Fighting CO_2 pollution and poverty while promoting growth: searching for triple dividends in South Africa

Van Heerden, J.[1, 2], Gerlagh, R.[3], Blignaut, J.[2], Horridge, M.[4], Hess, S.[3], Mabugu, R.[5], Mabugu, M.[2]

1 Corresponding author: jan.vanheerden@up.ac.za
2 Department of Economics, University of Pretoria, Pretoria.
3 Institute for Environmental Studies, Free University, Amsterdam.
4 Centre of Policy Studies, Monash University, Melbourne.
5 Centre of Environmental Economic Policy in Africa, University of Pretoria, Pretoria

Abstract

A CGE model of South Africa is used to find the potential for a 'double or triple dividend', if the revenues raised from an energy related environmental tax are recycled into households and industry through lowering existing taxes. Four environmental taxes and three revenue-recycling schemes are compared. The environmental taxes are (i) a tax on greenhouse gas emissions, (ii) a fuel tax, (iii) a tax on electricity use, and (iv) an energy tax. The four taxes are constructed such that they have a comparable effect on emissions. The revenue is recycled through either (i) a direct tax break on both labour and capital, (ii) an indirect tax break to all households, or (iii) a reduction in the price of food. A triple dividend is found when any one of the environmental taxes is recycled through a reduction in food prices.

PREM Working Paper: 05/02

Keywords: CO_2, Poverty, Double-dividend, CGE, Environmental tax

Date: 8 March 2005

Table of Content

1. Introduction	1
2. Double dividend	3
3. Data and Model	6
4. Scenarios	9
5. Results	10
6. Conclusion	17
References	17

Acknowledgements

The authors wish to thank the Poverty Reduction and Environmental Management (PREM) Programme, which is fully funded by the Ministry of Foreign Affairs, the Netherlands, for financial support. The authors also thank Richard Tol and Theuns de Wet for their invaluable inputs during the course of the model development. The views expressed are, however, those of the authors and do not necessarily reflect those of any institution they may be involved with.

Poverty Reduction and Environmental Management (PREM)

PREM aims to deepen and broaden the exposure of economic researchers and policy advisors in developing countries to the theory and methods of natural resource management and environmental economics. It is envisaged that this will encourage effective policy change in developing countries with the joint goals of poverty reduction and sustainable environmental management.

This Working Paper Series provides information about the scientific findings of the PREM projects. All publications of the PREM programme, such as working papers, press releases and policy briefs are available on the website:
www.prem-online.org

PREM Poverty Reduction and Environmental Management

Institute for Environmental Studies
Vrije Universiteit
De Boelelaan 1087
1081 HV AMSTERDAM
The Netherlands
Tel. +31 (0)20-5989 555
Fax. +31 (0)20-5989 553
E-mail: prem@ivm.vu.nl

1. Introduction

Although classified as a developing country, the South African economy resembles that of a developed economy in many respects. It is not surprising that the country's economy has been referred to as being a "double-decker" economy, meaning an economy with various layers of income (Sparks 2003). This notion is mirrored by the United Nations Development Programme (UNDP) (2003) which states that South Africa is a country of two societies, one being ranked 18th in the world (the top-deck) and the other 118th (the middle and bottom decks) based on gross domestic product per capita. This dichotomy is further expressed by the fact that the economic structure of the country resembles that of a developed economy (see Figure 1) with a high carbon footprint because of its energy intensive manufacturing and services sectors.

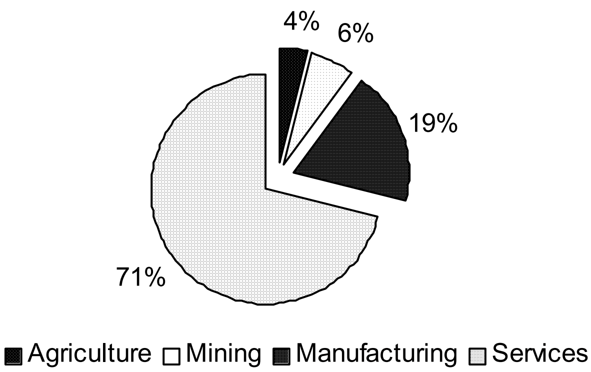

Figure 1 Percentage contribution to real GDP by industry in South Africa: 2003[1].

The dichotomy is also clearly illustrated by the fact that although the countries gross national income is considerably smaller than that of upper-middle income countries (Table 1); its electricity consumption is 3.8 Megawatt hours (MWh) per capita compared to the 2.5 MWh for upper-middle income countries. Coal is the dominant source of primary energy supply (see Figure 2) and is used as fuel stock for the generation of 94 per cent of the country's electricity. South Africa's carbon-dioxide emissions lie between that of the high-middle income and the high-income countries at 7.4 tonnes (t) carbon dioxide (CO_2) per capita.

Because of its peculiar economic structure, the usual economic growth and carbon mitigation strategies cannot be applied to South Africa without further scrutinising them. As a non-Annex I country according to the Kyoto protocol, South Africa does not have any emission reduction targets for the first commitment period, 2008-2012, but this position might change after 2012. The concern is that any emissions reduction strategy (voluntary or otherwise) could have a negative impact on the economic development potential, as well as the much-needed integration of the various income layers.

---

1 Sources: The South African Reserve Bank, *Quarterly Bulletin,* various issues.

Alternative policies are sought that could reduce the country's carbon footprint, while at the same time alleviating poverty and stimulating economic development (Blignaut and De Wit 2004).

Table 1 Economic and environmental indicators: 2002[2].

	World	Low income	Lower middle	Upper middle	High income	South Africa
Population (millions)	6,199	2,495	2,409	329	966	45
GNI per capita (USD/p.c.)	5,120	430	1,400	5,110	26,490	2,500
Energy						
Electricity consumption per capita (kWh/p.c.)	2,159	317	1,304	2,505	8,421	3,793
Share of electricity generated by coal (%)	38.8	49.2	42.5	24.0	37.6	94.0
Emissions and pollution						
CO_2 emissions per capita (metric tons CO_2/p.c.)	3.8	0.9	3.0	6.2	12.4	7.4

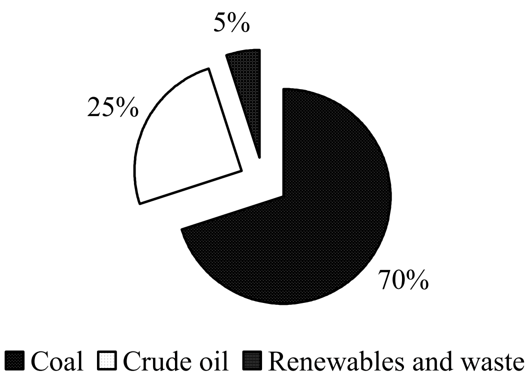

Figure 2 Primary energy supply 1998: 4 876PJ[3].

