduced tax rates*

Exemptions and reduced tax rates (Figure 5.2), the second and third options mentioned by De Kam (2002), are present in every environmental tax ever implemented. Normally firms qualify for an exemption if they meet certain criteria, where the first criterion usually relates to some measure of energy intensity (UP 2007).

Figure 5.2: Exemptions and reduced tax rates



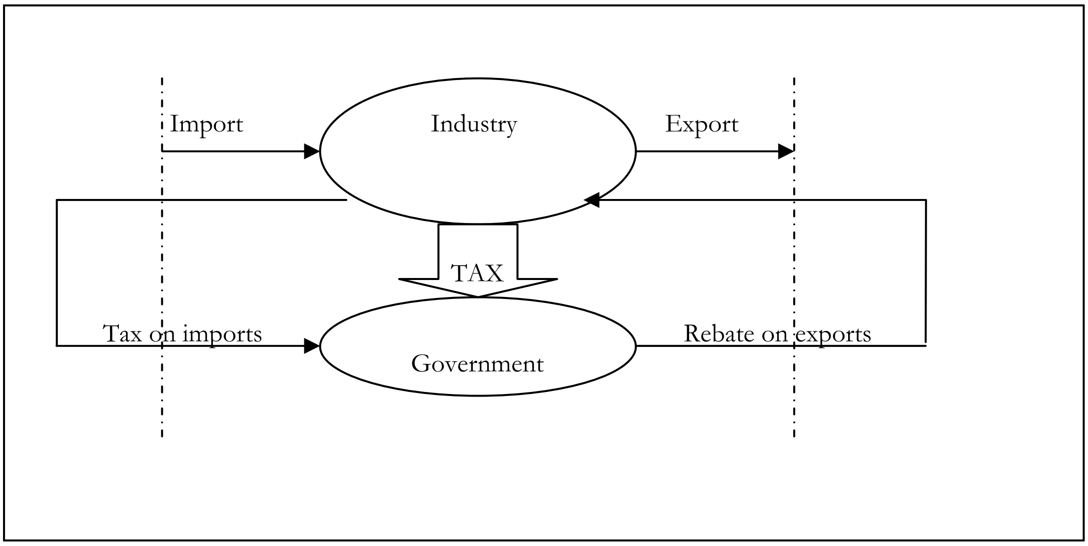
Source: Republic of South Africa 2008

Current tax systems tend to "favour" certain energy products, especially coal. The coal sector has gained either complete or partial exemption in many countries due to strong political influence (UP 2007). For instance, the political influence of the coal sector prevented the United Kingdom Climate Change Levy (UK CCL) from becoming a real carbon tax, which would have meant a higher tax rate on coal. Although the energy tax directive set a minimum tax rate for coal, the use of coal for electricity generation and non-fuel inputs in industrial processes are exempted in the directive (UP 2007).

- *Border tax adjustments*

The final option mentioned by De Kam (2002) to protect industries against the negative competitiveness impact of an environmental tax is BTAs, which are illustrated in Figure 5.3.

Figure 5.3: Border Tax Adjustments



Source: Republic of South Africa 2008

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 judged by the World Trade Organisation (WTO) to be undue protection of national interest (UP 2007).

Ismer and Neuhoff (2004) address the issue of information constraints in the implementation of BTAs and propose an indirect approach to induce participants to reveal information. They conclude, 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) compare the effectiveness of BTAs and Integrated Emission Trading (IET). They find BTAs to be more effective in protecting domestic competitiveness, and IET more effective in reducing foreign emissions.

Debate regarding BTAs dates back to the adoption of Value Added Tax (VAT) in the European Union in the early 1960s. Following the 1958 Neumark Committee, it was agreed that the European VAT system would be administered on a destination basis, involving taxes on imports and rebates on exports (Lockwood and Whalley 2008). Initially this was viewed by US business as conferring a trade advantage on the EU, and the US pushed for a negotiation on BTAs as part of the Tokyo Round in the General Agreement on Tariffs and Trade (GATT) (Lockwood and Whalley 2008). The issue of BTAs was later examined by a GATT working party in 1970 (Goh 2004).

BTAs reappeared in national policy debates on the use of economic instruments to counter global warming. For example, in 1996 a Research Panel Report of the Japanese Environment Agency (Goh 2004), suggested the use of BTAs to address carbon leakage. However, the debate centred mostly on WTO compatibility of BTAs (Ismer and Neuhoff 2007). Although there are currently no BTA measures in place to offset the competitiveness impact of environmental taxes, two different bills relating to BTAs are currently under discussion in the US Senate (Lockwood and Whalley 2008). Furthermore, the harmonising of EU energy taxes between member states is likely to provide momentum to the BTA debate (Goh 2004).

Although BTAs involve both import tariffs and export rebates, if both import tariffs and export rebates were implemented simultaneously, the principle of neutrality might come into play and render BTAs ineffective (Meade 1974). However, the WTO has a clear set of stringent rules for export rebates as a result of the agreements reached in the Uruguay Round and Tokyo Round of trade negotiations (Pugel 2007). Since import tariffs are more likely to be implemented than export rebates, and to avoid the neutrality principle, this chapter will consider only import tariffs.

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

5.3 THE SOUTH AFRICAN ELECTRICITY CONSUMPTION AND TARIFF PROTECTION PROFILE

5.3.1 South African industries: Production, export and electricity needs

South African electricity usage is characterised by a few energy-intensive industries as shown in Table 5.1. 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[8]. 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.

Table 5.1: 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

5.3.2 Industrial tariff protection by region

During the 1960s and 1970s, South Africa pursued an import substitution policy through high trade tariffs and physical import controls, (Gunnar and Subramanian, 2000).An import surcharge was introduced during 1985, 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,

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

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 was 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 an attempt to negate the negative economic impact of an electricity generation tax through BTAs, industry protection through the implementation of import tariffs ought to be considered. The average weighted *ad valorem* tariffs by industry per region are shown in Table 5.2.

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 5.2: 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.

5.4 MODEL AND DATA

5.4.1 Introduction

This chapter 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.

5.4.2 The GTAP model

A description of the GTAP model, as well as the assumptions, limitations and closure has been provided in Chapter 2. The same regional aggregation as in Chapter 3 is used in this chapter.

5.4.3 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 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.

5.5 RESULTS

A unilateral 2c/kWh electricity generation tax in South Africa will affect not only the South African economy, but also the SACU, SADC, the EU and the rest of the world, via changes in South Africa's export and import volumes. Chapter 3 discussed the results of such an electricity generation tax, these results are shown in Table 5.3 for ease of reference. It should be noted that revenue neutrality was also simulated and the results reflected no statistically significant differences from the results reported below.

As shown in Table 5.3, 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. Chapter 2 explained that this is the result of the decline in domestic demand for domestic production outweighing the reduction in production, which leads to lower domestic prices and an increase in exports. Imports decreased due to lower domestic demand.

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.

Table 5.3: Results of a ten percent tax on the generation of electricity

10 PERCENT TAX	**SouthAfrica**	**SACUexclSA**	**SADCexclSACU**	**EU_25**	**restofworld**
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

As discussed above, one method that could be utilised to counter the negative impact of the electricity tax is BTAs. However, as shown in Table 5.3, 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 5.4: 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 South African competitiveness. Therefore, the appropriate action to counter the contraction in 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[9]. The new revised tariffs are provided in Table 5.4. The average required reduction in import tariffs was calculated at 29 percent. The low baseline of the tariffs explains the relatively high result.

Table 5.5: 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

As shown in Table 5.5, the import tax adjustments could succeed in neutralising the effect of an electricity generation tax on real GDP, although this will be at the cost of weaker terms of trade. Nevertheless, 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 decreases by 0.11 percent, as compared to 0.17 percent under scenario 1.

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[9] This was done through trail and error.

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.

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 in Part 3, South Africa is not only simplifying the South African Tariff Book, but is also committed towards tariff reductions.

Table 5.6: 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
	407.31	-9.70	970.48	-8.25	824.86

The CO_2 abatement before and after the reversed BTAs has been calculated. This was done 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 8 euros for a Certifiable Emissions Reduction Certificate. As reflected in Table 5.7, 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 5.6.

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

5.6 CONCLUSION

An electricity generation tax is set to have an impact on the South African economy. However, several instruments have been proposed in the literature to protect the competitiveness and economy of a country when imposing a green tax, one of these being BTAs.

An electricity generation tax will lead to a contraction in South African GDP. However, traditional BTAs are unable to address these negative impacts. We proposed a reversed-BTA approach 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. This could be achieved through a reduction in import tariffs, as this reduction could reduce production costs and thereby restore South African competitiveness. The reduction in import tariffs could not only negate the negative GDP impact of the electricity generation tax, but the bulk of CO_2 abatement from the electricity generation tax could be retained.

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.

CHAPTER 6

AN ELECTRICITY GENERATION TAX AND DEMAND SIDE MANAGEMENT: THE ECONOMIC IMPACT OF SIMULTANEOUSLY IMPLEMENTED POLICIES

6.1 INTRODUCTION

As discussed in Chapter 2, the South African Government proposed to impose a 2 cents/kilowatt-hour (c/kWh) tax on the sale of electricity generated from non-renewable sources. In addition to the tax, The Electricity Supply Commission (ESKOM) launched a Demand Side Management Policy (ESKOM 2008), aimed at reducing household demand for electricity by 10 percent, mainly through more efficient use of electricity.

This chapter will utilise The University of Pretoria General Equilibrium Model of South Africa (UPGEM) in an attempt to analyse the impact of the simultaneous implementations of these two policies on the South African economy. It will also attempt to shed some light on the household welfare effects of such a simultaneous implementation.

6.2 BACKGROUND

6.2.1 The South African electricity sector

The electricity distribution industry in South Africa is dominated by ESKOM. As shown in Table 6.1, coal-fired power stations contribute approximately 89 percent of electricity generation capacity in South Africa. In total ESKOM owns 96 percent of all generation capacity and 100 percent of the national transmission grid. ESKOM distributes 60 percent of electricity directly to end use consumers and the remaining 40 percent is distributed through municipal distributors (Republic of South Africa 2007).

Table 6.1: South Africa's electricity capacity – 2004

ENERGY SOURCE	CAPACITY (MW)	PERCENT OF TOTAL
Coal	38 209	88.8
Nuclear	1 800	4.2
Bagasse	105	0.2
Hydro	668	1.6
Gas turbines	660	1.5
Pumped storage	1 580	3.7
Total	43 022	100

Source: Republic of South Africa 2006

The South African electricity usage is characterised by a few energy intensive industries. Table 6.2, following the UPGEM industry classification, shows that the gold industry (12.02 percent) as well as the iron, steel and base metal industry (11.47 percent), are the industries consuming the most electricity. These industries are followed by the electricity industry (6.92 percent), the trade industry (6.91 percent), the transport industry (5.91 percent), the non-ferrous metals (5.13 percent) and the mining industry (4.44 percent).

Table 6.2: Percentage of electricity consumption by industry

	CONSUMPTION OF ELECTRICITY (PERCENTAGE)	CONTRIBUTION TO PRODUCTION (PERCENTAGE)	LABOUR-CAPITAL RATIO
IRField	0.20	0.22	0.32
DRField	0.66	0.73	0.32
IRHorti	0.36	0.60	0.65
DRHorti	0.10	0.16	0.65
Livestock	0.44	1.05	0.87
Forestry	0.08	0.31	1.56
OAgric	0.30	0.40	0.75
Coal	1.92	1.36	1.00
Gold	12.02	2.13	3.08
CruPetGas	0.00	0.32	1.07
Mining	4.44	2.17	1.06
Food	3.15	6.56	0.78
Textiles	1.37	1.67	6.27
Footwear	0.05	0.20	1.91
OChemRub	3.77	4.12	1.35
PetRefPrd	3.26	2.56	0.49
ONMetMin	1.72	0.92	1.17
IroStBI	11.47	1.57	1.01
NFerMetBI	5.13	0.90	0.39
OMetPrd	2.41	1.91	2.19
OMach	1.91	2.38	2.05
ElecMach	0.57	0.92	1.07
Radio	0.14	0.47	3.94
TransEquip	1.55	3.14	2.43

WodPulPap	3.19	3.16	1.04
OManuf	0.36	1.18	0.96
Electricty	6.92	2.10	0.54
Water	1.81	0.63	0.25
Constr	1.00	5.20	1.64
Trade	6.91	10.09	1.21
Hotels	2.82	1.64	0.36
TransSer	5.91	5.46	0.97
Comms	3.10	2.75	0.90
FinInt	2.55	7.45	0.73
Realestate	2.08	4.37	0.07
BusAct	0.25	2.62	2.71
GenGov	1.71	11.74	8.05
HealthSoc	1.29	1.83	0.96
OActSer	3.09	3.00	4.77
Total	100.00	100.00	

Source: UPGEM database

In other words, the seven industries consuming the most electricity, consume approximately 53 percent of total electricity distributed to industries in the South African economy. However, these seven industries contribute only 24.4 percent to total production in South Africa. The trade industry is the only industry with a higher share in total production than in electricity consumption. The trade industry contributes 10 percent to total production, while consuming approximately 7 percent of electricity distributed to industries.

