REDISTRIBUTING ENVIRONMENTAL TAX REVENUE TO REDUCE POVERTY IN SOUTH AFRICA: THE CASES OF ENERGY AND WATER

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Abstract

South Africa, as an upper middle-income, resource-intensive developing country with an open economy, has to find innovative ways to combat poverty, promote economic growth and reduce the intensity of resource use, simultaneously. One option is to explore the plausibility of achieving a double dividend by levying a tax on water and energy and recycling the revenue back to the economy by allowing for a reduction in other forms of taxation. According to the double dividend theory it is possible, under some conditions, to achieve both environmental and economic objectives. We investigated such a possibility in the South African economy using an integrated economy/environment CGE model and found that it is indeed possible to achieve such double dividend benefits. Given the prevailing economic and environmental contexts, government should actively search for ways to achieve such dividends.

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1
Introduction

South Africa, as an upper middle-income, resource-intensive developing country with an open economy, has to find innovative ways to combat poverty, promote economic growth and reduce the intensity of resource use simultaneously. The double dividend theory

has been a popular research theme for at least 15 years, following papers by Pearce (1991) and Bovenberg and De Mooij (1994)[1]. The main reason for this popularity is its seeming promise of a free ride: environmental taxes could diminish pollution at no costs or even lead to additional benefits, if the revenues of the tax are used to reduce other distortionary taxes, for instance on labour or capital. These

additional benefits – the second dividend – are usually an increase in welfare or GDP, or a decrease in unemployment[2]. In this study, our focus is on GDP and poverty. In South Africa the latter is not linked to employment in general, but to employment of the poor and prices of commodities bought by poor households specifically. We carry out an empirical analysis using a CGE model to calculate the potential for a triple dividend – an environmental, economic (GDP) and poverty dividend.

The question that is posed in this paper is whether there is empirical support for the possibility of double (or even triple) dividends concerning specific environmental tax reform initiatives relating to the energy and water sectors. To give effect to this question, the next section provides a brief synopsis of the South African economy, followed by a discussion of the literature concerning double dividends. This is followed by a description of the model used to test for such a dividend in South Africa, the data and empirical results. The paper is concluded by two policy recommendations.

2
Background

Since South Africa's first democratic elections in 1994 the GDP/capita has been growing positively for the first time since the early 1980s. Unfortunately the growth in GDP/capita has not led to an improvement in income distribution. In 1998 the Gini-coefficient was 0.56, it deteriorated to 0.59 in 2004, with an unemployment rate of between 25 and 40 per cent (Statistics South Africa, 2004). Consequently, a large percentage of the population (between 45 and 55 per cent) lives in poverty (Committee of Inquiry into a Comprehensive Social System for South Africa, 2002).

Additionally, South Africa has a resource extraction economy that is heavily dependent on mining, agriculture and manufacturing, even though the combined contribution of the former two sectors to GDP is less than 10 (South African Reserve Bank, Q*uarterly Bulletin*). These sectors are the major employers and they generate much economic activity, through electricity generation and fuel production from coal. Therefore, although being a developing country, South Africa's electricity consumption (93 per cent of which is coal based) is 3.8 megawatt hours (MWh) per capita compared to 1.3 MWh for other lower-middle-income countries and 2.5 MWh for upper-middle-income countries. The country's carbon-dioxide emissions lie between that of upper-middle-income and high-income countries at 7.4 (metric) tonnes (t) carbon dioxide (CO_2) per capita.

South Africa had 44 million people in 1998 and a total water inflow of 65.3 million m^3, therefore the number of people per flow unit is 1 481, or 982 m^3 per capita per annum (World Bank, 2005). Not only does South Africa have a disproportionately high carbon footprint, the country has a chronic water scarcity as well, as indicated in Table 1. To address this water scarcity problem in the past, South Africa resorted to the development of new water sources. This option is no longer feasible and government has embarked on a programme to reduce water consumption using other mechanisms, such as water pricing (DWAF, 1998 and 2002).