One way to achieve such an integrated policy is to search for double or triple dividends through environmental taxes. Although a study searching for such dividends would by no means be new to the literature (Bosello *et al*. 2001, Bossier and Brechet 1995, Bovenberg 1999, Fullerton and Metcalf 1997, Jorgenson and Wilcoxen 1993), it is South Africa's concern with poverty alleviation, carbon reduction and at the same time ensuring continued economic growth, that distinguishes this study from related work.

The paper is structured as follows. Section 2 introduces the double dividend concept in the context of the paper, followed by a discussion of the data and model in Section 3. Section 4 contains the scenarios analysed, Section 5 discusses results, and Section 6 offers conclusions.

2 Sources: The World Bank. 2003. *The little green data book,* (from the World Bank Development Indicators). Notes: Low-income economies are those with a GNI per capita of $745 or less in 2001.

3 Source: Department of Minerals and Energy. 2000. *Energy balance for South Africa: 1998*, Pretoria.

2. Double dividend

The search for double dividends is a recurring issue in the literature (Goulder *et al.* 1999) and centres around the question whether there are benefits obtained by an environmental policy in addition to the environmental benefits. These benefits, the second or third dividend, could be an increase in GDP or the reduction in poverty. It seems to be common place to distinguish between at least two forms of double dividends (following Goulder 1995): weak double dividends when a recycling of environmental tax revenues reduce the income losses associated with the environmental tax, and strong double dividends when a 'smart' environmental tax scheme succeeds to let both income (or GDP) and environmental quality increase. The most interesting discussion is related to the notion of strong double dividends (we refer to Bovenberg and de Mooij 1994, Goulder 1995, and Parry 1997 for more details). One well-known result from the theoretical literature is that, through tax interaction, a double dividend is improbable (see, e.g., Bovenberg and de Mooij 1994), unless there are initial distortions in the tax system or in the market, in which case a tax change might cause an efficiency gain and a strong double dividend may be found (see, e.g., Bovenberg and Van der Ploeg 1998).

Another second dividend, different from the overall income gain, which has received special interest in Europe, is an employment dividend from revenue neutral environmental tax reforms. This dividend is easier to obtain than the efficiency or income dividend. If, for instance, revenues from the tax are devoted exclusively to cuts in labour taxes, the reform might produce an employment dividend even in the absence of a (strong) efficiency dividend. Bosquet (2000) surveys 56 different studies and concludes that when environmental tax revenues are used to reduce payroll taxes, and if wage inertia is prevented, small gains in employment are likely in the short and medium term. For employment gains to materialize, the labour market must be flexible. Since we empirically study the potential for a triple dividend using a CGE-model, we first review the literature on this topic.

In most of the earlier papers, relatively simple computable general equilibrium (CGE) models are used to show that double dividends are unlikely to materialise. The paper by Bovenberg and De Mooij (1994) is a good example of this. They use a CGE model with competitive markets and labour as the only production factor, and both a clean and a dirty commodity as outputs. In their model, the environmental tax – in this case a tax on the dirty consumption good – boils down to an implicit tax on labour. It leads to price rises, which reduce the real wage. This, in turn, results in a reduction of the labour supply. Recycling the revenues from the environmental tax through lower labour taxes leads to an increase in the real wage and therefore an increase in the labour supply. Yet, the recycling only partially cancels out the fall in labour supply. The reason for this is as follows: The environmental tax not only distorts the labour market, but also the commodity market: it reduces demand for the dirty good[4].

[4] In the theoretical tax literature, taxes on intermediate inputs generally have larger welfare costs than do equal-revenue taxes on primary factors or final goods for the same reason, i.e., they distort both the intermediate input choice and factor markets (Goulder 1995: 288).

This is, of course, the intention of the environmental tax reform. However, Bovenberg and De Mooij are mostly interested in the possibility of the second dividend. Furthermore, they assume that initially the tax on the dirty good is at its Pigouvian level, and in that case, an extra distortion of the distribution of consumption over the two goods must decrease total income.

The effect of the above Pigouvian environmental tax on income can also be understood from a tax-base perspective. The reduced demand for the dirty good erodes the base of the environmental tax, which means that revenues decrease. This tax base erosion effect limits the extent to which the environmental tax can finance a reduction in the labour tax. In the end, the shift in taxes must decrease the real wage. Therefore, labour supply drops and employment and welfare decline.

In another paper with similar assumptions, Fullerton and Metcalf (1997) come to the same general conclusions. Analysis with a more complicated CGE model in a paper by Goulder *et al*. (1997) also corroborates Bovenberg and De Mooij's results. They include intermediate inputs – labour is still the only factor of production – and distinguish between a tax interaction and a revenue recycling effect. The tax interaction effect measures the costs of extra distortions due to the higher environmental taxes without lowering existing taxes, while the revenue recycling effect measures the benefits of a reduction in distortions[5]. In the above-mentioned models, the tax-interaction effect dominates.

When more factors of production, labour and capital, are introduced in later papers, there appears to be more scope for a double dividend. Another important addition to the analysis described above is the introduction of strategic behaviour into the labour market, for example, leading to involuntary unemployment in the initial situation. These papers also generally assume an environmental tax that is levied on inputs instead of on a dirty consumption good. Energy is most often used as this polluting input.

Including a second factor of production (capital) into the analysis introduces the possibility that a revenue-neutral environmental tax could shift the burden of taxation from one factor to another. If there are initial differences in marginal efficiency costs of taxation (that is, the loss of overall production efficiency due to taxation, of say labour and capital) then the efficiency of the tax system can be increased by shifting the tax from the over-taxed factor to the under-taxed factor. According to Goulder (1994), the costs of an environmental tax reform will be lower if the following three conditions are met: (i) the difference in marginal efficiency cost is large, (ii) the burden of the environmental tax falls primarily on the under-taxed factor, and (iii) the revenues from the tax are used to reduce the tax rate on the over-taxed factor. He also mentions a more general factor influencing the distortionary effects of taxes: its breadth. The broader the tax base, the lower the erosion.

Environmental taxes, however, are relatively narrow by nature because they are meant to change specific behaviour. Goulder (1995), Bovenberg and Goulder (1997) and Jorgenson and Wilcoxen (1993) all study the results of a revenue-neutral environmental tax reform for the United States with an inter-temporal CGE analysis. Whereas the first

---

5 The earlier described tax base erosion contributes to the (more general) tax interaction effect (Goulder 1994).

two studies find no double dividend, the third analysis by Jorgenson and Wilcoxen (1993) does find a double dividend if taxes on capital are lowered with the revenues of a carbon tax. A double dividend does not materialise if labour taxes are cut instead. This fits in nicely with the general notion that the marginal excess burden of capital taxation in the US is higher than that of labour. But, the occurrence of a double dividend in this analysis may also be explained by the assumed full mobility of capital in the Jorgenson and Wilcoxen model, while Bovenberg and Goulder assume that capital is immobile between different sectors. The elasticity in capital demand is thus substantially larger in the Jorgenson and Wilcoxen model (Bye 2000).