Table 6.3: Household expenditure on electricity

	PERCENTAGE OF TOTAL EXPENDITURE
H01	4.60
H02	3.78
H03	3.63
H04	3.51
H05	3.20
H06	3.16
H07	2.88
H08	2.78
H09	2.23
H10	1.79
H11	1.41
H12	0.84

Source: UPGEM database

Household consumption of electricity is shown in table 6.3. H01 represents the poorest households and H12 represents the richest households. The classification of households is taken from the Statistics South Africa classification (Statistics South Africa 2004). It is clear from table 6.3 that expenditure on electricity as percentage of income decrease with an increase in income. This is consistent with the notion that electricity is a normal but necessary commodity.

6.2.2 Electricity generation tax

The goal of environmental taxation is to internalise the externalities caused by polluting industries, this should then fully reflect the negative impact of production on the environment (OECD 2001). According to Stern and The Great Britain Treasury (2006 p xviii), *"Putting an appropriate price on carbon, explicitly through a tax or trading, or implicitly through regulation, means that people are faced with the full social cost of their actions. This will lead individuals and businesses to switch away from high-carbon goods and services, and to invest in low-carbon alternatives."*

De Kam (2002 p2) defined environmental taxes as "Any compulsory, unrequited payment to general government levied on a tax base deemed to be of particular environmental relevance". Since the payments by taxpayers are normally not in proportion to the benefits they receive from government, environmental taxes can be classified as unrequited.

According to the OECD (2001), environmental taxes could be effective and efficient instruments for environmental policy to reduce pollution. Through their price signals to the economy, these measures could ensure that polluters take into account the detrimental impact of their production and consumption decisions on the environment (OECD 2001). Environmental improvements are achieved through price increases of environmentally harmful products. The quantity demanded of the product will reduce due to these price increases, leading to fewer of the product being consumed. The idea is that the most efficient and cheapest abatement could be achieved if marginal abatement costs are equalised across all agents (UP 2007).

The OECD (2001) indicated that economic instruments used for pollution abatement purposes, especially if these instruments are implemented through a unilateral policy decision, are likely to have detrimental effects on the international competitiveness of certain industries. A unilateral environmental tax will increase domestic production costs, forcing the prices of domestically produced products higher in the international market. Exports will then become less attractive and imports will become more attractive. In the short run, this will lead to potential job losses, lower domestic production and other adjustments caused by the tax in the economy (De Kam 2002).

6.2.3 Demand Side Management

What is Demand side Management (DSM)?

Demand side management (DSM) was first used in the context of energy demand during oil price shocks in the 1970s (Bredekamp and Atkinson-Hope 2009). Gellings (1985) defined DSM as the planning and implementation of activities by the electricity utility to influence customers' uses of electricity in such a way that the desired changes in the utility's load shape are realised. Furthermore, DSM includes only those activities that involve a deliberate intervention by the utility to alter consumer demand.

Since then, various definitions have been proposed for DSM, including the following recurring definitions:

"DSM includes only those activities that involve a deliberate intervention by the utility in the marketplace so as to alter the consumer's demand." (Gellings 1985)

"DSM broadly refers to technologies, products, and programs that involve reducing buyer demand for electricity by substituting conservation on-site for fuel use. DSM can take on a number of meanings, based upon specific purpose, funding method and context. (Brennan 1998)

"DSM refers to active efforts by electric and gas utilities to modify customers' energy use patterns." (Eto 1996)

"DSM encompasses a variety of utility activities designed to change the level or timing of customers' electricity demand." (Battelle-Colombus Division and Synergic Resources Corporation 1984)

"DSM encompasses planning, evaluation, implementation and monitoring of activities selected from a wide variety of DSM alternatives." (Gellings and Smith 1989)

According to the Electric Power Research Institute (EPRI), *"DSM encompasses all utility activities aimed at modifying the timing and level of consumer demand."* (Conner 1990)

There seems to be two necessary components of any program to be classified as a DSM program. Firstly, it must be a deliberate effort or intervention by the utility and secondly, it must attempt to change consumer behaviour towards more efficient use of the product.

Demand Side Management: Theoretical benefits

Potential benefits of DSM range from providing better service reliability to the ability to use power more efficiently. According to Conner (1990), there are also indirect benefits through improved relations with regulatory bodies, which are likely to welcome the reduced environmental battles and lower rates as well as fewer consumer complaints that could flow from effective DSM practices.

Gellings and Smith (1989) stated that DSM provides a workable solution to some of the challenges confronting electricity utilities today. For example, DSM offers utility management many alternatives improving customer satisfaction and maintaining good customer relations, while improving the utility's financial health. Also, where utilities find it desirable to postpone the need for additional capacity, increasing the use of cost-effective DSM resources might assist in achieving postponing this need (Schweitzer, Hirst and Hill 1991).

The crucial factor for the success of DSM programs is the elasticity of demand for energy, derived from the demand for the services energy delivers. If the elasticity of demand exceeds one in absolute value, increasing energy efficiency will increase energy use. However, according to Brennan (1998), in many if not most cases, underlying demand for electricity-using services (refrigeration, laundry, hot water heating) are likely to be sufficiently inelastic to allow us to ignore this effect.

A further argument supporting DSM is that consumers are too short-sighted to spend a lump-sum on energy efficient appliances, in order to reap greater savings from reduced energy use over time (Brennan 1998). DSM could assist consumers in rational decision making. Unlike some public policies, such as government standards that mandate efficiency levels for products, utility DSM programs could be seen as a non-coercive way to promote energy efficiency (Eto 1996).

In addition, Eto (1996) remarks that DSM program funding has indirectly contributed to the development of a private-sector energy-efficient industry. Therefore, DSM programs could make lasting changes in the creation of private-sector entities that depends on improving customer energy efficiency, unlike energy taxes whose effects only continue as long as the taxes continue (Eto 1996).

However, according to Wirtshafter (1992), short-term gains in DSM market share may not be the optimal approach to ensure the long-term viability of the industry. New programs should be concerned with market research and the testing of alternative delivery mechanisms rather than with the number of units installed. A slower pace in the beginning will be compensated by stronger programs with a better chance of maximising the effectiveness of DMS's in the long run.

Lastly, DSM proponents regard the increase energy efficiency of these appliances primarily as a means for conserving fossil fuels and limiting the environmental effects of their use (Brennan 1998). The reduced use of energy is believed to limit the need to build power plants as well. State regulators could encourage utilities to take greater advantage of the technical potential of DSM resources to reduce electricity generation where this is judged to have important environmental benefits or other desirable effects (Schweitzer, Hirst and Hill 1991).

Demand side Management: Some evidence

The previous section provided the theoretical benefits that could be derived from DSM programs. Literature seems to suggest that at least some of the benefits could realise if DSM is effectively implemented.

A study by Wijaya and Limmeechokchai (2010) tested DSM in the household sector by applying lighting efficiency improvement, through replacing 40W incandescent lamps with 8W compact fluorescent lamps (CFL), replacing 60W incandescent lamps with 12W CFLs, and replacing 100W incandescent lamps with 20W CFLs. The scenario succeeded in reducing the electricity demand in 2020 by 5.2 percent. The scenario also reduced electricity generation capacity needed by about 5 percent of total generation capacity in 2025 (Wijaya and Limmeechokchai 2010).

A survey of 24 electric utilities that have well-developed integrated planning processes suggested that greater use of DSM resources can lead to less growth in electricity generation and postpone the date when new capacity will be needed (Schweitzer, Hirst and Hill 1991).

Eto (1996) found that U.S. utility DSM programs have been highly successful in overcoming shortcomings in the markets for energy services. The experience in the U.S. showed that utilities could provide a powerful stimulus to energy efficiency in the private sector when provided with appropriate incentives..

Furthermore, DSM programs in the U.S. could reduce annual energy consumption by 4.3 percent and summer peak demand by 8.3 percent (Faruqui *et al.* 1993). At the margin, Faruqui *et al.* (1993) found that DSM will offset 22 percent of the growth in annual energy consumption and 36 percent of the growth in summer peak demand. These estimates were derived by reviewing 70 utility resource plans. The review helped to identify typical program concepts, and representative impacts per customer and number of participating customers for each of these program concepts. These estimates were combined with a forecast of customer usage in the absence of utility DSM programs developed with EPRI's system of end-use forecasting models to yield DSM impacts by program type (Faruqui *et al.* 1993).

According to Chamberlin and Herman (1996), even though traditional DSM activities will shrink significantly as utility markets become increasingly competitive, the provision of energy efficiency services will be an increasingly important part of competitive retail service. And on average, households could have reduced lighting electricity consumption by 50.9 percent if all incandescent bulbs were replaced with CFLs (Wall and Crosbie 2009).

Customer adoption techniques

EPRI has outlined six avenues a utility can use to implement DSM:

Table 6.4: DSM avenues

Technique classification	Objective	Examples
Alternative pricing	Provide customers with pricing signals that reflect real economic costs and encourage a desired market response	Demand rates Time-of-use rates Off-peak rates Seasonal rates Inverted rates Variable service rates
Direct incentives	Reduce up-front purchase price and risk of hardware investments to the customer and increase short-term market penetration	Low/ no interest loans Cash grants/ Rebates/ Buy back Subsidized installation/ modification
Customer education	Increase customer awareness of utility programs	Bill inserts Brochures Information packets Displays
Direct customer contact	Encourage greater customer response to utility programs through face-to-face communication	On-site energy service audits Workshops/ Energy clinics Store fronts/ Vendor sales/ Service
Advertising and promotion	Increase public awareness of new programs, and influence and control customer response	Mass media Point-of-purchase advertising
Trade ally cooperation	Increase utility capability in marketing and implementing programs	Cooperative advertising Cooperative marketing Cooperative training Cooperative product sales/ service

Source: EPRI 1986

Although pricing is an important part of DSM programs, this study only considers the other avenues of DSM. The reason for this is that we also separately consider the impact of an electricity generation tax, which affects demand through price signals. From a broader perspective, the tax could be viewed as part of a comprehensive DSM strategy. Furthermore, the focus will be on household DSM.

DSM programs typically cover a variety of policies under which utilities have been directed to subsidize or otherwise encourage the installation of appliances (e.g. air conditioners) that use less electricity to perform their functions (Brennan 1998).

Utility programs could generally be divided into seven categories (Nadel 1992):

- general information to increase consumer awareness of energy use and of opportunities to save energy;
- technical information, including energy audits, which identify specific recommendations for improvements in energy use;
- financial assistance in the form of loans or direct payments to lower the cost of energy-efficient technologies;

- direct or free installation of energy-efficient technologies;
- performance contracting, in which a third party contracts with both the utility and a customer and guarantees energy performance;
- load control and load shifting, in which the utility offers financial payments or bill reductions in return for controlling a customer's use of certain energy-using devices or in return for customer adoption of technologies that alter the timing of demands on the electric system; and
- innovative tariffs, such as time-of-day and real-time prices, price signals that can enhance the effectiveness of other DSM programs.

The first five types of programmes are intended to promote energy efficiency. The last two are intended to promote specific load-shape objectives, such as peak-load reduction, load shifting, or off-peak load building (Eto 1996).

Household Demand Side Management in South Africa

ESKOM launched a demand side management policy (ESKOM 2008), aimed at reducing household demand for electricity by 10 per cent, mainly through more efficient use of electricity.

The benefits of a demand side management policy include (ESKOM 2008):

- reduces the demand on the electricity network,
- keeps electricity costs down, and
- delays the need for new power stations to be built.

The demand side policy consists of various initiatives, including (ESKOM 2008):

- compact fluorescent lamp (CFLs) exchanges,
- power alert, a media tool giving consumers information regarding the power generation situation in South Africa,
- solar water heating programme, mainly providing rebates to households when converting to solar water heating,
- an energy efficient motors rebate programme, and
- the introduction of load limiting technology.

The next section will provide a short description of the UPGEM model that will be used to analyse the impact of the electricity generation tax and an effective demand side policy on the South African economy and household welfare.

6.3 MODEL DESCRIPTION

6.3.1 The UPGEM model

We are interested in the economy-wide impacts, and in particular the impact on the GDP, production structure, household demand, household welfare and the labour market, therefore a computable general equilibrium (CGE) model is an appropriate modelling tool. A CGE model is *"an economy-wide model that includes feedback between demand, income and production structure, and where all prices adjust until decisions made in production are consistent with decisions made in demand"* (Dervis, De Melo and Robinson 1985 p132).

The University of Pretoria CGE model of South Africa (UPGEM model), used in these simulations, is formulated and solved using GEMPACK, a flexible system for solving computable general equilibrium (CGE) models. The UPGEM model is designed for comparative-static analysis of policy issues and is similar to the ORANI-G model of the Australian economy, which is fully presented and explained by Horridge (2002).