Table 1

Categories of water scarcity associated with varying levels of water supply per person per year, the typical scales of problems encountered in each category in Africa

Water scarcity category and associated problems	Original index: number of people per flow unit (million m3)	Modified index: volume of water available per person (m3 person year)
Beyond the "water barrier": continual, wide-scale water supply problems, becoming catastrophic during droughts.	> 2000	< 500

Chronic water scarcity: continual water supply problems, worse during annual dry seasons, frequent severe droughts (**South Africa falls in this category**)	1000 –2000	500 – 1000
Water stressed: frequent seasonal water supply and quality problems, accentuated by occasional droughts.	600 – 1000	1000 – 1666
Moderate problems: occasional water supply and quality problems, with some adverse effects during severe droughts.	100 – 600	1666 – 10 000
Well-watered: very infrequent water supply and quality problems, except during extreme drought conditions.	< 100	> 10 000

Source: Ashton (2002)

South Africa's economy is currently growing strongly, but the growth in the commercial sector is not directly benefiting the unemployed and the poor through more commercial opportunities for them. Moreover, this growth depends significantly on the resources (water and energy) sectors. The country is seeking innovative ways to grow; ways that will benefit the poor and reduce the impact of such growth on the environment. In the following section we explore international literature concerning double dividend, in anticipation of finding such dividend in South Africa pertaining to the energy and water sectors.

3
Double dividend

The paper by Bovenberg and De Mooij (1994) is a good example of earlier papers in which relatively simple CGE models are used to prove that double dividends are unlikely to materialise. These earlier papers only incorporate one factor of production, namely labour. An environmental tax is then really just an implicit tax on labour and leads to a decrease in labour supply. The recycling of revenues through lower labour taxes only partly compensates for the lower 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 the demand for the dirty good[3]. This is, of course, the intention of the environmental tax reform. However, Bovenberg and De Mooij 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 welfare. These results are corroborated in other papers, which similarly use only one factor of production (Fullerton & Metcalf, 1997; Goulder *et al.*, 1997).

In later papers, the introduction of more than one production factor (capital) enhances the scope for a double dividend because it allows the possibility of inefficiencies in the tax system[4]. These inefficiencies occur when the marginal efficiency costs of taxation are not the same for all production factors, i.e. one of the factors is over-taxed relative to the other[5]. By shifting the tax burden from the over-taxed to the under-taxed factor, efficiency can be increased and the total costs of taxation reduced. A double dividend becomes possible when an environmental tax reform induces such a shift. Conditions for this route to a double dividend are: (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 (Goulder, 1994).

Results from papers using more than one factor of production are mixed. Goulder (1995) and Bovenberg and Goulder (1997) study the results of a revenue neutral environmental tax reform for the United States with an inter-temporal CGE analysis and find no double dividend. On the other hand, Jorgenson and Wilcoxen (1993), who also use a model for the US, find a double dividend when they lower capital taxes with the revenues of a carbon tax, but it does not materialise if labour taxes are cut instead. This agrees with the general notion that the marginal efficiency costs of capital taxation in the US are higher than those of labour. 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 Goulder and 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, which increases the marginal costs of taxation of capital. Bye (2000) also finds a double dividend in a CGE model of the Norwegian economy. Norway is a small open economy characterised by a particularly high marginal excess burden of labour taxation. The double dividend occurs when the revenues from a carbon tax are used to lower payroll taxes.

Overall, the literature concludes that the correct tax reform would reduce environmental emissions while stimulating economic growth and employment. This would be the case if the environmental tax reform reduces the overall level of distortion of the economy, and this depends on the state of the economy, the pre-existing tax system, and the details of the reform. That is, environmental tax reforms need to be smart to yield a double dividend. This is already true in the simplified representation of the economy and tax system used in models. In reality, environmental tax reform should be very clever indeed.

Based on these previous studies, we can say that the attainment of a double dividend in South Africa will depend mainly on the current inefficiencies in the tax system, and how these are influenced by the environmental tax reform. Concerning the elasticity of capital

and labour supply, saving rates in South Africa are low, and capital formation depends to a large extent on foreign capital inflow. The capital supply is therefore 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 are very high. 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. Therefore, a double dividend is most likely to occur if the environmental taxes fall mostly on capital and skilled labour, and the tax revenues can be used to increase the demand for unskilled labour.