In contrast to the US, in Europe labour is generally considered over-taxed compared to capital, according to Bye (2000). She uses an inter-temporal CGE model for Norway, a small open economy characterised by a particularly high marginal excess burden of labour taxation. A carbon tax, the revenues of which are used to reduce payroll taxes, leads to a small rise in welfare and a reduction of CO_2 emissions, which is mainly the result of two effects. Firstly, the carbon tax reduces emissions, and secondly, the reduction in payroll taxes raises employment. According to Bye (2000), the carbon tax works as an indirect tax on capital and, since the marginal excess burden of labour is large in Norway, she indicates that the tax reform brings the tax system closer to optimality.

To apply the mechanisms laid out in the above literature to South Africa, we have to understand whether, in South Africa, i) energy in production is relatively complementary to capital or labour, ii) whether capital and labour are relatively elastic in supply, and iii) what the relative tax rates are. To start with, it has been indicated that electricity demand is complementary to capital (Blignaut and De Wet 2001), but we could find no comprehensive efficiency tax study for South Africa. There have been partial studies on the equity aspects of tax policy. Earlier studies concluded that the VAT system in South Africa was regressive, implying that differential VAT rates or zero-rating some commodities could enhance equity (Fourie and Owen 1993). There are also some studies on the relationship between wage inequality and skill bias. Edwards (2001) concludes that skills are essential to employment, while Abdi and Edwards (2002) look at the paradox of how relative unskilled wages have been increasing at the same time as unskilled unemployment since the 1970s.

As far as the tax erosion effect is concerned, South Africa is among those countries with the lowest energy prices in the world. The virtual absence of initial energy taxes implies that a reduction of the energy demand through increased energy taxes will not lead to a reduction in tax revenues. Thus, the costs of a shift in taxes towards energy, in terms of lost public funds, are limited. This makes a double dividend more probable.

With regard to the elasticity of capital and labour supply, savings rates in South Africa are low, and capital formation depends to a great extent on foreign capital inflow. The capital supply is thereby dependent on trust in present and future institutional quality, absence of corruption, secure property rights and low inflation. In that context, a marginal change in the rate of return on capital may be less important. As for labour, a distinction must be made between skilled and unskilled labour. Most skilled labour is employed, while unemployment rates for unskilled labourers reach very high levels. In abstract terms, we can assume that unskilled labour is in infinite supply, and that the effect of tax shifting on the unskilled labour market will be of major importance for its overall effect on output and income. All in all, when energy is complementary to capital, and when tax revenue recycling can be used to increase unskilled labour demand, a double dividend (similar to that found in the model by Bovenberg and van der Ploeg (1996; 1998)) may materialize in South Africa.

3. Data and Model

Emissions data

South Africa has official greenhouse gas emission inventories for both 1990 and 1994, but two complications make it difficult to utilise them for economic analysis. Firstly, the data are old and their dates do not coincide with the social accounting matrix (SAM) employed in the CGE-model used in this study. Secondly, the inventories are classified according to different industrial sectors to those used in the SAM. In light of this, a new greenhouse gas (GHG) emissions database was compiled (Blignaut *et al*. under review) using the national energy balance as published by the South African Department of Minerals and Energy (DME 2000). The Department's energy balances are compiled on an annual basis, providing production and consumption data for coal, crude oil, petroleum products, natural gas, and electricity in both native units (tons, MWh and kl) and standardised energy units (tons of oil equivalent (TOE) and terajoule (TJ)).

Since the industrial classification of the DME's energy balances resembles that of the SAM, it was possible to compile energy tables by commodity (coal, crude oil and gas, petroleum products and electricity) and activity (39 industrial sectors). Using various country and gas-relevant emission coefficients, the tables were subsequently used to calculate the carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) emissions per sector per fuel for 1998[6], all expressed in terms of CO_2-equivalent values. This implies that both the emissions by fuel and sector, and also the energy consumption by fuel and sector in both standardised (TJ) and native units have been mapped, creating three 2-dimensional matrices according to the same industry classification as the SAM. These matrices are:

1. A matrix describing greenhouse gas emissions resulting from the combustion of fuels by industry (measured in Gg CO_2-equivalents);
2. A matrix describing energy consumed by the industries. Matrix dimensions are "sources of energy" and "industries" (electricity has been added as source of energy); and;
3. The same matrix as in point 2, but in native units.

Table 2 presents the first two matrices in aggregated form.

From Table 2, it is clear that the combustion of coal is the main source of CO_2 emissions in South Africa, accounting for approximately 75 per cent of all GHG emissions. These coal-based emissions originate from the generation of electricity and petroleum (South Africa is one of the few countries in the world that produces petroleum from coal).

6 1998 was selected because it corresponds to the SAM used, but the same methodology could easily be applied to the latest energy balance for the country, namely 2002.

Table 2 Greenhouse gas emissions and energy consumption by fuel and sector in South Africa: 1998.

	Emission from (Gg)				
	Renewables	Coal	Crude oil, petrol & gas	Petroleum	Total
Coal	-	22	3	940	965
Crude petr. & gas	-	-	11	274	285
Petr. refineries	-	53,704	7,286	-	60,990
Electricity	4,608	173,802	-	-	178,410
Agriculture	-	381	-	6,850	7,231
Mining[1]	-	3,113	14	1,756	4,883
Manufacturing[2]	-	26,862	4,810	3,191	34,863
Services[3]	-	1,997	7	38,755	40,759
Residential	18,666	3,904	-	1,979	24,549
Total	23,274	263,785	12,131	53,745	352,935

	Final demand for energy (TJ)					
	Renewables	Coal	Crude oil, petrol & gas	Petroleum	Elect.	Total
Coal	-	284	56	12,929	11,029	24,298
Crude petr. & gas	-	-	193	3,766	25	3,984
Petr. refineries	-	253,359	2,738	-	4,390	260,487
Electricity	-	-	-	-	-	-
Agriculture	-	4,958	-	94,150	21,406	120,514
Mining[1]	-	40,699	249	24,154	94,667	159,769
Manufacturing[2]	-	350,680	71,488	43,605	257,127	722,900
Services[3]	-	25,807	117	538,953	73,924	638,801
Residential	190,400	50,483	-	27,033	108,587	376,503
Total	190,400	726,270	74,841	744,590	571,155	2,307,256

Notes:

1 Excluding Coal, Crude, petroleum and gas.

2 Excluding Petroleum refineries.

3 Excluding Electricity.

Source: Own Calculations based on energy balance for 1998.