The UPGEM model is based on the official 1998 social accounting matrix (SAM) of South Africa, published by StatsSA (Statistics South Africa 2004). This SAM consists of 27 sectors, which was split into 39 sectors (Van Heerden and De Wet 2004), 12 household types and 4 ethnic groups.

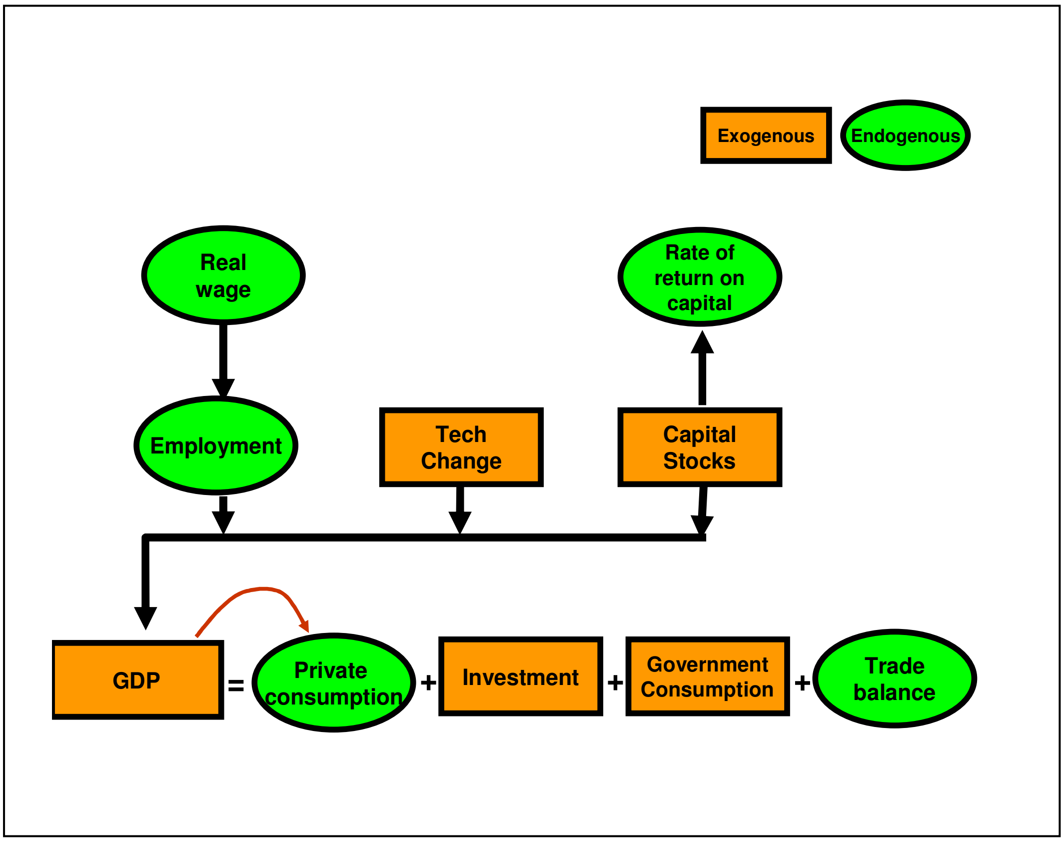
The model has a typical static CGE model theoretical structure, and consists of equations describing producers' demands, producers' supplies, demands for inputs for capital formation, household demands, export demands, government demands; the relationship of basic values to production costs and to purchasers' prices and numerous other macro-economic variables and price indices (Van Heerden, Blignaut and Horridge 2008).

The behaviour of all private agents' in the model is driven by conventional neoclassical assumptions. Producers minimise cost while consumers maximise utility, resulting in the corresponding demand and supply equations in the model. It is assumed that the agents are price takers, in competitive markets, which prevent the earning of pure profits (Van Heerden, Blignaut and Horridge 2008). Household demand is modelled as a linear expenditure system that differentiates between necessities and luxury goods, while households' choices between imported and domestic goods are modelled using the CES structure.

6.3.2 Closure rules

As shown in Figure 6.1, the closure rule in each of the scenarios tested reflects a short-run time horizon. In other words, the rate of return on capital is allowed to change while the capital stock is fixed. Furthermore, the supply of land is fixed. Aggregate investment, inventories and government consumption are exogenous, but the trade balance and consumption are endogenous.

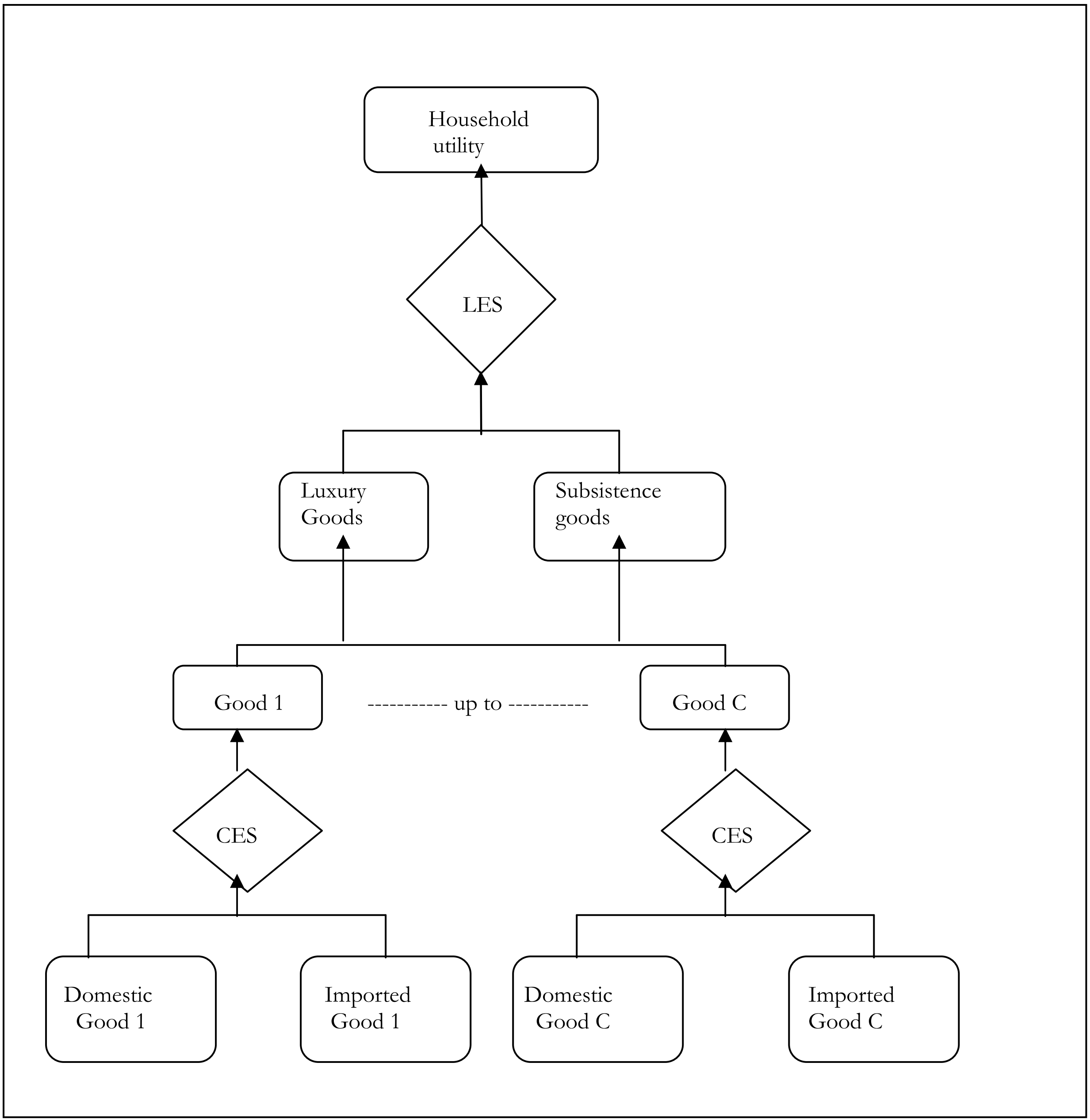
Figure 6.1: UPGEM closure



6.3.3 Equivalent Variation calculation

A measure that provides a comprehensive understanding of the impact of the electricity generation tax and the demand side policy on the welfare of households is the equivalent variation (EV). EV measures how much more money a consumer would pay to avert the price increase, before the price increases.

Figure 6.2: UPGEM household expenditure



Source: Horridge 2000

The concepts compensating variation (CV) and equivalent variation (EV), used to empirically measure welfare changes arising from price changes were proposed by Hicks (1939). Both concepts, measured in units of the numeraire, measure a change in real income that is equivalent to a change in utility. The difference between the two concepts is the reference prices used to evaluate the consumption decisions of consumers. The EV uses the initial set of prices, whereas the CV uses the new set of prices. In the context of applied general equilibrium modelling, EV provides the most accurate measure, since the initial price set is given.

Following Bowen, Hollander and Viaene (1998), assume there are N goods and let $p_0 = (p_2^0,...,p_N^0)$ and $p_1 = (p_2^1,...,p_N^1)$ denote the two alternative vectors of relative goods prices (good 1 is the numeraire). Using an expenditure function, the EV can be defined as:

$$EV = S(p_0,u_1) - S(p_0,u_0)$$

Where u_0 and u_1 are respectively, the utility levels achieved at prices p_0 and p_1.

Given a price change p_0 to p_1, EV measures the income change, at initial prices, p_0, that would allow the consumer to achieve the welfare level u_1 in the absence of the price change. In other words, the EV is the income change that is equivalent to the welfare change arising from the price change from p_0 to p_1. The EV represents a gain (loss) if the price is changed and the resultant EV value is positive (negative). The UPGEM code for the calculation of the EV values is shown in Appendix 6.A1.

Calculation of the EV is possible if the form of the expenditure function is known. Applied general equilibrium models typically assume a specific form for the utility function and can therefore derive the form of the associated expenditure function. In the case of UPGEM, commodity composites are aggregated by a Klein-Rubin function, leading to a linear expenditure system (LES). The nesting of household expenditure in UPGEM is shown in Figure 6.2, with expenditure on all the goods defined over subsistence and luxury expenditure respectively.

6.4 SCENARIOS

Three scenarios have been tested. Firstly, the electricity generation tax, implemented in 2009, of 2c per kWH (equivalent to a 10 per cent price increase) has been introduced to the model (Blignaut, Chitiga-Mabugu and Mabugu 2005). The UPGEM model described in the previous section is used to simulate a 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 10percent. The shocks 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. Thus, a simulation of a 10 percent increase in the output tax of electricity was imposed.

Secondly, the household demand side management policy of Eskom was tested. The household demand side policy aims at reducing household demand for electricity by 10 percent. This was simulated through a 10 percent change in households' tastes for electricity. In other words, we test the successful implementation of the household demand side policy, assuming that the policy will succeed in shifting the household demand by 10 percent to the left. This chapter only considers an effective household demand side policy.

Lastly, both the first and second scenarios were run in the model simultaneously. The impact of these shocks on the GDP, production structure, household demand, household welfare and the labour market were analysed.

6.5 RESULTS

6.5.1 Back of the envelope (BOTE) equations

The results on an aggregate level will be discussed in this section, using in part a stylised model proposed by Adams (2003). The results should provide a high level explanation of the detailed results provided in the next section.

In Chapter 2 it was shown that the Keynesian macroeconomic identity could be approximated by:

$$y = S_c * c + S_I * i + S_G * g + S_X * x - S_M * m$$

Where y, c, i, g, x and m are the percent changes in Y, C, I, G, X and M respectively and S_C, S_I, S_G, S_X and S_M are the shares of the respective macroeconomic entities of total GDP.

Table 6.5: Real GDP changes

		Scenario 1		Scenario 2		Scenario 3	
	Share of total GDP	**CGE results**	**Share times the percentage change**	**CGE results**	**Share times the percentage change**	**CGE results**	**Share times the percentage change**
y	1.000	-0.1300	**-0.1300**	-0.0150	**-0.0149**	-0.1440	**-0.1477**
c	0.5953	-0.2510	-0.1494	-0.0390	-0.0232	-0.2810	-0.1673
i	0.1618	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
g	0.1806	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
x	0.2325	-0.0340	-0.0079	0.0510	0.0119	0.0080	0.0019
m	0.1676	-0.1300	-0.0218	0.0230	0.0039	-0.1020	-0.0171
Stocks	-0.0026	-0.1640	0.0004	-0.1040	0.0003	-0.2610	0.0007

Table 6.5 illustrates the real GDP impact in bold if the right hand side of the Keynesian macroeconomic approximation is calculated. The second column represents the share of total GDP and the CGE results column represents the percentage change due to the electricity generation tax. For example, the share of Consumer spending in total GDP is about 60 percent and Consumer spending is expected to decrease by 0.25 percent due to the electricity generation tax. Therefore, the contribution of Consumer spending to the new equilibrium GDP in Scenario 1 would be -0.15 percent. Based on the stylised model, real GDP is expected to decrease by 0.13 percent in Scenario 1, decrease by 0.015 percent in Scenario 2 and decrease by 0.15 percent in Scenario 3. In Scenario 1, the decrease in real GDP is mainly due to the impact of the electricity generation tax on real household consumption (C) and is reinforced by a decrease in exports (x). However, the decrease in imports (m) will moderate the real GDP decrease. In Scenario 2, real household consumption is the driver of the real GDP decrease, moderated by an increase exports but reinforced by an increase in imports. The combined impact would be a real GDP reduction of 0.15 percent driven by a decrease in real household consumption and moderated by lower imports. These results are discussed in more detail in the next section.