4
Philosophy of double dividends with energy and water

The typical second target variable studied in the double dividend literature is real GDP. The decrease in GDP that results from an increase of R1,00 in total tax revenue is referred to as the marginal excess burden (MEB) of a tax, that is:

MEB = decrease in real GDP/increase in real government income[6]

Conversely, when a tax is reduced, as under the recycling schemes, the MEB measures the increase in GDP per decrease in total tax revenues. The MEB is a measure of the distortionality of a tax. As both the numerator and the denominator have the same unit of measurement (rand), the MEB measure is without dimension. 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 constant.

The third dividend in this study is poverty reduction. We define the marginal poverty burden (MPB) as:

MPB =   decrease in real income of the poorest households/increase in real government income

As GDP is our income measure, MPB has the same properties as MEB. Indeed, MEB is the weighted average of the MEB per income class, while the MPB is the same, but then with zero weights for the higher incomes.

Could appropriate ways of recycling revenue from energy and/or water-related environmental taxes result in double or triple dividends? We implement a CGE model to calculate and compare the marginal excess burdens of energy- and water-related environmental taxes with the MEBs of recycling the revenue, in order to find possible double or even triple dividends.

4.1 Tax instruments for carbon reduction

Four policy simulations are run to analyse the effects of various environmental tax instruments related to CO_2 reduction, namely (i) a carbon tax, (ii) a fuel tax, (iii) an electricity tax and (iv) an energy tax.

The carbon tax implies a levy of R35 per tonne CO_2[7], which is approximately equivalent to 5 USD/tonne CO_2[8], based on the conservative estimate of Sandor (2001)[9]. Such a tax would capture all emissions from burning fossil fuel at the point of combustion and is applied to the CO_2-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 (Van Heerden *et al*., 2006). (Note that emissions from burning biomass - mostly firewood gathered by households - are not taxed.)

The fuel tax is relatively easy to implement, since it excludes coal used in electricity and gasoline production. It amounts to a 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, and gasoline. The tax is calculated as the carbon tax (35 R/tonne CO_2) multiplied by the average

carbon content per energy unit of the fuels (124. 67, and 70 tonne CO_2/TJ, respectively). The industrial use of coal, crude oil and gas, and petroleum products is taxed, as well as the household consumption of petroleum products (Van Heerden *et al*., 2006).

In scenario three a tax is levied on all intermediate and household consumption of electricity. The tax per MWh is again based on a carbon tax of 35 R/tonne CO_2, using conversion factors from Blignaut and Zunckel (2004: 298-303). 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 (in rand per energy unit) is due to conversion losses when fuels are converted to electricity (Van Heerden *et al*., 2006).

Lastly, in scenario four, a tax is levied on intermediate and household consumption of energy – a combination of scenarios two and three. This tax is comparable to scenario one (except for the exclusion of the conversion losses from coal to petroleum products which account for approximately 10 per cent of the emissions), but is based on the consumption of energy and not the level of emissions itself. Also, coal consumption by poor households is excluded from taxation as this consumption is considered part of their basic needs. Poor households only pay the environmental tax on petroleum products and electricity (Van Heerden *et al*., 2006).

4.2 Tax instruments for reduced water consumption

Figure 1 describes water requirements by sectors in South Africa. Irrigated agriculture is the largest consumer at 62 per cent; afforestation requires 3 per cent of the total water use; rural and urban populations 4 per cent and 23 per cent, respectively. Mining and bulk industrial, and power generation use 8 per cent on aggregate.
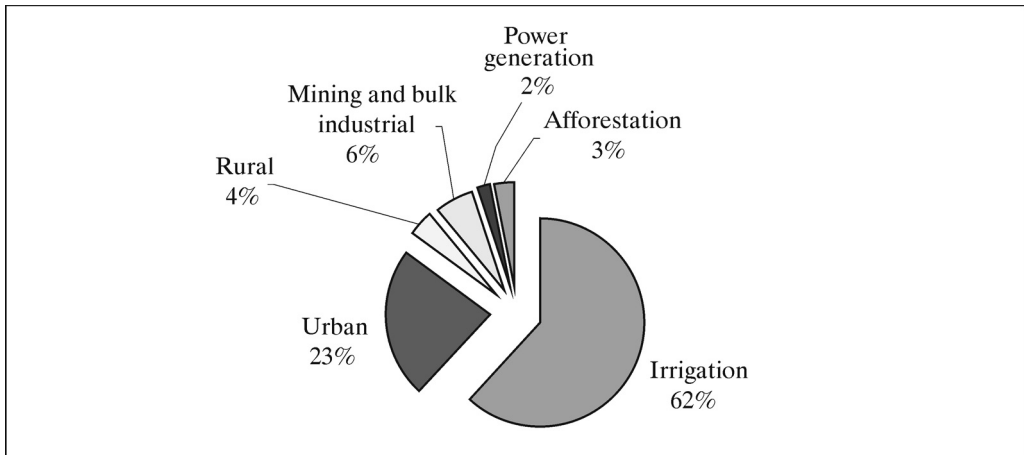
Figure 1
Water requirements by sectors in South Africa: 2000