Another major source of greenhouse gas emissions is the combustion of petroleum products by motor vehicles, indicated here under ‘Services’ (retail trade specifically). We allocated these emissions to the respective users of the fuel, i.e. households and industries, according to the SAM weights. Of considerable concern are the emissions produced by the combustion of biomass (renewable resources), since they mainly reflect the use of fuel wood by rural households (due to the absence of grid electricity), as well as the occurrence of wild fires.

Emissions from sources related to activities other than the combustion of fossil fuels, i.e., agriculture residuals (mainly methane) are excluded from the database. It should be noted that the final demand series in Table 2 presents final energy consumption and does not include the use of energy resources in the production of other energy resources, e.g. the use of coal to produce electricity or petroleum.

Furthermore, the loss of energy during the conversion from coal to petroleum (accounting for approximately 10 per cent of the emissions) is also not accounted for under final energy demand.

The model

The model is similar to the general equilibrium ORANI-G-model of the Australian economy, and is written and solved using GEMPACK (Harrison and Pearson 1996). In general, the model allows for limited substitution on the production side, focusing rather on substitution in consumption. It is a static model with an overall Leontief production structure and CES sub-structures for (i) the choice between labour, capital and land, (ii) the choice between the different labour types in the model, and (iii) the choice between imported and domestic inputs into the production process. 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.

The model is based on the official 1998 social accounting matrix (SAM) of South Africa, published by Statistics South Africa (SSA 2001). This SAM divides households into 12 income and 4 ethnic groups, and distinguishes 27 sectors. For the purpose of this study, we further split the energy and water intensive sectors into 39 sectors. The elasticities used for the CES functions in the model have been taken from De Wet (2003).

The model's closure rules reflect a short-run time horizon. The capital stock is assumed to be fixed, while the rate of return on capital is allowed to change. Labour supply is modelled differently in comparison to the Australian-based ORANI, which employs an elastic demand and supply for its short-run closure. The South African labour market is characterised by large unemployment of unskilled labour, and a shortage of skilled labour. The model differentiates between 11 different labour groups that are classified as either skilled or unskilled. Skilled labour is treated as human capital with inelastic short-term supply. This approach applies to seven labour categories: legislators, professional workers, technicians, clerks, service industry workers, skilled agricultural workers, and craftsman. Unskilled labour is assumed to be perfectly elastic, with fixed real wages. This approach applies to three labour categories: elementary workers, domestic workers, and operators. The distinction between skilled and unskilled labour supply reflects the South African labour market realistically and allows investigation of the effect of certain policies on the levels of employment of unskilled labour. The supply of land is also assumed inelastic.

With reference to the macroeconomic variables, it is assumed that aggregate investment, government consumption and inventories are exogenous, while consumption and the trade balance are endogenous. This specification gives us an insight into the effect of the suggested policies on South Africa's consumption and competitiveness. All technological change variables and all tax rates are exogenous to the model. Finally, the nominal exchange rate is set to be the numeraire in each of the simulations.

4. Scenarios

The focus of this paper is on whether an appropriate recycling of tax revenue following energy related environmental taxes could result in double or triple dividends. To answer this question various taxes, as well as revenue recycling scenarios, are analysed.

Tax instruments for carbon reduction

Seven policy simulations are run: four simulations to analyse the effects of various environmental tax instruments and three simulations to analyse recycling schemes. The environmental tax instruments are the following: (i) a carbon tax, (ii) a fuel tax, (iii) an electricity tax, and (iv) an energy tax.

The first scenario is a carbon tax of R35 per ton of CO_2. This is equivalent to 5 USD/ton CO_2 and is based on the conservative estimate of Sandor (2001), who estimated the global damage cost of a ton of CO_2 as being between USD 5 and USD 10. This tax has a broad base and captures all emissions at source of combustion (and hence emission), and is applied to the CO_2-equivalent emission by sector. From an environmental perspective, this tax would be the best alternative since it is directly linked to the environmental objective of a reduction in CO_2-emissions. However, such a tax would be difficult to administer, since no independent air quality monitoring system exists in South Africa, and emissions are not accounted for on a regular basis.

The second scenario is, administratively, relatively easy to implement: namely a fuel tax of 4,330 R/TJ, 2,337 R/TJ, and 2,454 R/TJ on the final consumption of coal, crude oil and gas, as well as petroleum. This tax is calculated as the carbon tax (35 R/tonCO_2) multiplied by the carbon content per energy unit of the fuels (124, 67, and 70 tons CO_2/TJ, respectively). Under this scenario the intermediate consumption of coal, crude oil and gas, and petroleum products are taxed, as well as the household consumption of petroleum. This tax has a narrower base than the carbon-tax, since the energy loss from converting coal to petroleum is excluded from the base. A difficulty that arises is that petroleum from crude oil and petroleum from coal are perfect substitutes for each other; the former is produced with a fairly clean technology, while the latter is very dirty. We have not succeeded in taxing them at different rates.

In scenario three, a tax is levied on all intermediate and household consumption of electricity. Several studies have been conducted to estimate the global damage cost of greenhouse gas emissions related to electricity generation (for a summary of these, see Blignaut and Zunckel 2004: 298-303). These studies conclude that the global damage cost is between R20 (approximately USD 3) and R80 (approximately USD 11) per ton of CO_2, and translates to between R0.01/kWh and R0.04/kWh of electricity consumption (Blignaut and Zunckel 2004: 302). In this paper, the impact of a tax equal to R38/MWh is modelled and calculated in the same way as scenario two, namely as the carbon tax (35 R/ton CO_2) multiplied by the average carbon dioxide emissions per electricity output (1.095 ton CO_2/MWh). In SI units, the tax level is equivalent to an electricity tax of 10,651 R/TJ, using the conversion of 1MWh = 0.0036TJ. The gap between the electricity tax and the fuel tax levels is due to the conversion losses when fuels are converted to electricity.

Lastly, in scenario four, a tax is levied on intermediate and household consumption of energy[7] – a combination of scenarios two and three, but in SI units. This tax is comparable to scenario one (except for the exclusion of the conversion losses from coal to petroleum which accounts for approximately 10 per cent of the emissions), but based on the consumption of energy and not the level of emissions itself.

Recycling schemes

Three recycling schemes are analysed, namely: (i) a decrease in direct tax, (ii) a decrease in indirect tax, and (iii) a decrease in taxes on food. These recycling schemes are as politically sensitive as the respective tax instruments discussed above. The chamber of business in South Africa prefers the reduction of direct taxation (which is progressive), while the labour unions prefer a reduction in indirect taxes (which is regressive). All households, however, would benefit from a reduction in food prices.

The first recycling scenario implies a reduction in capital and labour taxes. The second scenario implies a reduction in the general value added tax (VAT) rate, while the third scenario is a reduction in the VAT-rate on food. All three scenarios would be simple to administer.