Part of the reason for the dominance effect in real household expenditure might be due to the price impacts. To consider this, an approximation of the GDP price index could be given as:

$$p_y = S_C p_C + S_I p_I + S_G p_G + S_X p_X - S_M p_M - p_C$$

Substituting this equation into the real GDP approximation gives:

$$X_C = X_Y + S_C p_C + S_I p_I + S_G p_G + S_X p_X - S_M p_M - p_C$$

In Table 6.1 it was shown that real household consumption is the main driver of the real GDP reduction. To explain real household consumption (X_C), we simplify the equation by keeping the balance of trade constant:

So,

$$S_X = S_M = S_T$$

Then

$$S_C + S_I + S_G = 1$$

Thus,

$$x_c - x_Y = S_I(p_I - p_C) + S_G(p_G - p_c) + S_T(p_x - p_M)$$

Table 6.6: Real household consumption domination

	Real household expenditure	Consumer price index	Nominal household expenditure	Real GDP	GDP price index	Nominal GDP
	Xc	Pc	Xc+Pc	Xy	Py	Xy+Py
Scenario 1	-0.251	0.025	-0.226	-0.130	0.020	-0.110
Scenario 2	-0.039	-0.007	-0.046	-0.015	-0.014	-0.029
Scenario 3	-0.281	0.019	-0.262	-0.144	0.009	-0.135

In Table 6.6 it is shown that real household expenditure decreases more than the real GDP in all three scenarios. It is also shown that in Scenario 1 the household price increases, in terms of the consumer price index, exceed the price increases for the total GDP. Moreoever, the price decreases in Scenario 2 are smaller for households than for the total GDP. Real household expenditure is therefore expected to decrease by more than the decrease in real GDP.

Because nominal household expenditure and nominal GDP moves together it must follow that:

$$x_C + p_C = x_Y + p_Y,$$

So if:

$$p_Y \rangle p_C$$

Then:

$$x_Y \langle x_C$$

In Table 6.7 below these price increases are disaggregated.

Table 6.7: Price impacts

	Scenario 1		
	Investment	Government	Exports
Price changes	0.012	0.014	0.007
Shares	0.159	0.181	0.200
Shares times differential	-0.002	-0.002	0.001
	Scenario 2		
	Investment	Government	Exports
Price changes	-0.023	-0.007	-0.010
Shares	0.159	0.181	0.200
Shares times differential	-0.003	0	-0.002
	Scenario 3		
	Investment	Government	Exports
Price changes	-0.009	0.008	-0.002
Shares	0.159	0.181	0.200
Shares times differential	-0.004	-0.002	-0.000

In Scenario 1, around half of the price difference between GDP and household consumption is explained by the lower inflationary pressure on government expenditure and the other half is explained by the lower inflationary pressure on investment. In Scenario 2 the price differences could be explained by the lower price increases in investment and exports. The combined impact shows that around two thirds of the price differential could be explained by lower investment price increases and the other third by lower government price increases. These results are explained in more detail in the next section.

6.5.2 Scenario 1: An electricity generation tax

Table 6.8 shows the macroeconomic impact of the electricity generation tax on prices, values and real volume changes. The tax leads to a 0.02 percentage increase in the GDP price index, directly causing a 0.02 percentage real depreciation of the currency. Real GDP contracts by 0.13 percent and as a result, the nominal value of GDP decreases by 0.11 percent.

Nominal wages increase by 0.025 percent; however this is offset by a 0.025 percent increase in the consumer price index, keeping the real purchasing power of wages constant. The value of aggregate nominal post-tax wages decrease by 0.225 as fewer workers are employed. The lower spending power of households is reflected in the 0.226 percent decrease in the nominal value of household consumption leading to a 0.251 percent decrease in real household consumption, the difference being equal to the consumer price index change of 0.025 percent.

Export prices increase by 0.007 percent due to higher productions cost, and due to the loss of competitiveness, export volumes decrease by 0.034 percent. The net effect is that the local currency value of exports decreases by 0.027 percent. The real volume of imports decreases by 0.129 percent. This reflects the reduction in household demand as well as the overall GDP contraction.

Table 6.8: Macroeconomic impact

	ELECTRICITY TAX	**DEMAND-SIDE POLICY**	**COMBINED IMPACT**
Prices			
GDP price index, expenditure side	0.02	-0.014	0.009
Real devaluation	-0.02	0.014	-0.009
Average nominal wage	0.025	-0.007	0.019
Consumer price index	0.025	-0.007	0.019
Exports price index, local currency	0.007	-0.01	-0.002
Value			
C.I.F. local currency value of imports	-0.129	0.022	-0.103
Nominal GDP from expenditure side	-0.11	-0.029	-0.135
Nominal total household consumption	-0.226	-0.046	-0.261
Local currency border value of exports	-0.027	0.041	0.006
Aggregate post-tax wages	-0.225	-0.043	-0.258
Real volume changes			
Import volume index, C.I.F. weights	-0.129	0.022	-0.103
Real GDP from expenditure side	-0.13	-0.015	-0.144
Real household consumption	-0.251	-0.039	-0.281
Export volume index	-0.034	0.051	0.008

All industries use electricity directly or indirectly as an input, therefore an electricity generation tax increases the cost of production, leading to a loss of competitiveness, and as a result, all industries will reduce output as shown in Table 6.9. As expected, the industries with the highest electricity intensity will be affected the most, notably the gold mining industry (0.278 percent) with electricity intensive, deep level mining, characterising the South African gold mine industry. The electric manufacturing industry (0.183 percent) and the water industry (0.194 percent) are also some of the worst hit industries. Furthermore, the heath and social services sector contracts by 0.241 percent, indicating the impact of higher electricity prices on households. Lastly, the direct increase in the price of electricity will have a 1.798 percent impact on electricity output as the demand for electricity decreases.

The industries least affected by the price increases are low intensity electricity users, namely, agriculture (0.046 percent), other mining, including open cast mines (0.027 percent), radio equipment (0.035 percent) and real estate services (0.043 percent).

Table 6.9: Output of commodities

	ELECTRICITY TAX	DEMAND-SIDE POLICY	COMBINED IMPACT
Agriculture	-0.046	0.032	-0.013
Coal	-0.209	-0.112	-0.317
Gold	-0.278	0.102	-0.175
OtherMining	-0.027	0.011	-0.017
Food	-0.121	0.103	-0.014
Textiles	-0.09	0.095	0.005
Footwear	-0.111	0.108	0.001
Petroleum	-0.116	0.044	-0.072
OthNonMetal	-0.095	-0.002	-0.095
BasIronStl	-0.126	0.04	-0.089
ElectricMach	-0.183	-0.137	-0.316
Radio	-0.035	0.019	-0.02
TransEquip	-0.097	0.025	-0.072
OthManufact	-0.108	0.046	-0.061
Electricity	-1.798	-2.457	-4.174
Water	-0.194	0.127	-0.063
Construction	-0.065	-0.07	-0.132
Trade	-0.111	0.054	-0.054
HotelRest	-0.15	0.068	-0.085
TranService	-0.13	0.048	-0.08
Communicate	-0.111	0.027	-0.081
Financial	-0.092	0.006	-0.083
RealEstate	-0.043	0.017	-0.025
BusinessAct	-0.107	0.029	-0.076
HealthSocial	-0.241	0.052	-0.18
OthActivity	-0.128	0.079	-0.046

Table 6.10 shows that 20 of the 26 industries experience an increase in production costs, as direct result of the electricity price tax, as well as the increased production cost of inputs used in production. The intermediate cost price index in the gold mine industry increases by almost 1 percent, the water industry costs increase by 0.712 percent and the electricity industry experiences an increase of 0.82 percent in costs.

The marginal reduction in the intermediate cost of footwear is due to the highly competitive nature of the market. Output of footwear decreases by 0.111 percent. This can be explained through the labour intensity of the footwear industry. Since labour is one of the main cost factors in footwear production and real wages decrease (see the labour market impact), it can be expected, that in the case of footwear, this cost reduction outweighs the electricity driven production cost increase. The same argument applies to the trade industry (0.09 percent), the financial industry (0.213), business activities industry (0.161 percent) and the health and social sector (0.038 percent).

Table 6.10: Intermediate cost price index

	ELECTRICITY TAX	DEMAND-SIDE POLICY	COMBINED IMPACT
Agriculture	0.044	-0.012	0.034
Coal	0.187	-0.077	0.111
Gold	0.998	-0.372	0.62
OtherMining	0.245	-0.1	0.146
Food	0.045	0.003	0.051
Textiles	0.076	-0.029	0.05
Footwear	-0.013	0.009	0
Petroleum	0.154	-0.07	0.085
OthNonMetal	0.142	-0.063	0.079
BasIronStl	0.293	-0.124	0.168
ElectricMach	0.051	-0.034	0.019
Radio	0.014	-0.013	0.004
TransEquip	0.002	-0.007	-0.003
OthManufact	0.001	-0.002	0.002
Electricity	0.82	-0.378	0.439
Water	0.712	-0.251	0.46
Construction	-0.003	-0.025	-0.025
Trade	-0.09	0.006	-0.077
HotelRest	0.376	-0.132	0.247
TranService	0.066	-0.046	0.024
Communicate	0.007	-0.023	-0.011
Financial	-0.213	0.014	-0.188
RealEstate	0.016	-0.04	-0.019
BusinessAct	-0.161	0.036	-0.118
HealthSocial	-0.038	0.003	-0.03
OthActivity	0.071	-0.042	0.033

Labour intensive industries experience a relatively small impact on production, shown in Table 6.9. However, the relatively small impact leads to a relatively large impact on employment, due to the labour intensive nature of these industries. The Labour-Capital ratio is shown in the last column of Table 6.2. For example, the real estate industry is expected to decrease employment by 0.293 percent (capital-labour ratio of 0.07) and the communication industry decrease employment by 0.334 percent (capital-labour ratio of 0.90). Electricity intensive industries will reduce output (Table 6.9) due to higher production costs and as a result employ fewer workers. For example, employment is decreased by 0.54 percent in the gold mine industry (capital-labour ratio of 3.08) and 0.291 percent in the base metal, iron ore and steel industry (capital-labour ratio of 1.01).

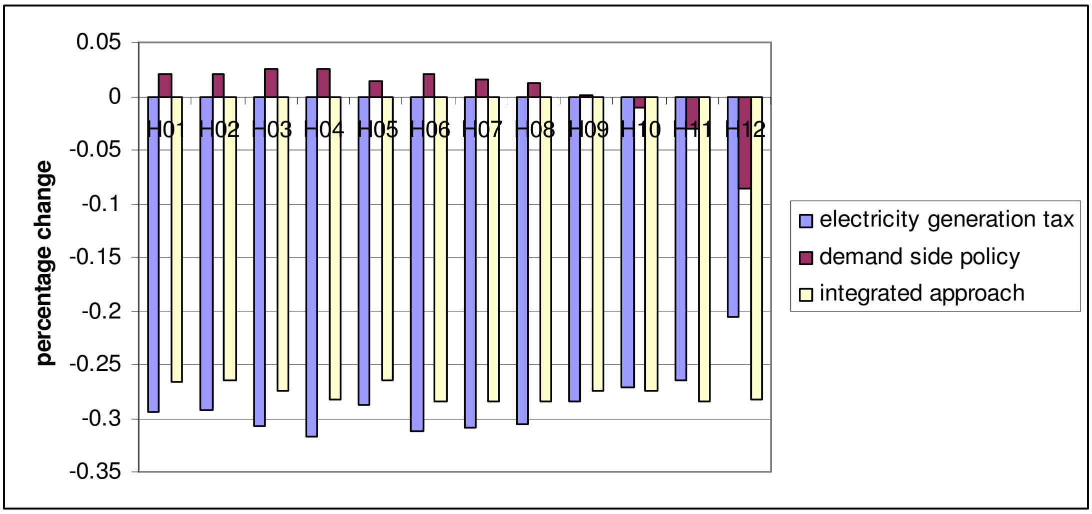
Table 6.11: Employment by industry

	ELECTRICITY TAX	DEMAND-SIDE POLICY	COMBINED IMPACT
Agriculture	-0.188	0.131	-0.054
Coal	-0.557	-0.296	-0.841
Gold	-0.54	0.197	-0.341
OtherMining	-0.089	0.034	-0.056
Food	-0.297	0.247	-0.042
Textiles	-0.141	0.147	0.007
Footwear	-0.228	0.229	0.01
Petroleum	-0.29	0.111	-0.178
OthNonMetal	-0.281	-0.005	-0.282
BasIronStl	-0.291	0.096	-0.202
ElectricMach	-0.286	-0.223	-0.502
Radio	-0.057	0.039	-0.027
TransEquip	-0.163	0.042	-0.122
OthManufact	-0.223	0.094	-0.127
Electricity	-4.514	-6.107	-10.239
Water	-0.635	0.416	-0.205
Construction	-0.091	-0.111	-0.196
Trade	-0.217	0.11	-0.104
HotelRest	-0.4	0.183	-0.222
TranService	-0.292	0.108	-0.181
Communicate	-0.334	0.081	-0.244
Financial	-0.237	0.028	-0.201
RealEstate	-0.293	0.103	-0.18
BusinessAct	-0.129	0.034	-0.092
Government	-0.005	0.001	-0.004
HealthSocial	-0.476	0.102	-0.354

The electricity generation tax will have a direct negative impact on the demand for electricity (1.798 percent) and employment in the electricity sector (4.514 percent). As a result, electricity output will decrease, leading to a reduction in the demand for downstream intermediate products. Coal is extensively used in the generation of electricity in South Africa. Due to the lower demand for coal, employment in this industry is expected to decrease by 0.557 percent. Petroleum, on a smaller scale, is also used to generate electricity; therefore employment is expected to decrease by 0.29 percent. However, the 0.29 percent includes the direct effect of the GDP contraction and the associated demand for petroleum, as well as the reduction in household spending.