The following scenarios were extracted from the suggestions proposed by water authorities and experts in South Africa:

(i) A surcharge of 10c per m³ water used by forestry.

(ii) A surcharge of 10c per m³ water used by irrigated agriculture.

(iii) A surcharge of 10c per m³ water used by all mining industries.

In South Africa, according to the National Water Act (Act No 36 of 1998), the government is regarded as the public trustee of the nation's water resources. Under previous water legislation, pricing of water did not generally take into account the real cost of managing water, the cost of water supply and the scarcity value of water (MacKay, 2003: 64). Except for the fact that water is required to meet basic human needs and ecological reserve, the principle behind the current water pricing policy in South Africa is that payment for water should be at a level that reflects its scarcity. Currently 25 litres of water per day per person is assumed to meet these needs. The pricing policy is structured into three tiers (CSIR, 2001):

• First tier: raw water tariffs administered by DWAF for the sale of water to water boards.

• Second tier: water boards set the wholesale price of water to bulk water users such as

municipalities and industries such as Eskom and Sasol.

• Third tier: municipalities determine the price of water to charge end-users such as households and industries.

A rise in raw water tariffs will automatically lead to an increase in the price in the second and third tiers. The South African government is introducing a water resource management charge to recover some of the costs for water management and to reflect water scarcity in the country.

4.3 Recycling schemes

Three recycling or handback schemes are analysed: (i) a decrease in direct tax, (ii) a general decrease in indirect taxes, and (iii) a decrease in taxes on food. These recycling schemes are as politically sensitive as the environmental tax instruments discussed above, since business usually prefers a reduction of progressive direct taxes, while the labour unions prefer a reduction in regressive indirect taxes (Du Toit & Koekemoer, 2003: 49).

We implement the first recycling scenario *via* a uniform ordinary change in *ad valorem* rates of the direct tax on capital and labour. The second two scenarios are implemented *via* reductions in commodity taxes levied on purchases by households (VAT). In scenario two the tax

reduction lowers the prices of all consumer goods by an equal percentage. In scenario three only food becomes cheaper. All three scenarios would be simple to administer.

4.4 Target variables

Four target variables are calculated by the model to compare the different scenarios in terms of the three dividends: (i) environment *via* CO_2 emissions or water consumption, (ii) economy *via* GDP and employment, and (iii) equity *via* total consumption by the poor. Changes in each target variable are expressed per change of government revenue, so that different policy scenarios can easily be compared to each other on the basis of equal extra tax revenues.

These target variables have been chosen to see which energy tax or water charge and tax-recycling scenarios would best yield environmental, economic and equity dividends.

5
The model and data

We use a computable general equilibrium (CGE) model for all our simulations. It is called "UPGEM", and is based on the structure of the ORANI-G model (Horridge, 2002) written and solved using the GEMPACK suite of software (Harrison & Pearson, 1996). The model has a theoretical structure that is typical of a static CGE model, and consists of equations describing producers' demands for produced inputs and primary factors; producers' supplies of commodities; demands for inputs to capital formation; household demands; export demands; government demands; the relationship of basic values to production costs and to purchasers' prices; market-clearing conditions for commodities and primary factors; and numerous macroeconomic variables and price indices.

Conventional neoclassical assumptions drive all private agents' behaviour in the model. Producers minimise costs while consumers maximise utility, resulting in the demand and supply equations of the model. The agents are assumed to be price takers, with producers operating in competitive markets, which prevents the earning of pure profits.