Target variables

Four target variables are calculated by the model, and utilised as instruments to guide our policy conclusions, namely (i) CO_2 emissions, (iia) GDP, (iib) employment, and (iii) total consumption by the poor. All the target variables are expressed in 'per unit of government revenue', so that different policy scenarios could be compared to each other. Therefore, the target variables presented in the next section are:

(i) The change in Gg CO_2 per billion Rand government revenue;
(iia) The percentage change in real GDP per million Rand;
(iib) The percentage change in total employment per billion Rand; and
(iii) The percentage change in total consumption by the poorest household group per billion Rand, by ethnic group.

These target variables have been specifically chosen since they reflect the elements necessary to ascertain whether energy related environmental taxes would yield various economic/environmental dividends if recycled through the economy. Furthermore, changes in these variables would also reflect the much-needed structural changes to address the specific peculiarities of the country's "double-decker" economy referred to earlier.

5. Results

Overview of results

Table 3 provides a summary of model results of the environmental tax simulations and recycling schemes. In brief, two forces are at play in the model when new environmental taxes are levied: (i) taxes increase the cost of production and therefore decrease the

7 Since poor households consume coal for basic energy purposes, we exclude them from the tax on coal – they only pay the environmental tax on petroleum products and electricity.

supply of most commodities, while (ii) the increase in government revenue without an accompanying increase in government spending decreases overall demand. With supply being very inelastic (as a result of inelastic capital supply as well as supply of skilled labour), the fall in demand causes a significant fall in price levels, and only a small decrease in real GDP. The fall in domestic prices causes increased exports of most commodities, and even coal, which is not the most desirable result in the context of the goals of the tax policies. Equilibrium levels of household consumption and imports fall. The recycling schemes have similar effects, with opposite signs.

Table 3 Results of key variables from the modelling simulations.

	Environmental tax				Recycling scheme		
	CO2	Fuel	Electricity	Energy	Dir tax	VAT	Food
Percentage change in							
Real total consumption	-1.680	-0.714	-1.017	-1.728	0.963	0.372	0.893
Investment	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Government expenditure	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Exports	2.596	0.887	1.608	2.466	-1.724	-0.647	-1.411
Imports	-0.930	-0.595	-0.563	-1.140	0.436	0.165	0.477
Real GDP	-0.201	-0.093	-0.113	-0.213	0.084	0.037	0.104
Consumer price index	-1.410	-0.791	-1.045	-1.788	0.980	-0.117	-0.353
Investment price index	-1.085	-0.518	-0.721	-1.210	0.381	0.141	0.252
Government price index	-2.490	-1.218	-1.661	-2.822	0.712	0.255	0.485
Export prices	-0.511	-0.176	-0.319	-0.486	0.349	0.130	0.285
Import prices	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GDP deflator	-1.732	-0.876	-1.196	-2.020	0.913	0.036	-0.065
Nominal exchange rate	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Unskilled employment	-0.824	-0.384	-0.537	-0.926	0.359	0.181	0.517
Skilled employment	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Intermediate prices of							
Agriculture	-1.043	-0.493	-0.783	-1.246	0.628	0.225	0.853
Coal	-0.859	-0.428	-0.440	-0.849	0.140	0.051	0.085
Other Mining	-0.159	-0.131	0.060	-0.065	0.065	0.022	0.037
Crude Oil and Gas	-3.668	-1.900	-0.535	-2.438	0.222	0.083	0.111
Food	-1.702	-0.822	-1.118	-1.893	0.954	0.350	1.877
Petroleum	0.565	0.048	-0.458	-0.381	0.465	0.174	0.249
Iron and Steel	1.509	2.005	0.912	2.997	0.201	0.075	0.121
Other Manufacturing	-0.943	-0.448	-0.539	-0.957	0.412	0.151	0.259
Electricity	11.770	-1.871	-4.824	-6.549	0.886	0.359	0.588
Transport Services	-1.375	-0.670	-1.019	-1.644	0.694	0.266	0.409
Other Services	-2.562	-1.286	-1.685	-2.909	1.133	0.433	0.681
% change in production of							
Agriculture	-0.035	-0.017	0.025	0.004	0.168	0.073	0.331
Coal	0.908	0.517	0.517	1.011	-0.413	-0.145	-0.266
Other Mining	0.692	0.648	-0.398	0.226	-0.317	-0.108	-0.193
Crude Oil and Gas	-1.011	-0.585	0.407	-0.188	-0.149	-0.052	-0.102
Food	-0.194	-0.077	-0.164	-0.240	0.310	0.120	1.136
Petroleum	-2.198	-1.181	0.038	-1.153	-0.013	-0.003	-0.022
Iron and Steel	-5.347	-7.379	-3.280	-10.603	-0.985	-0.367	-0.652
Other Manufacturing	0.736	0.327	0.352	0.663	-0.189	-0.069	-0.166
Electricity	-4.942	-0.378	-2.239	-2.626	0.200	0.093	0.119
Transport Services	-0.270	-0.231	-0.013	-0.252	0.203	0.096	0.152
Other Services	-0.043	-0.046	-0.030	-0.076	0.123	0.051	0.085

First dividend: environmental effects

For each target variable, scenarios are interpreted in terms of changes in the target variable, divided by changes in the overall tax revenues, in real terms. For the first dividend, the CO_2 emission reductions, we calculate the change in emissions divided by the change in total tax revenues for all four climate change tax instruments and for the three recycling schemes. These numbers are presented inTable4. We see that a carbon tax reduces CO_2-equivalent emissions by 1.051 Gg CO_2 per billion Rand increased tax revenue. Recycling the extra tax revenues through an indirect tax break increases emissions by 0.048 Gg CO_2 per billion Rand tax revenue. Thus, together, the combination of the two policies reduces emissions by 1.003 Gg CO_2 per billion Rand tax revenue that is recycled. The first dividend materializes. This is not too surprising; replacing a broad tax scheme by a specific environmental tax usually lowers the environmental burden.

Table 4 Marginal change in CO_2-equivalent emissions, and an indication of scenarios that result in a CO_2 dividend (numbers present change in CO_2 emissions in Gg CO_2 per billion Rand tax revenue).

		Recycling scheme		
		Direct tax break	Indirect tax break	Food tax break
Environmental tax		0.025	0.048	0.019
Carbon tax	1.051	+	+	+
Fuel tax	0.610	+	+	+
Electricity tax	0.787	+	+	+
Energy tax	0.714	+	+	+

The production of industries that are targeted by the tax decline the most, namely the production of industries combusting the most fuels. The most severely affected industries are Iron and Steel, Electricity, Petroleum Refineries, and Crude Oil and Gas. The climate change policy does not result in reduced production for the coal industry. On the contrary, production increases due to an increase in exports. This actually happens with all four environmental tax scenarios.