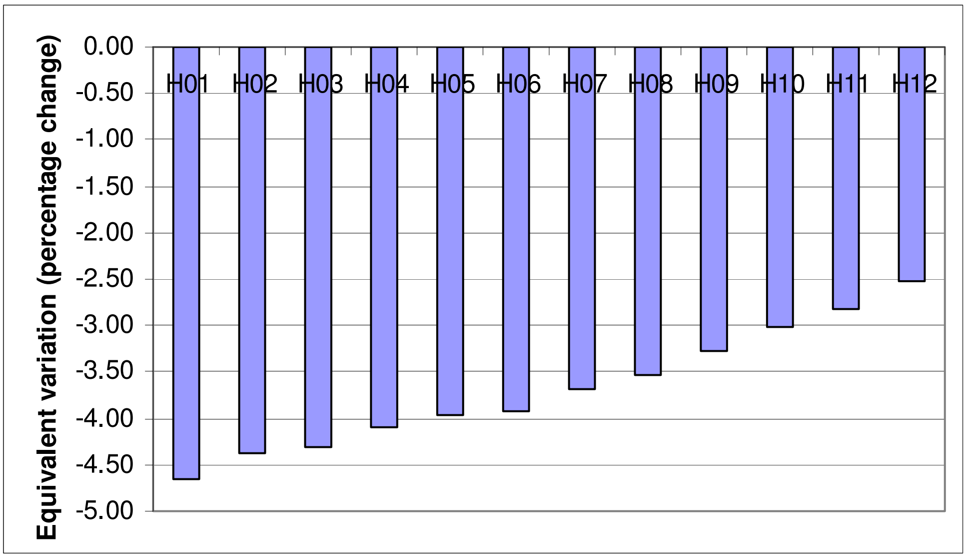
It is clear from Figure 6.3 that the burden of the electricity generation tax will not be shared proportionally amongst households. Lower and middle income groups, especially H01 – H08 will reduce real household consumption by between 2.8 percent and 3.2 percent. From H08 upwards, real household consumption will continue to decrease, but at a slower rate. The higher the income of a household, the smaller percentage of income is spent on electricity, with H12 experiencing the smallest real consumption contraction of 0.207 percent. It could therefore be argued, based on real household consumption, than an electricity generation tax is a regressive tax.

Figure 6.3: Real household consumption



The EV values have been calculated in UPGEM as shown in Appendix 6.A1. Under an electricity generation tax all consumers experience a decrease in utility as shown in Figure 6.4. However, the electricity generation tax is clearly regressive in nature since poorer households suffer higher utility losses. For example, H01 experience an income equivalent welfare loss of approximately 4.7 percent, while H012 suffer a welfare loss of around 2.6 percent. This regressive nature of the tax is due not only to the higher portion of income that poor households spend on electricity, but also due to the general inflationary impact of the tax.

Figure 6.4: Scenario 1, electricity generation tax, EV values (percentage change)



The impact on employment by industry (shown in Table 6.7) can be divided into three distinct groups, labour intensive industries, electricity intensive industries and downstream electricity generation industries.

6.5.3 Scenario 2: An effective demand side policy

Under scenario 2, if the demand-side policy results in a 10 percent decrease in household electricity demand, the GDP price index will decrease by 0.014 percent, and the real exchange rate will appreciate by 0.014 percent. This price decrease is in line with expectations since the demand for electricity decrease, leading to lower electricity prices, an input cost in all production processes.

The appreciation of the currency will be favourable for imports which increase by 0.022 percent in both real volume and value. With regards to exports, two forces are at work. Firstly, the appreciation makes exports more expensive, but due to the lower input cost of electricity, exporters will be more competitive in the world market. The net impact is a 0.051 percent increase in the volume of exports, but a 0.041 percent increase in the Rand value of the exports.

Although the nominal GDP decreases by 0.029 percent, real GDP only decreases by 0.015 percent, due to the deflationary impact of the demand-side policy. This real decrease is due to the direct decrease in the demand for electricity, but also due the 0.043 percent decrease in aggregate post-tax wages, which depresses the value of real household consumption by 0.039 percent.

The decrease in labour demand is due to two effects flowing from the Rand appreciation as well as the impact of the policy on the industry structure of the economy. Firstly, the higher level of imports indicates a substitution away from domestically produced goods to imported products. Secondly, a stronger Rand implies higher relative domestic wages, since the appreciation of the currency exceeds the nominal contraction of wages, compared to global wages, exerting downward pressure on domestic employment. Since nominal wages decrease by 0.007 percent, the same as the deflationary pressure on the consumer price index (0.007 percent), the decrease in aggregate post-tax wages can be attributed to lower employment.

These lower levels of employment are also due to the impact on the industry structure. Lower electricity demand will adversely affect employment in the coal industry, the electric machinery sector and electricity sector. An effective demand side policy will affect the labour market mainly through a decrease in demand for workers in the electricity sector (6.107 percent). Employment in the coal industry (-0.296 percent), the electrical and machinery industry (-0.223 percent) and the construction industry (-0.111 percent) will follow the reduction in output in these industries.

Lower levels of employment will result in a 0.039 percent reduction in household consumption. Lower household expenditure will then attribute to the real GDP contraction of 0.014 percent.

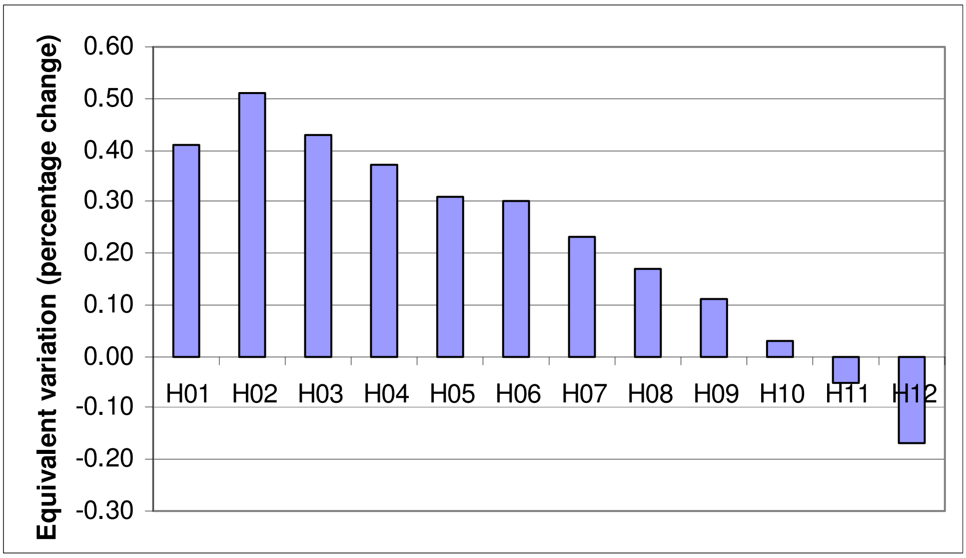
An effective demand side policy will affect the output of most industries positively, due to the deflationary impact on the economy. Lower input costs, especially lower electricity prices will result in increased production. However, upstream and downstream industries will be adversely affected. The coal industry, a major input in the production of electricity will decrease output by 0.112 percent, while downstream industries, including the electrical and machinery industry (0.137 percent), as well as the other non-metal industry (0.002 percent), will also decrease production. Construction will decrease by 0.07 percent contributing to the 0.015 percent real GDP contraction.

The demand side policy is expected to result in an increase in household consumption from H01 to H08. These low income households will be the main beneficiaries from increased efficiency in production processes and increased international competitiveness. On the other hand, H10 to

H12, will reduce household consumption, accounting for the net reduction in household consumption for households. These are the households that are most likely to be affected by the employment impact as shown in Table 6. The electricity sector is expected to decrease employment in excess of 6 percent. However, the electricity sector makes use of highly skilled workers, which normally fall in H10 to H12. This decrease in skilled employment will spill over to a decrease in high income real household consumption. Furthermore, H10 to H12 are most likely to be recipients of dividends and the contraction of real GDP is likely to adversely affect dividend payouts.

As shown in Figure 6.5, an effective demand side policy will be progressive in nature. Since poor households spend proportionally more on electricity than rich households it is expected that poor households will benefit proportionally more from more efficient energy consumption than rich households.

Figure 6.5: Scenario 2, demand side management, EV values (percentage change)



Furthermore, all households except H11 and H12 will experience a small increase in welfare, as opposed to a decrease under an electricity generation tax. The decrease in welfare experienced by the H11 and H12 is due to the labour and capital market impact as discussed in the previous section.

6.5.4 Scenario 3: The combined effect if both policies are simultaneously implemented

When both measures are implemented simultaneously, price effects, import effects and export effects are somewhat moderated by the demand side policy but, the electricity tax effects still outweigh the demand side policy effects. However, the adverse impact of the electricity tax on GDP from expenditure side, household consumption and post-tax wages are reinforced by the demand side policy as discussed above.

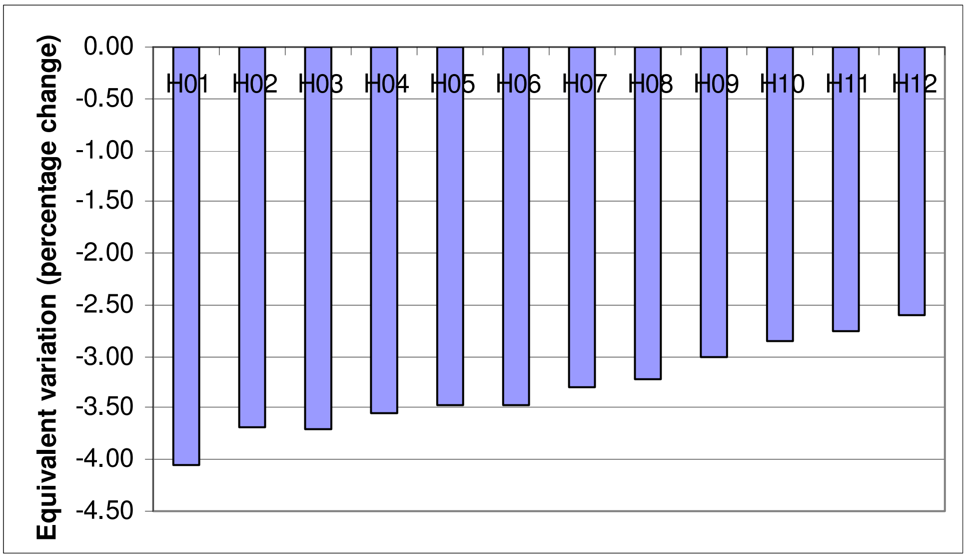
As shown in Table 5, an effective demand side policy will partially offset the detrimental impact of an electricity generation tax on the output in all industries, except upstream industries, downstream industries and construction. The intermediate cost price index (Table 6.6) will increase slightly if both policies are implemented simultaneously.

The results from simultaneous implementation on the labour market are shown in the last column of Table 6.7. A simultaneous implementation of the electricity tax and demand side policy will moderate the adverse impact of the electricity tax in 21 industries. Textiles (0.007) and footwear (0.01) even record a small net increase in employment. However, the adverse impact will be reinforced in the downstream industry (coal industry), upstream industries (other non metal industry, electrical and machinery industry), construction industry and electricity industry.