In general, the static model with its overall Leontief production structure allows for limited substitution on the production side, but more substitution in consumption. It has CES substructures 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. In the short-run simulations reported here we do not allow for substitution in production between either energy or water and other inputs. 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 primary model database is the official 1998 SAM of South Africa, published by Statistics South Africa (SSA, 2001). This SAM divides households into 48 groups (12 income by 4 ethnic), and distinguishes 27 sectors. For the purpose of this study, we split the energy-intensive as well as the agricultural sectors further to arrive at 39 sectors.

The model's closure rules reflect a short-run time horizon. The capital stock in each sector is assumed fixed, while the rate of return on capital is allowed to change. 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 in inelastic short-term supply. The supply of unskilled labour is assumed to be perfectly elastic at fixed post-tax real wages (i.e. nominal post-tax wages deflated by the economy-wide CPI). The distinction between skilled and unskilled labour supply reflects the South African labour market realistically and allows for investigating the effect of certain policies on employment of unskilled labour. The supply of land is also assumed to be inelastic (Van Heerden *et al*., 2006).

It is assumed that aggregate investments, government consumption and inventories are exogenous and unaffected by the change in environmental taxes under consideration. Consumption spending by each of the 48

representative households follows labour income earned by each household, and the trade balance is endogenous. This specification allows us 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 the numeraire in each simulation.

5.1 Energy data

To update and conform the greenhouse gas (GHG) emissions data to our SAM, a new emissions dataset was compiled (see Blignaut *et al.*, 2005). The 1998 data from South Africa's Department of Minerals and Energy (DME) was used for these calculations. To calculate the energy balances, the Intergovernmental Panel on Climate Change (IPCC) defaults were used for non-coal and non-CO_2 GHG emissions, while CO_2 factors specific to South Africa were used for coal. The calculated balances were used to then calculate the final CO_2 and CO_2 equivalent (from methane, and nitrous oxide) figures as directed by the IPCC.

For each of the 39 activity sectors in the SAM, three matrices are appended in terms of (i) GHG emissions from burning of fuels, (ii) energy, including electricity consumed, (measured in TJ) and (iii) the same energy in (ii), including electricity, measured in native terms. From the calculations it was found that total emissions were estimated at 353Tg, a figure close to the 344Tg reported by the International Energy Agency (IEA) for the same year. Using the SAM weights, the emissions were then shared between final demand and intermediate demand. South Africa extensively uses coal for energy and from the calculations of GHG emissions, 75 per cent of all emissions are generated by coal.

5.2 Water data

South Africa is a semi-arid country. Precipitation has fluctuated over the years with an average of 500 m³ per annum, well below the world average of about 860 mm per year (DWAF, 2004). The total flow of all the rivers in the country amounts to approximately 49,000 million m³ per year, less than half that of the Zambezi,

the closest large river to South Africa. The National Water Resource Strategy estimates the total water requirement for the year 2000 at 12,871 million m³ (at a 98 per cent assurance of supply), excluding environmental requirements, but including the basic human needs reserve (DWAF, 2004).

The water supply and use accounts of the CSIR (2001) were used to calculate a vector of "taxable water" for each industry in the SAM, as well as a vector of "extra water charges" that may be charged on volumes of water used. The total water supply includes volumes of water from underground or rivers, or water returned from the formal water sectors. The water use by economic sectors was discussed in Section 4.

6
Results

6.1 Energy

An analysis of the results from the environmental taxes versus the recycling simulations shows that the experiments have largely opposing effects. While the energy tax tends to raise production costs thereby depressing sales and overall output, the recycling schemes reduce the production costs and thus boost sales. The environmental tax experiments lead to price increases through the cost effect, while recycling the revenue back reduces prices of commodities. Environmental taxes lead to a substitution to non-energy-rich activities away from the energy rich production, thus reducing emissions. On the other hand, with recycling schemes there is an indirect effect of increasing emissions through increased production. The results show that for all the four environmental taxes and the three recycling options, there is a fall in CO_2 emissions. These emissions are recorded in CO_2 Gg and are taken as emissions per million rand increase in total tax revenue. This reduction occurs because the fall in emissions due to the tax is larger in all experiments than the increase in emissions due to recycling.