The marginal change in CO_2-equivalent emissions per Rand is larger for the carbon tax, since it incorporates all emissions (including the conversion related emissions), while the fuel tax does not. A large quantity of energy is lost in the ‘petroleum from coal’ process, which is not taxed with the fuel tax. This explains the lower value for the fuel tax. The electricity tax is much higher in absolute terms, to allow for the fact that some emissions are not included. However, its effect is similar to that of the fuel tax, because demand for electricity is inelastic. The energy tax is just a combination of the fuel and electricity taxes, and hence of the same magnitude as these two.

Second dividend: GDP and employment effects

The typical second target variable studied in the double dividend literature is GDP, or output. The change in GDP divided by the change in total tax revenues is referred to as the ‘marginal excess burden’ (MEB) of a tax, or, alternatively:

MEB = change in real GDP/change in real government income[8] (3)

For our analysis we use this variable more generally, and calculate the marginal excess burden for the carbon tax, the fuel tax, the energy tax, the electricity tax, and the three recycling tax schemes. By comparing MEBs of different scenarios, we find combinations of scenarios that produce a second dividend, i.e. an increase in GDP while maintaining total government revenues as constant.

Table 5 presents the MEBs for GDP, and lists the consequences of all scenario combinations. The four environmental tax instruments are associated with losses of GDP per change in real government revenues of 0.141, 0.148, 0.145, and 0.152 for the carbon tax, fuel tax, electricity tax, and energy tax respectively. These numbers should be interpreted as follows: When a carbon tax is levied such that government revenues increase by 1 million Rand, then real GDP decreases by 141 thousand Rand. Similarly, the MEBs are calculated for the recycling schemes, producing values of 0.101, 0.136, and 0.155 for the direct tax break, indirect tax break, and food tax break respectively. We conclude, for example, that the combination of a carbon tax with a direct tax cut, maintaining constant total tax revenues, decreases GDP slightly. This is marked with a '–' in the table. Also, when we recycle the carbon tax revenues through an indirect tax cut, net GDP decreases slightly.

Table 5 Marginal excess burdens of different tax instruments, for GDP, and an indication of scenarios that result in a GDP dividend.

		Recycling scheme		
		Direct tax break	Indirect tax break	Food tax break
Environmental tax		0.101	0.136	0.155
Carbon tax	0.141	–	–	+
Fuel tax	0.148	–	–	+
Electricity tax	0.145	–	–	+
Energy tax	0.152	–	–	+

The reduction in taxes on food consumed by households increases GDP more than the reduction experienced when levying a carbon tax. This is marked with a '+' in the table, signalling a positive dividend for the specific policy combination. Table 5 shows that all four environmental taxes are more distortionary than a general direct or indirect tax, which makes these two recycling schemes ineffective in combination with the environmental taxes. However, as long as the revenue is recycled through a decrease in taxes on food, it doesn't matter which one of the environmental taxes is implemented, a double dividend will be found.

Employment and GDP are closely linked in the model, as low-skilled labour is the production factor with the highest elasticity of supply. Qualitatively, the employment effects are very similar to the GDP measure given in the MEBs of Table5. We calculated the percentage change in employment per one billion Rand change in real government revenue for each of the seven tax regimes. Comparing the effects of the environmental taxes with the effects that the three means of recycling would have, we find slightly different results than in Table 5.

[8] For readers familiar with MCPF (marginal cost of public funds): the MCPF is equal to 1+ MEB.

Table 6 Marginal change in employment (number of employed people per billion Rand tax revenue), and an indication of scenarios that result in an employment dividend.

		Recycling scheme		
		Direct tax break	Indirect tax break	Food tax break
Environmental tax		0.0143	0.0221	0.0257
Carbon tax	0.0196	–	+	+
Fuel tax	0.0206	–	+	+
Electricity tax	0.0234	–	–	+
Energy tax	0.0225	–	–	+

A double dividend is found for all tax combinations that include recycling through a food tax break, as well as for some combinations with an indirect tax break. According to the double dividend literature, this would happen if (i) employment of unskilled labour[9] increases through the recycling scheme or if (ii) capital[10] is complementary to energy in the model, even though fixed. Both of these are true in the model, and tie in with reasonable assumptions about the situation ‘on the ground’ in South Africa, so that we are not surprised to see the double dividend here. The two industries most affected by the environmental tax are iron and steel, and electricity, both very capital intensive in nature. The average real wage paid by producers decreases where we have a + in Table 6, indicating that employment of unskilled labour increases.

The carbon tax proves to be the least distortionary tax, with the lowest MEB. Its base is the broadest, including the emissions related to petroleum from coal. Likewise, the fuel tax is less distortionary than the tax on electricity. Not all fuel is produced from coal, while almost all electricity is. The latter production process involves more emission losses, and hence provides a narrower base for taxation. In terms of the MEBs in Table 5, the two policies with slightly fewer positive effects on GDP (namely on fuel and electricity), render some weighted average of their MEBs when combined on energy.

The indirect tax break is more distortionary than the direct tax break in terms of both GDP and employment. Usually a VAT is expected to be less distortionary than direct taxes, because it excludes investment and exports, and thus stimulates them. However, in our short run, closure investment is exogenous, and therefore not stimulated. The tax base is restricted to household expenditure, a much narrower base than that of the direct tax, which includes total GDP from the income side.

The tax break on food has the highest MEB, and this could have a number of explanations: (i) Consumption by households is a function of post-tax wages received by them. These wages increase with both the general indirect and food tax breaks, which increases real consumption by households. Since only unskilled labour is flexible, and their major consumption basket contains much food, the food tax break increases GDP more than the general tax break. (ii) The food tax break increases demand for food; the food industry has high inputs from agriculture, which uses relatively more unskilled labour. Total agricultural production increases with this scenario.

9 The elastic factor of production.

10 The inelastic factor of production.

Third dividend: Effects on poverty

In this section we discuss the effects of the various policy scenarios on consumption of households. There are twelve household income groups in the model and the results are shown for the poorest income group, and four race groups, namely Africans (a), Coloureds (c), Indians (i) and Whites (w). We analyse the impact of policies on income distribution by considering racial disparities, because, even though average income statistics imply that South Africa is a middle-income country, most of the population experience serious absolute poverty or are vulnerable to poverty (May 2000; Klasen 2000; Woolard 2002). Poverty levels in South Africa are highest within African and Coloured race groups. In 1995, 61% of Africans, 38% of Coloureds, 5% of Indians and 1% of Whites were classified as poor (May 2000). Aliber (2002) quoting Schlemmer's work based on the All Media and Products Surveys (AMPS) shows that overall poverty has been increasing since 1993. A poverty line of R400 in 1989 Rand prices was used. Furthermore, the data also shows that Africans and Coloureds have been the worst affected in terms of increasing poverty over the years. The table below shows this evidence.