Under an effective demand side policy, 20 of the 26 industries will record a reduction in input cost. This reduction will partially offset the production cost increase under the electricity generation tax. The only two industries expected to experience an increase in production costs, in excess of 0.01 percent, are the financial industry (0.014 percent) and the business activity industry (0.036 percent). The financial and business activity industries are relatively low electricity intensive industries. Therefore the lower electricity prices will not reduce their input cost to the same extent as the other industries. Furthermore, both industries are expected to increase employment and output, putting upward pressure on marginal costs.

Real household consumption across all household categories will be lower (Table 6.8). However, the demand side policy will provide some relief for households H01 to H08.

Figure 6.6: Scenario 3, simultaneous implementation, EV values (percentage change)



The simultaneous implementation of the two policies will have a regressive impact on households as shown in Figure 6.6. The relatively small progressive impact of the demand side policy moderates the regressive impact of the electricity generation tax, but only slightly.

6.6 Limitations of the model

It is important to note that the UPGEM analysis presented in this chapter has some limitations. UPGEM as a single-country model focuses on the South African economy. As a result, impacts on neighbouring countries, specifically other members of the Southern African Customs Union (SACU) can not be analysed.

The emergence of new industries cannot be predicted in UPGEM. These new industries, such as coal generation with carbon capture and storage, must be exogenously introduced, with the size as well as timing being specified by the modeller. In this study it was assumed that no new industries will emerge as a result of the electricity generation tax. Thus the impact analysis is a relatively short to medium term analysis.

The UPGEM version used in this chapter is comparatively static. Thus, an analysis of the inter-temporal linkages between savings and consumption, and investment and capital is not possible. Also, there is no endogenous mechanism to project the time-pattern of investment changes.

The possible effects of climate change have not been included in the simulations discussed in this chapter. There are no assumptions made about the possible costs under 'business as usual', as a result of climate change.

6.7 CONCLUSION

An electricity generation tax would lead to higher inflation, less production and lower employment while an effective demand side management policy would lead to lower inflation, higher economic growth and higher employment. However, the positive impact of the demand side policy seems unable to neutralise the adverse impact of the electricity generation tax.

Based on EV values an electricity generation tax would be regressive with a negative impact on the utility of all households. An effective demand side policy would be progressive, with most households gaining in welfare, while an integrated approach would be regressive, moderated slightly by the progressiveness of an effective demand side policy.

The policy implications of this chapter are that an electricity generation tax would create some distortions in the economy and would eventually lead to structural adjustments in the economy. Most of the adverse impacts on the economy could be moderated through an effective demand side policy. In terms of household welfare, an electricity generation tax was shown to be regressive, an effective demand side policy progressive, but the former outweighs the latter. In other words, an integrated approach would affect the poorer part of the population more negatively than it would affect the higher income households.

APPENDIX 6.A1

Equivalent variation code

```
!utility!

variable (change)
(all,p,pop1)
(all,h,hou)
Utility(h,p) # utility #;

equation
E_Utility
(all,p,POP1)
(all,h,HOU)

utility(h,p)=sum{c,COM,S3LUX(c,h,p)*x3lux(c,h,p)};

Variable (change)
(all,h,hou)
Utility_p(h) # utility over pop #;

Equation
E_Utility_p

(all,h,hou)

utility_p(h)=sum{p,pop1,utility(h,p)};



!ev calculation!

variable (change)
(all,h,hou)
```

```
EV(h) #equivalent variation#;

coefficient
(all,h,hou)
(all,p,pop1)
luxreal(h,p) #current v3lux_c deflated by pfrisch#;

(parameter)
(all,h,hou)
luxreal_p(h) #luxreal for households#;

formula (initial)
(all,h,HOU)
(all,p,POP1)
luxreal(h,p) = V3TOT/ABS[FRISCHX(h,p)];

formula (initial)
(all,h,hou)
luxreal_p(h)=sum{p,pop1,luxreal(h,p)};

update (change)
(all,h,hou)
(all,p,pop1)
luxreal(h,p) = utility(h,p);

equation
E_EV

(all,h,HOU)

100*EV(h) = luxreal_p(h)*utility_p(h);

Write LUXREAL to file SUMMARY header "LUXR";
```

CHAPTER 7

REVERSING REGRESSIVE ELECTRICITY TAX EFFECTS THROUGH REVERSED BORDER TAX ADJUSTMENTS

7.1 Introduction

The previous chapter explored the economic impacts of an electricity generation tax, as well as an effective electricity demand side policy in South Africa. It also considered the household welfare effects if these two policies were simultaneously implemented. It was shown via the equivalent variation values, that simultaneous implementation would have a regressive impact on household welfare.

In this chapter reversed border tax adjustments (reversed BTAs), the tool developed in chapters 4 and 5, is used to offset the regressiveness of the simultaneously implemented policies.

Firstly, we summarise the household welfare impacts from the previous chapter and we also provide a short summary of the concept of reversed BTAs. This is followed by a theoretical Heckscher-Ohlin analysis of the two policies and the possible impacts of reversed BTAs on a representative household. Then we introduce import tariffs to the UPGEM model and simulate reversed BTAs on industry as well as aggregate levels. Lastly, industry results as well as aggregate results are reported.

7.2 Welfare implications of an integrated approach towards the electricity market in South Africa: a review

In Chapter 6 the UPGEM model was used and three scenarios were tested. Firstly, the electricity generation tax, implemented in 2009, of 2c per kWH (equivalent to a 10 per cent price increase) was introduced to the model. Secondly, the Demand Side Management Policy of Eskom, aimed at reducing household demand for electricity by 10 percent, through a change in households' tastes and preferences was shocked. Lastly, both the first and second scenarios were shocked and solved in the model simultaneously.

A measure that provides a comprehensive understanding of the impact of the electricity generation tax and the demand side policy on the welfare of households is the equivalent variation (EV). EV was defined and values were calculated for each household in Chapter 6.

H01 represents the poorest households and H12 represents the richest households. The classification of households is taken from the Statistics South Africa classification (Statistics South Africa 2004). The EV values were calculated (Figure 6.5) and it was shown that an electricity generation tax would be regressive with a negative impact on the welfare of all households. H01 will sacrifice the most welfare, while H12 will sacrifice the least welfare.

It was shown that effective demand side policy would be progressive, with H01 gaining the most welfare and H12 losing welfare. All households except H11 and H12 will increase household welfare. The simultaneous implementation of both policies would be regressive, moderated slightly by the progressiveness of an effective demand side policy.

7.3 Reversed Border Tax Adjustments: A Review

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.

Chapter 4 aimed to provide a theoretical analysis that not only challenged the effectiveness of BTAs, but also proposed an alternative approach to mitigate the welfare effects of environmental taxes. In the model, we utilized the conventional Heckscher-Ohlin methodology to illustrate the welfare impact of unilateral environmental taxation. Then we showed that, under certain assumptions, reversed BTAs might offset the adverse competitiveness impact of unilateral environmental taxation on GDP as well as employment.

Chapter 5 applied the Global Trade Analysis Project (GTAP) model to evaluate the impacts of an electricity generation tax on the South African, SACU and SADC economies and explored the possibility to reduce the economic impact of the electricity generation tax through traditional border tax adjustments. The results showed that an electricity generation tax would lead to a contraction of the South African gross domestic product. However, traditional BTAs are unable to address these negative impacts. The chapter then tested 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 was achieved through a reduction in import tariffs, as this reduction would 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 mostly the CO_2 abatement from the electricity generation tax was retained.

7.4 Reversed BTAs: A theoretical Heckscher-Ohlin approach

In this section the theoretical case is considered where there is an import tariff, but no export refunds; so an impact on the real economy is expected. In other words, only partial BTAs or partial reversed BTAs are considered.

In Chapter 5, conventional Heckscher-Ohlin methodology was utilised to illustrate, consistent with literature (Salvatore 1998, Pugel 2007), the equilibrium welfare level under a normal system of import tariffs and the absence of unilateral environmental taxes and a demand side policy. Chapter 5 also introduced a unilateral environmental tax, in the form of a tax on energy intensive production based on carbon content, and established the new equilibrium welfare level. In this chapter, we expand on the analysis of Chapter 5 by the introducing an effective demand side policy. Thereafter, we explore the possibility to offset the welfare impact of the simultaneous implementation of the two policies through reversed BTAs.

7.4.1 Setting up the model with environmental taxation

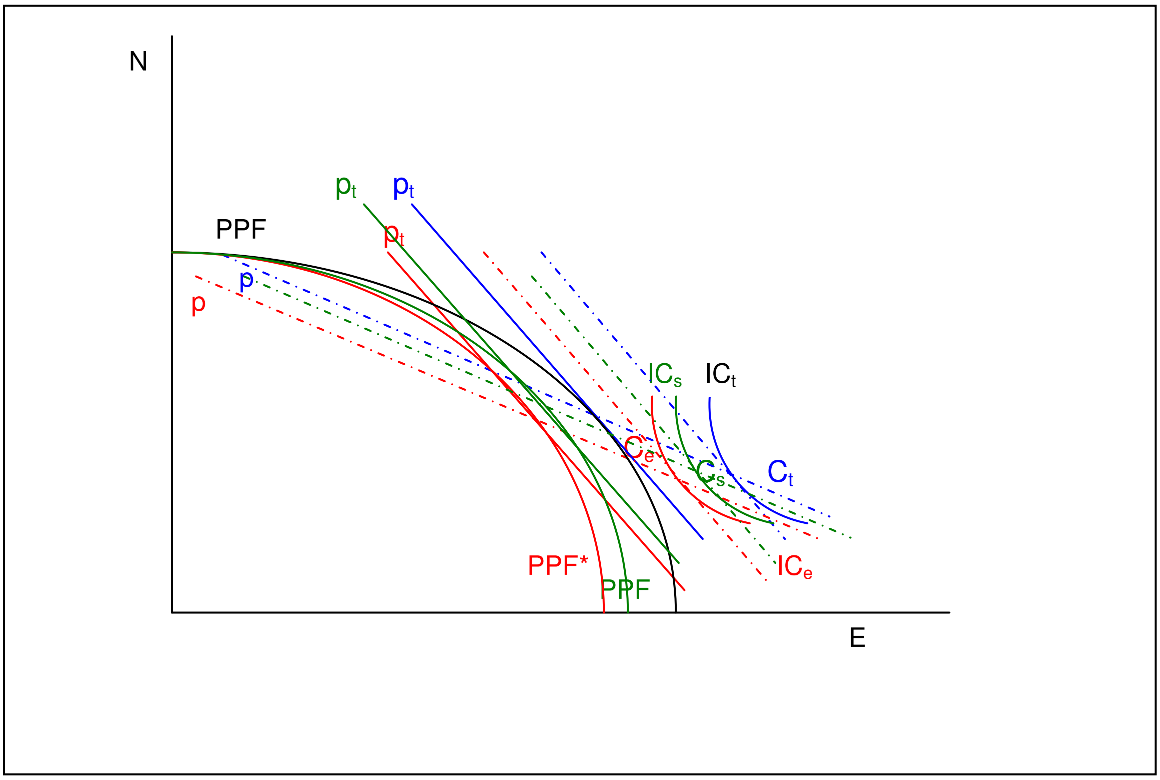
This section provides a brief overview of the Heckscher-Ohlin model in the presence of an environmental tax, as described in Chapter 4.

Suppose small country A imports energy intensive products (E) and exports non-energy intensive products (N). A distortion, to represent a unilateral environmental tax, in the form of a tax on energy intensive production based on carbon content, was introduced in Figure 4.2, the tax shifted the production possibility frontier inwards. This distortion affected the production potential of energy intensive products proportionally more than the production potential of non-energy intensive products. Next, an import tariff was imposed on energy intensive products. The import tariff on energy intensive products distorted the free trade equilibrium and the post-tariff consumer equilibrium was on a lower indifference curve than under free trade, with a unilateral environmental tax, while the country produced more energy intensive products and less non-energy intensive products.

7.4.2 Introducing a household demand side management policy

A distortion, to represent an effective demand side policy, through the more productive use of energy, is introduced in Figure 7.1. The policy shifts the production possibility frontier outwards from PPF* to PPF^s. This distortion affects the production potential of energy intensive products proportionally more than the production potential of non-energy intensive products.

Figure 7.1: The introduction of a demand side management policy



However, since country A is assumed to be a small economy, the world price ratio as well as domestic price ratio is unaffected.

Since the price ratios remain constant and the PPF* moves to PPF^s, country A will be in new consumption equilibrium at C_s on IC_s as this is the only point where the equilibrium conditions still hold. However, $C_e < C_s$ therefore the welfare of country A increased due to the demand side policy.