To investigate whether a second dividend is found, the marginal excess burden (MEB) is calculated. This is calculated as a decrease in GDP divided by an increase in real government

income for the case of a decrease in GDP. For an increase in GDP due to the recycling options, MEB is the increase in GDP divided by the decrease in real total government income.

Table 2 shows that all environmental tax experiments reduce the MEB for GDP, while all recycling options increase GDP. The table gives the difference in MEBs between the environmental tax and recycling options. We see, for example, that a carbon tax together with a food tax break lead to a dividend because GDP increases. Thus, two recycling schemes, direct tax and indirect tax breaks, do not yield a second dividend. Only the food tax break gives the second dividend.

Table 2

Marginal excess burdens (MEB) of different tax instruments, for real 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	0.132	0.156
Carbon tax	0.140	–	–	+
Fuel tax	0.148	–	–	+
Electricity tax	0.145	–	–	+
Energy tax	0.151	–	–	+

* Numbers present the MEB for the environmental taxes and the recycling schemes, separately. They report the decrease in real GDP (rand) per increase in total tax revenue (rand), for the environmental tax, and increase in real GDP per decrease in total tax revenue, for the recycling scheme, respectively. Both series are without dimension. The central part of the table presents results for combined scenarios. The plus signs indicate that a budget neutral combination of the environmental tax and the recycling scheme yields a second dividend, i.e that the column MEB exceeds the row MEB.

Source: Van Heerden *et al*. (2006)

All experiments that lead to an increase in GDP also lead to an increase in unskilled employment, and vice versa, because of the close positive link between the two variables. Indeed, unskilled employment contributes about half of the GDP change. Using the change in unskilled employment per one billion rand change in real government income, the results show that in addition to the food tax break experiments, we also have a second dividend in some indirect tax break experiments. Employment is reduced the least by a carbon tax, then a fuel tax, then an energy tax and then an electricity tax. The reason for this order is that there is high complementarity between unskilled labour and electricity, while there is very little complementarity between unskilled employment and coal, the main source of carbon. This explains the difference in the results between the employment and GDP dividend.

The third dividend is a gain in consumption by poor households. Calculating the percentage change in real consumption of the poorest household per unit of real government income, it is realised that a triple dividend is obtained for all environmental taxes with a food tax break. This is because of the large share of food in the consumption basket of the poor. The fuel tax simulation is the best at reducing poverty, while the electricity tax simulation is the worst for poverty reduction, regardless of the recycling option. This is due to the relatively large expenditure allocated to electricity by the poor as opposed to the fuel tax.

Table 3

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 c=0.075 i=0.060 w=0.065	a=0.091 c=0.099 i=0.082 w=0.097	a=0.359 c=0.391 i=0.338 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

Source: Van Heerden *et al*. (2006)

6.2 Water

The first of the three dividends is the environmental dividend reaped which is derived by reduction in water use. Our results show that all the simulations do yield the first dividend, whether the revenue collected is recycled through a direct or indirect tax break. The water charge increases the price of water and directly affects the amount of water consumed, see table with elasticities in the Appendix.

The model predicts that the water charge will lead to a decline in water consumption in the forestry and irrigated agricultural sector by 32 per cent and 6 per cent per billion rand tax revenue received, respectively. Water consumption by the mining sector would decrease by only 3 per cent per billion rand. The decrease in water consumption as a result of water charge is greater than an increase in water consumption because of tax breaks, thereby yielding the environmental dividend.

The second dividend is the effect on the total economy, and is determined using the concept of marginal excess burden. The marginal excess

burden (MEB) is defined as the change in real GDP divided by the change in real government revenue. The MEBs for all eight water charge

policy measures as well as the three recycling measures are given in Table 4.

Table 4
Marginal excess burdens of different tax instruments, and an indication of scenarios that result in a GDP dividend *

		Recycling scheme		
		Direct tax break	Indirect tax break	Food tax break
Water tax		0.586	0.722	0.703
Tax on forestry water	−0.825	−	−	−
Tax on mining water	−0.547	+	+	+
Gold mining	−0.964	−	−	−
Coal mining	−0.658	−	+	+
Other mining	−0.249	+	+	+
Tax on irrigated agriculture	−0.372	+	+	+
Field crops	−0.338	+	+	+
Horticulture	−0.442	+	+	+

* The numbers represent the percent change in gross domestic product per 10 million rand tax revenue. In the column, a water tax is levied; the numbers are the reduction in GDP. In the row, the tax is recycled; the numbers are the increase in GDP. If the sum of the two effects is positive, GDP increases, and a "+" is given.