Table 7 Proportion of households below poverty line, by year and population group.

	Africans	Coloureds	Indian	White
1989	51%	24%	6%	3%
1993	50%	26%	8%	3%
1996	57%	22%	9%	3%
1997	55%	21%	6%	4%
2001	62%	29%	11%	4%

Source: Aliber quoting Schlemmer 2002: 3.

Table 8 shows the results of the calculations of the percentage change in real consumption per unit of change in real government revenue. Two results stand out from the table: 1) A fuel tax seems to have more positive results than other environmental taxes. 2) A food tax has only positive results and it does not matter which environmental tax is levied, as long as recycling takes place through a food tax break, consumers benefit. Poor consumers spend most of their consumption basket on food, so this result is to be expected.

The results in the table show that the poorest household group would generally prefer a fuel tax to a carbon tax, as well as an electricity tax.

A carbon tax affects electricity prices severely, which provides a common explanation: food uses more electricity than fuel as a source of energy, so an electricity tax leads to a higher price increase of food than a fuel tax.

To verify the robustness of our results, we also calculated the potential for a double dividend for the three poorest household groups, as opposed to only the poorest group. The results show the same signs as the results shown here for the poorest household group.

Table 8 Marginal change in poverty (change in real consumption of poorest household groups per billion Rand tax revenue), and an indication of scenarios that result in a poverty dividend.

			Recycling scheme	
		Direct tax break	Indirect tax break	Food tax break
Environmental tax		a=0.066	a=0.091	a=0.359
		c=0.075	c=0.099	c=0.391
		i=0.060	i=0.082	i=0.338
		w=0.065	w=0.097	w=0.299
Carbon tax	a=0.126	–	–	+
	c=0.113	–	–	+
	i=0.077	–	+	+
	w=0.230	–	–	+
Fuel tax	a=0.081	–	+	+
	c=0.075	0	+	+
	i=0.069	–	+	+
	w=0.083	–	+	+
Electricity tax	a=0.165	–	–	+
	c=0.122	–	–	+
	i=0.080	–	+	+
	w=0.266	–	–	+
Energy tax	a=0.129	–	–	+
	c=0.102	–	–	+
	i=0.076	–	+	+
	w=0.186	–	–	+

a = African, c = coloured, i = Indian, w = white.

Reaping the dividends

A summary of the simulation results is given in Table 9. Since all tax instruments studied are tailored towards curbing greenhouse gas emissions, they all contribute to the first environmental dividend. Only the policy combination that involves a recycling scheme through a cut in taxes on food achieves a double dividend - an increase in GDP and employment per unit of government revenue. The poverty dividend is always reaped through a food tax break, and through a fuel tax that is recycled through an indirect tax break.

Tabel 9 Summary of dividends (greenhouse gas emissions, GDP and employment, and poverty).

		Recycling scheme	
Environmental tax	Direct tax break	Indirect tax break	Food tax break
Carbon tax	+ – –	+ – –	+ + +
Fuel tax	+ – –	+ – +	+ + +
Electricity tax	+ – –	+ – –	+ + +
Energy tax	+ – –	+ – –	+ + +

6. Conclusion

In this paper we calculated the values of three key variables for four environmental tax scenarios and three recycling schemes. We are now ready to choose one combination of these that would be best for South Africa, from the summary of dividends in Table 9.

The choice of environmental tax lies between a carbon tax and a fuel tax. Both render triple dividends with a tax break on food. The carbon tax has a much stronger environmental effect than a fuel tax[11], because all emissions related to the conversion of fuels into energy is included in the tax base, while they are excluded from the fuel tax base. Also, the carbon tax has a lower GDP and employment cost[12] for the same reason. The fuel tax is slightly better for poverty reduction, since it renders the poverty dividend through a general decrease in indirect taxes to households as well.

The direct tax break is not suitable for South Africa, because it does not render a second nor a third dividend with any environmental tax. The direct taxes have smaller GDP and employment effects than any of the environmental taxes, because both capital and skilled labour have inelastic supply characteristics.

Both the indirect and food tax breaks render triple dividends if combined with a fuel tax. If the three target variables have to determine which one of the two recycling schemes is better, the food tax break renders better results. The environmental effects of both tax breaks are minute. However, the food tax break gives much larger GDP and employment dividends, because the base is much narrower than a general indirect tax on all commodities. Also, since the consumption basket of the poor includes a very large proportion of food, a tax break on food has a marked influence on the quantities of all commodities they consume.

We conclude that the best policy combination for a cleaner environment, as well as poverty alleviation, would be a carbon tax, recycled through a decrease in taxes on food.

References

Abdi, T. & Edwards, L. (2002). *Trade, technology and wage inequality in South Africa*. University of Cape Town: DPRU working paper.

Adams, P. (2003). *Interpretations of Macroeconomic Results from a CGE Model such as GTAP*. Paper Delivered at the 6th Annual Conference on Global Trade and Policy Analysis, The Hague, Netherlands.

Aliber, M.A. (2002). *Overview of the Incidence of Poverty in South for the 10-year review.* Paper commissioned by the President's office.

Black, P. & Rankin, N. (1998). On the Cost Increasing Effects of the new Labour Laws in South Africa. *The South African Journal of Economics, 66*(4), 452-463.

Blackman, A. (1999). *The Economics of Technology Diffusion: Implications for Climate Change Policy in Developing Countries*. Resources for the Future: Working Paper: 99-42.

Blignaut, J.N., Mabuga, R. & Chitiga-Mabugu, M.R. Under review. Calculating a greenhouse gas emissions database using energy balances: the case of South Africa 1998. *Journal of energy in southern Africa*.

---

[11] See Table 3.

Blignaut, J.N. & De Wet, T. (2001). Some recommendations towards reducing electricity consumption in the South African manufacturing sector. *South African Journal of Economic and Management Sciences, 4*(2), 359-379.

Blignaut, J.N. & De Wit, M.P. (2004). *Sustainable Options*. Cape Town: UCT Press.

Blignaut, J.N. & Zunckel, M. (2004). The cost of a decline in air quality. In Blignaut, J.N. & De Wit, M.P. (eds.), *Sustainable options*. Cape Town: UCT press.

Bosello, F., Carraro, C. & Galeotti, M. (2001). The double dividend issue: modelling strategies and empirical findings. *Environment and Development Economics, 6*, 9-45.

Bosquet, B. (2000). Environmental tax reform: does it work? A survey of the empirical evidence. *Ecological Economics, 34*(1), 19-32.

Bossier, F. & Brechet, T. (1995). A fiscal reform for increasing employment and mitigating CO_2 emissions in Europe. *Energy Policy, 23*(9), 789-798.

Bovenberg, A.L. (1999). Green tax reforms and the double dividend: an updated reader's guide. *International Tax and Public Finance, 6*, 421-443.