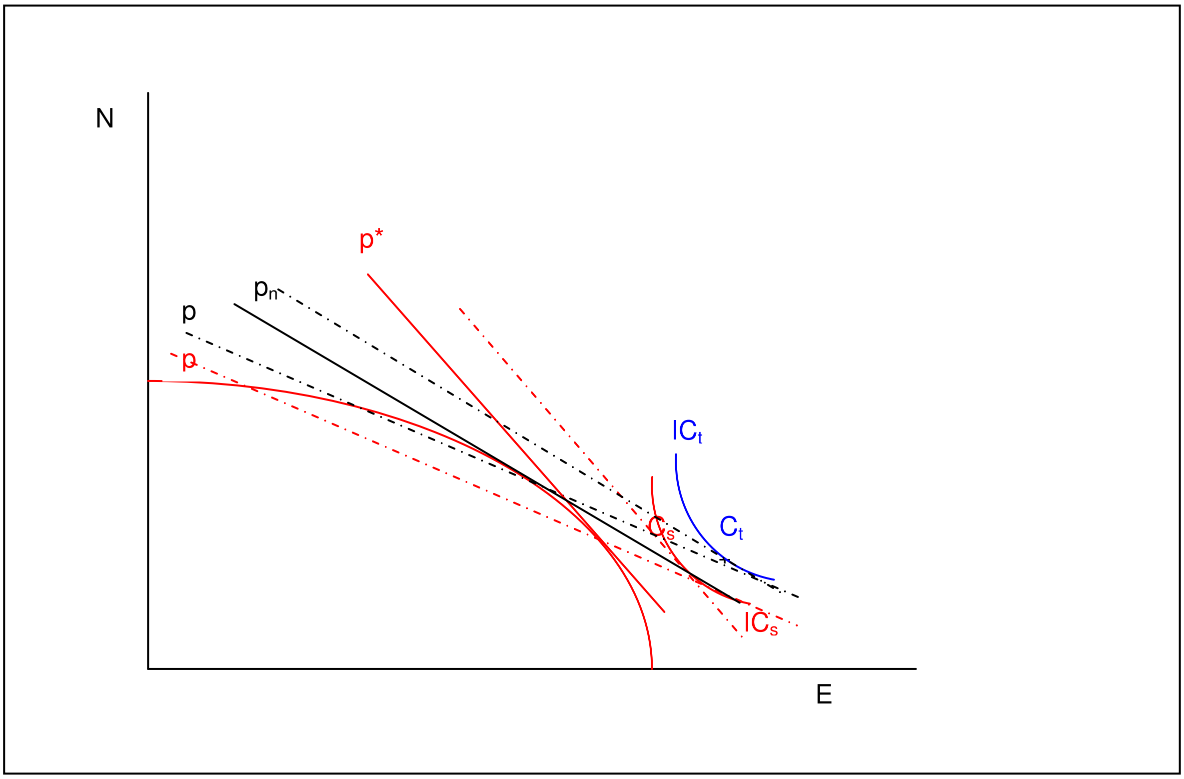
7.4.3 Introducing reversed border tax adjustments

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. On the other hand, a demand side policy will not affect world prices or domestic prices, but will increase the potential to produce more energy intensive products. This will increase the welfare of the economy from C_e to C_s . It was shown in the previous chapter, that in the case of South Africa, the simultaneous implementation of the two policies will result in a net welfare loss, thus $C_s < C_t$.

Since conventional BTAs will result in additional welfare losses, the question could be asked whether reversing BTAs could not offset the initial welfare losses of the simultaneously implemented policies. In other words, whether trade liberalisation could restore the welfare loss incurred as a result of the simultaneous implementation through gains from 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 7.2, 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 7.2: Reversing the impact of the distortion



Consumption in country A will return to equilibrium C_t. 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. However, since conventional Heckscher-Ohlin methodology assumes one representative household, it is not plausible to analyse whether reversed BTAs could be utilised to offset the regressiveness of the simultaneous implementation of an environmental tax as well as a demand side policy.

7.5 Targeted Reversed Border Tax Adjustments

In order to assess whether reversed BTAs could offset or partially offset the regressiveness of a simultaneous implementation of an environmental tax and a demand side policy, import tariffs must be introduced to UPGEM. In the first part of this section, average applied weighted tariffs are calculated and the UPGEM database is updated. This is followed by industry results and aggregated results.

7.5.1 Introducing import tariffs into UPGEM

South Africa has a complex tariff system in place. South Africa is a member of the Southern African Customs Union (SACU), in a Free Trade Agreement (FTA) with the European Union and a signatory of various other trade agreements with various countries. Furthermore, South Africa levies *ad valorem* taxes, specific taxes as well as combination taxes on imports. It is therefore not possible to find one explicit tariff per industry. In this section we attempt to calculate applied average weighted tariffs for the UPGEM industries.

The UPGEM model is based on the official 1998 social accounting matrix (SAM) of South Africa, published by StatsSA (Statistics South Africa 2004). This SAM consists of 27 sectors, which was split into 39 sectors (Van Heerden and De Wet 2004), 12 household types and 4 ethnic groups.

The South African Revenue Services (SARS) trade data are published for 22 industries. We map the SARS industries to the UPGEM industries, as shown in Appendix 7.A1. Three SARS industries are unassigned, the arms and ammunition industry (0.11 percent tariff), works of art (0 percent tariff) and industries that are not assigned (0.01 percent tariff), however, based on the customs value as published by SARS, the arms and ammunition industry accounts for only 0.1 percent of total customs value and works of art accounts for only 0.11 percent of total customs value. Unassigned industries account for 9.8 percent of total customs value.

The customs duty revenue per industry is divided by the customs value plus the customs duty received to calculate an applied average weighted tariff for the first 25 UPGEM industries. The remaining UPGEM industries are service industries with an actual tariff of zero percent. The applied average weighted tariffs, as shown in table 1 were used to update the UPGEM database.

Table 7.1: UPGEM tariffs

INDUSTRY	APPLIED AVERAGE WEIGHTED TARIFF	BASIC VALUE OF IMPORTS (R MILLION)	VALUE OF TARIFF REVENUE (R MILLION)
irrigated field	1.97	280	5.4
dry field	1.97	939	18.1
irrigated horticulture	1.97	507	9.8
dry horticulture	1.97	138	2.6
livestock	6.56	196	12.1
forestry	2.97	892	25.7
other agric	4.89	361	16.8
coal	0.55	580	3.2
gold	0.55	0	0
crude, petroleum and gas	1.28	2116	26.7
other mining	0.48	10587	50.1
food	11.36	7835	799.5
textiles	13.78	5089	616.2
footwear	25.50	1337	271.6
chemicals and rubber	3.05	10642	315.2
petroleum refineries	1.28	14894	188.2
other non-metal minerals	4.78	2013	91.9
iron and steel	1.54	12126	183.9
non-ferrous metal	1.54	5670	86.0
other metal products	1.54	9326	141.5
other machinary	1.77	12391	216.0
electrical machinary	1.95	4931	94.1
radio	1.95	15440	294.6
transport equipment	12.23	26109	2844.5
wood, paper and pulp	2.97	7563	218.2
other manufacturing	8.25	4114	313.4

Specifically, we aggregate the basic values of imports for producers, investors, households and change in inventories, and then use the applied average weighted tariffs to calculate the value of tariff revenue (V0TAR). Subsequently, V0TAR has been updated in the UPGEM database.

7.5.2 Industry results

The objective of this chapter is to investigate the possibility of applying reversed BTAs on an industry level to offset the regressiveness of the integrated approach analysed in the previous chapter.

After the UPGEM database has been updated with the applied average weighted tariffs on imports, reversed BTAs are simulated through complete liberalisation in each of the industries. The model is shocked and solved 25 times, liberalising each industry individually. The welfare impacts on households when each industry is liberalised individually are then separately recorded. Based on the household welfare impacts for each individual industry liberalisation, industry liberalisation are classified as progressive, as shown in Table 7.2, or regressive (Table 7.5). For example, as shown in Table 7.2, H01 will gain the most welfare from complete liberalisation in the food industry, this welfare gain remains positive, but declines with an increase in household income. H12 will experience a welfare gain, but this welfare gain will be the smallest. It is therefore clear that poorer households will gain more welfare than richer households throughout the economy.

Table 7.2: Progressive liberalisation

(Equivalent variation, percentage change)

	Irrigated field	**Dry field**	**Irrigated horticulture**	**Dry horticulture**	**Livestock**	**Other agriculture**	**Food**	**Other non-metal minerals**
H01	0.02	0.06	0.02	0.01	0.03	0.05	7.79	0.03
H02	0.02	0.05	0.02	0	0.03	0.05	7.29	0.02
H03	0.02	0.05	0.02	0	0.03	0.04	6.99	0.02
H04	0.01	0.05	0.02	0	0.03	0.04	6.53	0.02
H05	0.01	0.05	0.02	0	0.03	0.04	6.50	0.02
H06	0.01	0.05	0.02	0	0.03	0.04	6.14	0.02
H07	0.01	0.04	0.01	0	0.02	0.04	5.67	0.02
H08	0.01	0.04	0.01	0	0.02	0.04	5.12	0.02
H09	0.01	0.04	0.01	0	0.02	0.03	4.32	0.02
H10	0.01	0.03	0.01	0	0.02	0.03	3.63	0.02
H11	0.01	0.03	0.01	0	0.02	0.02	2.73	0.02
H12	0.01	0.02	0.01	0	0.02	0.02	1.73	0.02

Liberalisation in all the industries, except the other machinery industry and the gold industry (with a zero impact, since households do not buy gold) would result in higher net EV values for households. These increases in welfare due to liberalisation could be ascribed to welfare gains through gains from trade.

The industry with the most significant impact on welfare, when liberalised, is the food industry. The food industry is highly protected compared to the other sectors with an applied average weighted tariff of 11.4 percent. Liberalising the food industry would reduce domestic produced food prices 0.9 percent and decrease domestic food production by about 0.15 percent. Moreover, due to the liberalisation of the food industry, the price of imports is expected to decrease by 11.36 percent.

Table 7.3: Decomposition of food liberalisation

	LOCAL MARKET	DOMESTIC SHARE	EXPORT	TOTAL
Food	1.26	-1.75	0.34	-0.15

If the production changes in food are decomposed (Table 7.3), it could be seen that total supply to the local market would increase by 1.26 percent, but due to the increase in food imports (21 percent increase), the domestic share would decrease by 1.75 percent. However, lower domestic prices would lead to a 0.34 percent increase in food exports.

Table 7.4: Household spending on food

	HOUSEHOLD EXPENDITURE ON FOOD	TOTAL HOUSEHOLD EXPENDITURE	PERCENTAGE OF HOUSEHOLD EXPENDITURE ON FOOD
H01	7573.81	11162.97	67.85
H02	5358.8	8245.08	65.00
H03	7171.418	11819.24	60.68
H04	7024.093	12320.24	57.01
H05	6530.83	12207.59	53.50
H06	7584.766	15164.68	50.02
H07	9728.646	21303.07	45.67
H08	11976.16	29308.63	40.86
H09	15606.58	44754.04	34.87
H10	20438.35	70848.04	28.85
H11	13806.57	59711.71	23.12
H12	22435.63	163974.7	13.68

As shown in Table 7.4, food is an important expenditure item for households, but poor households spend a larger proportion of income on food (H01 spent 68 percent of income on food) than rich households (H12 spend 14 percent on food). Therefore, a decrease in food prices would increase the welfare of all households, but poorer households would benefit relatively more than rich households, resulting in a progressive impact on household welfare.

Figure 7.3: Equivalent variation value under food industry liberalisation

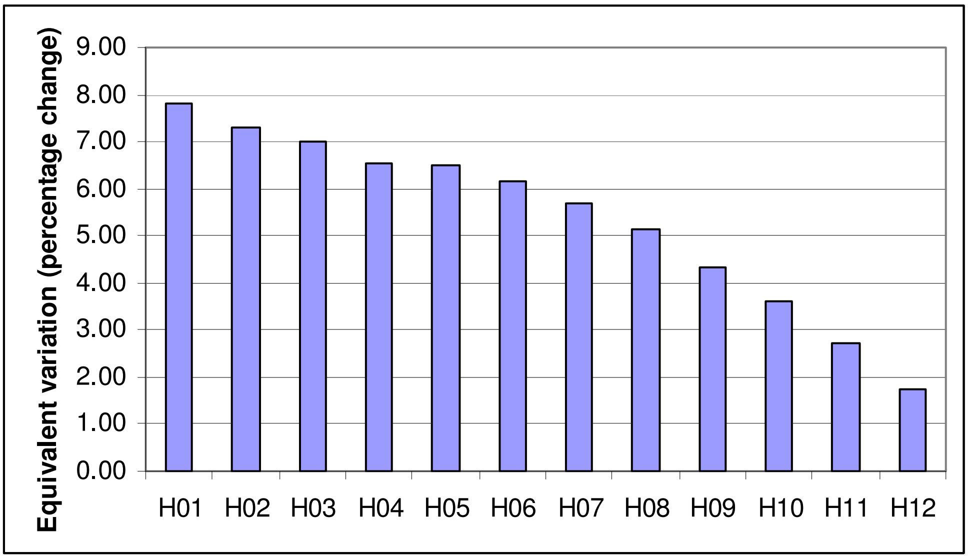


Figure 7.3 illustrates the EV decomposition of food liberalisation by households. All households would experience an increase in welfare, with H01 the poorest household recording the highest welfare gain, while H12 the richest household recording the smallest welfare gain. Therefore, food liberalisation could be seen as having a progressive impact on household welfare.