Source: Letsoalo *et al*. (2006)

A double dividend is indicated by a + sign in the table, that is, when the increase in real GDP per unit of real government revenue lost as a result of a tax break (recycling policy), is larger than the decrease in real GDP per unit of real government revenue collected from a new water charge. Only other mining, irrigated field crops and horticulture yield a double dividend.

The percentage change in total employment per unit of real government revenue collected was also calculated, and the plusses and minuses follow exactly the same pattern as in Table 3 above. That is, employment and GDP per unit of real government revenue are closely related to each other in the model. The explanation is simply that the total production function in the model has Leontief and CES characteristics in terms of intermediate and primary inputs, so that GDP and employment will always move in the same direction as a result of an exogenous shock.

The criterion used to measure an improvement in poverty levels is the percentage change in total real consumption of the three poorest household groups in the economy, by race. Some policy combinations render a net improvement for one race group, while they have detrimental effects on another. A tax on water consumption by mining industries other than gold and coal is the only water charge that could be recycled in a way that would benefit all four race groups within the poorest groups of households. However, all the water taxes except one would render the poverty dividend if they are combined with a tax break on food.

Table 5

Marginal change in poverty (%), and an indication of scenarios that result in a poverty dividend

		Recycling scheme		
		Direct tax break	**Indirect tax break**	**Food tax break**
Water tax		0.104	0.133	0.403
Tax on forestry water	–0.291	–	–	+
Tax on mining water	–0.285	–	–	+
Gold mining	–0.568	–	–	–
Coal mining	–0.268	–	–	+
Other mining	–0.092	+	+	+
Tax on irrigated agriculture	–0.196	–	–	+
Field crops	–0.175	–	–	+
Horticulture	–0.239	–	–	+

ᵃ The numbers represent the percentage change in real consumption of the poorest household group per billion rand tax revenue. In the column, a water tax is levied; the numbers are the reduction in consumption. In the row, the tax is recycled; the numbers are the increase in consumption. If the sum of the two effects is positive, poverty decreases, and a "+" is given.

For irrigated agriculture, it helps to differentiate between water charges on field crops and on horticultural crops. We found that a tax on irrigated horticultural crops has a more severe influence on the consumption of the poorest groups, in that at least one group is made worse off with this tax, while with irrigated field crops at most one group is made worse off.

7
Conclusion and policy recommendations

The food tax break renders the best results of all the recycling schemes in both groups of simulations discussed above, namely it leads to triple dividends in the efforts to reduce carbon emissions as well as the efforts to reduce water consumption in South Africa. We would like to make the following policy recommendation for South Africa: A tax break on food financed by:

1. A carbon tax on all emissions from burning fossil-fuel at the point of combustion, applied to the CO_2 emissions by sector.

2. A water charge on both irrigated field crops and some sectors of the mining industry.

Our results show that such a tax reform would increase the real income of the poorest households, increase economic growth, increase employment, reduce carbon dioxide emissions, and reduce water use.

Endnotes

1   There were, however, earlier authors who advanced these ideas. See Goulder (1994) for a more complete overview.

2   The literature distinguishes between a weak and a strong double dividend. In its weak form the theory requires revenue recycling to merely reduce the economic costs of the environmental tax compared to a situation where the revenues are returned as a lump sum. The literature widely supports this version of the theory. See for example Bovenberg and De Mooij (1994) for an analytical argumentation and Dellink (2003) for numerical results. A strong double dividend requires a revenue-neutral tax reform to produce both environmental and economic *gains*. The

discussion in the literature focuses on this more interesting version of the theory, as do we.

3   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).

4   Another important addition to the analysis described above is the introduction of strategic behaviour on the labour market, e.g. leading to involuntary unemployment in the initial situation. Because our model does not incorporate strategic behaviour, this strand of literature is not described here. For more information see Bovenberg and Van der Ploeg (1998), Strand (1998), and Koskela, Schöb and Sinn (1998).