Bovenberg, A.L. & De Mooij, R.A. (1994). Environmental levies and distortionary taxation. *American Economic Review, 84*(4), 1085-1089.

Bovenberg, A.L. & Goulder, L.H. (1997). Costs of environmentally motivated taxes in the presence of other taxes: General equilibrium analyses. *National Tax Journal, 50*(1), 59-87.

Bovenberg, A.L. & Van der Ploeg, F. (1996). Optimal taxation, public goods and environmental policy with involuntary unemployment. *Journal of Public Economics, 62*(1-2), 59-83.

Bovenberg, A.L. & Van der Ploeg, F. (1998). Consequences of environmental tax reform for unemployment and welfare. *Environmental & Resource Economics, 12*(2), 137-150.

Bye, B. (2000). Environmental tax reform and producer foresight: an intertemporal computable general equilibrium analysis. *Journal of Policy Modeling, 22*(6), 719-752.

Carraro, C. & Soubeyran, A. (1995). Taxation and Employment in a Multi-Sector General Equilibrium Model. In Carraro, C.; Siniscalco, D. (Eds.)*, Environmental fiscal reform and unemployment*, Boston: Kluwer, pp 3-52.

Cooper, C.J. (1998). *Digest of South African Energy Statistics*.

De Wet, T.J. (2003). *The effect of a tax on coal in South Africa: A CGE analysis,* Ph.D. Thesis, University of Pretoria, http://upetd.up.ac.za/thesis/available/etd-06302004-143319.

Department of Minerals and Energy (DME) (2000). *Energy balance for South Africa: 1998*. Pretoria: DME.

Dias, R. (2002). Exploring the Nature of Unemployment in South Africa: Insights from the Labour Force Survey 2000. *Unpublished Paper Presented at the Development Policy Research Unit's 2nd Annual Conference on Labour Markets and Poverty in South Africa*.

Dixon, P.B., Parmeter, B.R. Sutton, J. & Vincent, D.P. (1982). *ORANI: A Multisectoral Model of the Australian Economy*, Nort-Holland, Amsterdam.

Edwards, L. (2001). Globalisation and the skill bias of occupational employment in South Africa. *South African Journal of Economics, 69*(1), 40-71.

Fourie, F.C. & Owen, A. (1993). Value-added tax and regressivity in South Africa. *South African Journal of Economics, 61*(4), 281-300.

Fullerton, D. & Metcalf, G.E. (1997). *Environmental Taxes and the Double Dividend Hypothesis: Did you Really Expect Something for Nothing*? National Bureau of Economic Research (NBER): Working paper number w6199.

---

[12] See Tables 4 and 5.

Goulder, L.H., Parry, I.W.H., Williams, R.C. & Burtraw, D. (1999). The cost-effectiveness of alternative instruments for environmental protection in a second-best setting. *Journal of Public Economics, 72*(3), 329-360.

Goulder, L.H. (1994). *Environmental taxation and the "double dividend": A reader's guide*. NBER working papers: w4896.

Goulder, L.H. (1995). Effects of carbon taxes in an economy with prior tax distortions: an intertemporal general equilibrium analysis. *Journal of Environmental Economics and Management, 29*, 271-297.

Goulder, L.H., Parry, I.W.H. & Burtraw, D. (1997). Revenue-raising versus other approaches to environmental protection: the critical significance of pre-existing tax distortions. *The RAND Journal of Economics, 28*(4), 708-731.

Harrison, W.J. & Pearson, K.R. (1996). Computing solutions for large general equilibrium models using Gempack. *Computational Economics, 9,* 83-127.

Horridge, M. (2002). *ORANI-G: A Generic Single-Country Computable General Equilibrium Model*. Edition prepared for the Practical GE Modelling Course, June 17-21, 2002.

International Energy Agency (2001). *Key World Energy Statistics*.

Jaffe, A. & Palmer, K. (1997). Environmental Regulation & Innovation: A Panel Data Study. *Review of Economics and Statistics, 79*(4), 610-619.

Jaffe, A., Newell, R. & Stavins, R. (2000). *Technological Change and the Environment*. National Bureau for Economic Research: Working Paper No 7970.

Jorgenson, D.W. & Wilcoxen, P.J. (1993). Reducing US carbon emissions: An econometric general equilibrium assessment. *Resource and Energy Economics, 15,* 7-25.

Kingdon, G. & Knight, J. (2001). *Race and Incidence of Unemployment in South Africa*. Centre for the Study of African Economies, Department of Economics, Oxford.

Kingdon, G. & Knight, J. (2001). *Unemployment and wages in South Africa: A spatial approach.* Centre for the Study of African Economies, Department of Economics, Oxford.

Kingdon, G. & Knight, J. (2001). *Unemployment in South Africa: the nature of the beast.* Centre for the Study of African Economies, Department of Economics, Oxford.

Klasen, J. (2000). Measuring Poverty and Deprivation in South Africa. *Review of income and wealth, 46*(1), 33-58.

Lanjouw, J. & Mody, A. (1993). *Stimulating Innovation and the International Diffusion of Environmentally Responsive Technology: The Role of Expenditures and Institutions*. Mimeo.

May, J. (ed) (2000). *Poverty and Inequality in South Africa, meeting the challenge.* Cape Town and London: David Phillip and Zeb Press.

National state of the Environment Report – South Africa (2003). Climatic and Atmospheric Change. *National state of the Environment Report.*

Opschoor, H. (2001). Economic Growth, the Environment and Welfare: Are They Compatible? In Renaldo Seroa da Motta (ed), *Environmental Economics in Developing Countries*. UK: Edward Elgar Publishing Limited.

Parry, I.W., Williams, R.C. & Goulder, L.H. (1999). When Can Carbon Abatement Policies Increase Welfare? The Fundamental Role of Distorted Factor Markets. *Journal of Environmental Economics and Management, 37*, 52-84.

Parry, I.W.H. (1997). Environmental taxes and quotas in the presence of distorting taxes in factor markets. *Resource and Energy Economics, 19*(3), 203-220.

Sandor, R. (2001). How I see it: The Case for Coal. *Environmental Finance*. March, 12.

South African Reserve Bank. *Quarterly Bulletin*. Pretoria: South African Reserve Bank.

Sparks, A. (2003). *Beyond the Miracle. Inside the New South Africa*. Cape Town: Jonathan Ball.

SSA (Statistics South Africa) (2001). *Social Accounting Matrix 1998*. Pretoria: Statistics South Africa.

UNDP (2003). *South Africa Human Development Report 2003*. Cape Town: Oxford University Press.

Woolard, I. (2002). *An overview of Poverty and inequality in South Africa.* Working paper prepared for Department for International Development (DFID) (SA).

World Bank. (2003). *The little green data book.* World Bank: Washington DC.