Table 7.5: Regressive liberalisation (Equivalent variation, percentage change)

	Textiles	**Chemicals and rubber**	**Petroleum refineries**	**Iron and steel**	**Radio**	**Transport equipment**	**Wood, paper and pulp**	**Other manufacturing**
H01	-0.17	0.34	0.2	0.18	0.07	0.11	0.17	0.08
H02	-0.14	0.33	0.2	0.18	0.12	0.15	0.17	0.06
H03	0.09	0.35	0.2	0.18	0.09	0.12	0.18	0.13
H04	0.11	0.34	0.2	0.19	0.1	0.14	0.19	0.21
H05	0.16	0.35	0.2	0.19	0.13	0.16	0.19	0.2
H06	0.25	0.37	0.21	0.19	0.15	0.22	0.2	0.26
H07	0.43	0.38	0.22	0.2	0.17	0.26	0.2	0.28
H08	0.46	0.39	0.22	0.2	0.17	0.32	0.2	0.31
H09	0.58	0.43	0.24	0.2	0.22	0.51	0.21	0.37
H10	0.66	0.45	0.24	0.21	0.24	0.89	0.22	0.39
H11	0.78	0.45	0.24	0.21	0.27	1.43	0.22	0.44
H12	0.57	0.42	0.22	0.23	0.26	2.77	0.22	0.41

The industries, which lead to a regressive impact on household welfare when liberalised, are shown in Table 7.5. Other industries with a welfare impact of less than 0.01 percent per household group, when liberalised, are shown in Table 7.A2 in the Appendix.

When the textile industry is completely liberalised, total welfare will increase, but H01 and H02 will be worse off. The reason for this is the labour intensive, unskilled nature of the textile sector. All households will benefit from lower clothing and textile prices, but the negative employment impact for H01 and H02 will exceed the price benefit for these households. Liberalising the Other Manufacturing industry, Radio industry, Transport Equipment industry and Petroleum industry will all result in regressive welfare gains across all households. Liberalising these sectors will decrease the prices and this will increase household welfare. However, spending in these sectors tends to be more luxurious spending, benefiting higher income households more than poorer households. Liberalising the Chemical and Rubber industry, as well as the Wood, Pulp and Paper industry, will increase household welfare, but regressively. The positive impact is due to the price impact, while the regressiveness is due to the employment impact as these industries employ unskilled, low income workers as discussed in Chapter 6. However, the net impact for all household groups is still positive.

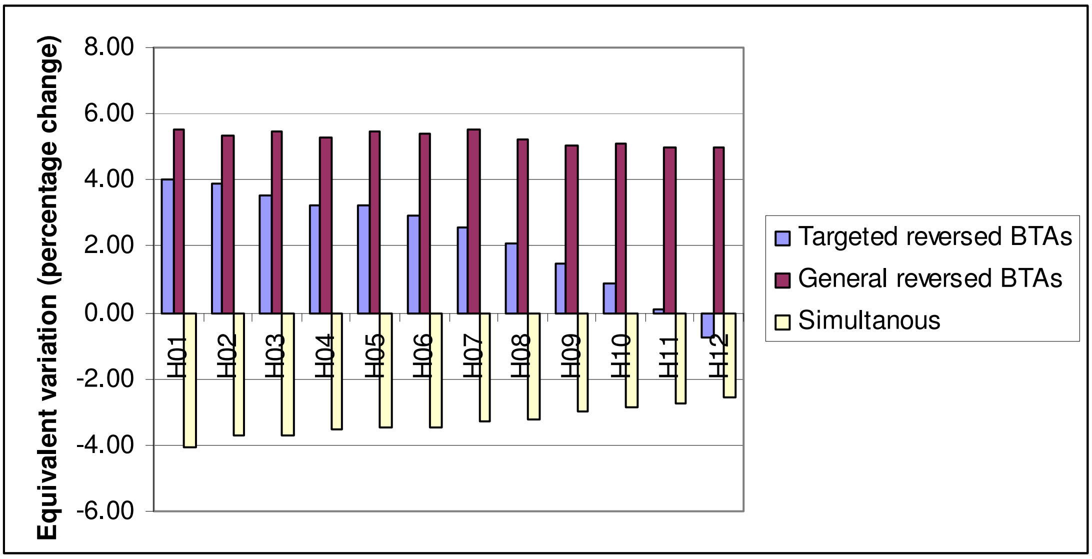
7.5.3. Aggregate results

After industries' liberalisation was classified as progressive, regressive or other, aggregate liberalisation is tested. Since the objective of this chapter is to analyse the possibility to offset the regressiveness of the simultaneous implementation of an electricity generation tax and a demand side policy, the simultaneous implementation is shocked and solved, together with all the progressive liberalisations. Then in the presence of simultaneous implementation, complete liberalisation across all industries are shocked and solved.

As shown in Figure 7.4, the net impact of the electricity generation tax and the demand side policy would be regressive, as discussed in section 2.

However, the regressiveness could be reversed when industries where liberalisation results in progressive welfare gains are identified and liberalised through reversed BTAs. The simultaneous implementation of an electricity generation tax, a demand side policy and targeted reversed BTAs would then be progressive and welfare enhancing for the majority of the households.

Figure 7.4: Simultaneous implementation with reversed BTAs
(Equivalent variation, percentage change)



Only H12 would still experience a decrease in welfare, but the welfare reduction is less than a third of the original welfare reduction under the electricity tax and demand side policy without reversed BTAs. Under complete liberalisation of all industries, welfare across all households would increase. In other words, targeted reversed BTAs or general reversed BTAs could be used to offset the regressiveness of an integrated approach. Targeted reversed BTAs could be used to progressively increase household welfare, while general reversed BTAs could be used to proportionally increase household welfare.

7.6 Conclusion

This chapter attempted, using reversed BTAs as developed in chapters 4 and 5, to offset the regressiveness of the simultaneous implementation of an electricity tax and a demand side policy as analysed in the previous chapter. Equivalent variation as modelled in the previous chapter was used as a measure of household welfare.

The results from the simultaneous implementation of the two policies on household welfare were briefly reviewed and we also provided a short overview of the concept of reversed BTAs. Thereafter, Heckscher-Ohlin methodology was used to theoretically explain why reversed BTAs, rather than BTAs are the tool that should be used to offset the welfare losses of a representative household.

Then we introduced import tariffs to the UPGEM model, using SARS data to calculate applied average weighted tariffs. This was followed by industry results as well as aggregate results. The results showed that gains from trade through reversed BTAs would not only be sufficient to offset the welfare losses of the integrated approach, but would be welfare enhancing. Should only the progressive industries be liberalised, the net impact would be welfare enhancing and progressive.

The policy implication, contrary to arguments made in literature (as explored in chapters 3 and 4) is that liberalisation though reversed BTAs, could be used to offset the adverse household welfare impact of an integrated approach.

Appendix 7.A1

Table 7.A1: Tariff map

UPGEM		SARS	
	Applied weighted tariff		Applied tariff
1	1.968658	2	1.968658
2	1.968658	2	1.968658
3	1.968658	2	1.968658
4	1.968658	2	1.968658
5	6.561219	1	7.778274
		3	3.412263
		8	15.86639
6	2.970069	9	4.374615
		10	2.504088
7	4.886297	1,2,3,8,10	4.886297
8	0.548542	5	0.548542
9	0.548542	5	0.548542
10	1.279814	6	1.279814
11	0.475557	5	0.548542
		14	0.275367
12	11.36281	4	11.36281
13	13.77802	11	13.77802
14	25.49766	12	25.49766
15	3.052158	6	1.279814
		7	6.71313
16	1.279814	6	1.279814
17	4.780968	13	4.780968
18	1.540259	15	1.540259
19	1.540259	15	1.540259
20	1.540259	15	1.540259
21	1.773436	16	1.945317
		18	0.106113
22	1.945317	16	1.945317
23	1.945317	16	1.945317
24	12.22634	17	12.22634
25	2.970069	9	4.374615
		10	2.504088
26	8.247096	20	8.247096

Source: SARS and UPGEM database

Appendix 7.A2

Table 7.A2: Regressive liberalisation, small EV values

EV	FORESTRY	OTHER MINING	NON-FERROUS METAL	OTHER NON-METAL MINERALS	OTHER MACHINERY	ELECTRICAL MACHINERY
H01	0.02	0.04	0.08	0.01	-0.04	0.01
H02	0.02	0.04	0.08	0.01	-0.04	0.02
H03	0.02	0.05	0.08	0.01	-0.04	0.02
H04	0.02	0.05	0.09	0.02	-0.03	0.02
H05	0.02	0.05	0.09	0.02	-0.04	0.02
H06	0.02	0.05	0.09	0.02	-0.04	0.02
H07	0.02	0.05	0.09	0.02	-0.04	0.02
H08	0.03	0.05	0.1	0.02	-0.03	0.02
H09	0.03	0.05	0.1	0.02	-0.03	0.03
H10	0.03	0.05	0.1	0.02	-0.03	0.03
H11	0.03	0.05	0.1	0.02	-0.03	0.03
H12	0.04	0.05	0.1	0.02	-0.03	0.04

CHAPTER 8

CONCLUSION AND POLICY IMPLICATIONS

8.1 Conclusion

In the 2008 budget of the Minister of Finance, the South African Government proposed to impose a 2 cents/kilowatt-hour (c/kWh) tax on the sale of electricity generated from non-renewable sources; this tax is to be collected at source by the producers/generators of electricity. The intention of this measure is to serve a dual purpose of protecting the environment and helping to manage the current electricity supply shortages by reducing demand.

Chapter 2 analysed, using the GTAP model, the impact of such an electricity generation tax on the South African economy. It was found that the overall impact on the South African economy would be negative. However, the electricity generation tax is also expected to yield a positive effect on the South African economy, in terms of the benefits derived from pollution abatement. Ultimately, the government will achieve the objective of the electricity generation tax, namely the reduction of CO_2 emissions, at the expense of a reduction in output.

Chapter 3 explored the possible competitiveness impact of a multilateral electricity generation tax. It was shown that an electricity generation tax will indeed affect the competitiveness of South Africa in a negative way. Furthermore, multilateral SACU or SADC implementation will marginally reinforce these negative effects. However, a multilateral electricity generation tax across SACU or SADC countries will result in emission reductions, but lower than in the case of a unilateral electricity generation tax.

In literature, border tax adjustments (BTAs) have been proposed as a possible competitiveness remedy under environmental taxation. Chapter 4 used Heckscher-Ohlin methodology to consider the welfare effects of BTAs and found that BTAs would be welfare reducing in a small country case. The chapter then proposed an alternative remedy, namely reversed BTAs. The GTAP model has been used in Chapter 5 to test reversed BTAs as a remedy under unilateral environmental taxation. It was found that reversed BTAs could, under certain assumptions, be successful to negate the economic impact of an electricity generation tax.

Demand side management was introduced to the UPGEM model in Chapter 6, and the focus was on the impact of effective demand side management, simultaneously implemented with an electricity generation tax, on household welfare. It was found than an effective demand side policy will be progressive, with most households gaining welfare, an electricity generation tax will be regressive, with most households losing welfare, while an integrated approach would be welfare reducing and regressive.

Chapter 7 considered reversed BTAs as a remedy for the regressiveness of the simultaneously implemented policies in Chapter 6. The results showed that gains from trade through reversed BTAs would not only be sufficient to offset the welfare losses of the integrated approach, but would be welfare enhancing. Should only the progressive industries be liberalised, the net impact would be welfare enhancing and progressive.

8.2 Policy implications

In Chapter 2, it was shown that an environmental tax would have an adverse impact on the South African economy, while Chapter 3 concluded that multilateral environmental taxes in SACU and SADC would not alleviate the competitiveness impact of an environmental tax on the South African economy. Policymakers should therefore consider the impact of any environmental tax, not only on the environment, but also on the economy. This will enable policymakers to better align environmental policy to other government policy objectives.

Chapters 4 and 5 showed that, contrary to literature, BTAs as a remedy under environmental taxes would be welfare reducing. Instead, reversed BTAs could, through gains of trade, negate the adverse economic impact of an electricity generation tax. The implication for policymakers is that BTAs is not a sound remedy to address the competitiveness impact of environmental taxation. Instead, policymakers could consider trade liberalisation through lower import tariffs.

In Chapter 6 it was shown that effective household demand side management would be progressive and welfare enhancing, while an electricity generation tax would be regressive and welfare reducing.

Chapter 7 concluded that reversed BTAs could be used to offset the household welfare losses, if demand side management and environmental taxation are simultaneously implemented.

Furthermore, if reversed BTAs are targeted, the net impact on household welfare could be welfare enhancing and progressive. Policymakers should take note of the regressive nature of environmental taxation, as well as the possibility to offset the regressiveness of environmental taxation through reversed BTAs. Specifically, the liberalisation of the agricultural industries, as well as the food industry and the other non-metal minerals industry seem to be progressive and welfare enhancing. However, targeted reversed BTAs will pose serious policy challenges as opposition from various stakeholders could be expected.

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