5   For a given labour tax, the distortion in the labour-leisure trade-off is greater as the (compensated) wage elasticity of labour supply increases. For a given capital income tax, and for a closed economy, the distortion along the intertemporal dimension – the margin of choice between consuming today and consuming in the future – is greater as the intertemporal elasticity of substitution in consumption increases. Thus, the relative marginal efficiency costs of labour and capital income taxes depend on these elasticities and on the magnitudes of labour and capital income tax rates. For an open economy, the distortion of a capital tax also depends on its base, either households' capital income or firms' profits, and on international capital mobility.

6   The MCPF (marginal cost of public funds) is equal to 1+ MEB.

7   The South African currency rand is abbreviated to 'R'.

8   It should be noted that the level of the carbon tax has little or no bearing on the results reported in Tables 3, 4, 5, 7 and 8, as we take ratios of tax effects divided by changes in tax revenues. If the model were linear, both the numerator and denominator would be proportional to the carbon tax level. Although the model is non-linear, the absolute size of the environmental taxes or tax handbacks only affects these ratios at the third decimal place.

9   5 USD/tCO_2 is close to the median of marginal climate change damages reported in the literature (Tol, 2005: Table 3).

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APPENDIX

Table A1
Average water tariffs (2002) and the semi-elasticity for water demand

Industry	Water tariff (R/ m³)	% change due to an increase of R1	Elasticity	Semi elasticity	Taxable water (million m³)
Irrigated field	0.05	2000.0	–0.25	–500.0	7152.0
Dry field	0.05	2000.0	–0.15	–300.0	0
Irrigated horticulture	0.05	2000.0	–0.25	–500.0	3400.0
Dry horticulture	0.05	2000.0	–0.15	–300.0	0
Livestock	0.05	2000.0	–0.15	–300.0	191.1
Forestry	0.025	4000.0	–0.40	–1600.0	1673.0
Other Agric	0.05	2000.0	–0.15	–300.0	24.8
Coal	2.12	47.2	–0.32	–15.3	40.3
Gold	2.12	47.2	–0.32	–15.3	284.8
Crude, petroleum & gas	2.12	47.2	–0.48	–22.6	0.7
Other mining	2.12	47.2	–0.32	–15.3	368.3
Food	4.00	25.0	–0.39	–9.8	376.4
Textiles	4.00	25.0	–0.33	–8.3	104.4
Footwear	4.00	25.0	–0.33	–8.3	0
Chemicals & rubber	2.12	47.2	–0.15	–7.2	59.4
Petroleum refineries	2.12	47.2	–0.48	–22.6	92.0
Other non-metal minerals	2.79	35.8	–0.32	–11.6	44.0
Iron & steel	2.79	35.8	–0.27	–9.8	56.2
Non-ferrous metal	2.79	35.8	–0.27	–9.8	14.0
Other metal products	2.79	35.8	–0.27	–9.8	60.0
Other machinery	4.00	25.0	–0.25	–9.5	37.3
Electricity machinery	4.00	25.0	–0.38	–9.5	6.2
Radio	4.00	25.0	–0.38	–9.5	0
Transport equip	4.00	25.0	–0.38	–9.5	20.4
Wood, paper & pulp	2.12	47.2	–0.59	–27.8	157.5
Other manufacturing	4.00	25.0	–0.38	–9.5	13.0
Electricity	2.12	47.2	–0.80	–37.7	207.9
Water	2.12	47.2	–0.60	–28.3	5906.5
Construction	4.00	25.0	–0.38	–9.5	167.1
Trade	4.00	25.0	–0.19	–4.8	491.4
Hotels	6.11	16.4	–0.19	–3.1	319.8
Transport services	6.11	16.4	–0.19	–3.1	497.1
Community services	6.11	16.4	–0.19	–3.1	175.8
Financial institutions	6.11	16.4	–0.19	–3.1	281.3

Real estate	6.11	16.4	–0.19	–3.1	662.0
Business activities	6.11	16.4	–0.19	–3.1	26.2
General government	6.11	16.4	–0.19	–3.1	524.8
Health services	6.11	16.4	–0.19	–3.1	331.3
Other service activities	6.11	16.4	–0.19	–3.1	198.7

Sources: Water tariff data: Own analysis based on various unpublished Department of
Water Affairs and Forestry, water board and municipal data.

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