
The Dividends from a Revenue Neutral Tax on Coal in South Africa

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ABSTRACT

South Africa is endowed with a significant proportion of the world's coal reserves, which is used relatively cheaply to supply in more than 75 per cent of the country's energy needs. In terms of its per capita South Africa is one of the largest air polluters in the world. Even higher on the list of social preferences in South Africa, however, is the problem of unemployment, which also ranks amongst the highest in the world. In this paper we use a Computable General Equilibrium (CGE) model to simulate fiscal policy scenarios that address both these problems, and try to establish a "double dividend", namely a reduction in CO₂ levels of pollution as well as a reduction in unemployment levels.

JEL E62, H21, J65, N5

1 BACKGROUND

The South African government has achieved remarkable results in the fiscal management of the country over the past decade. This achievement was the twofold result of broadening the South African tax base and prudent fiscal management. Although much success has already been achieved, a number of concerns remain. Of these, environmental reform and the high level of unemployment constitute major aspects.

South African policy makers will have to consider the objective of increasing future economic growth within a framework that ensures the sustainability of the current economic achievements. Sound management of natural resources is therefore becoming an integral part of the South African policy maker's responsibility.

A significant concern towards sustainable development is the current levels of carbon dioxide (CO₂) pollution in the country. South Africa is endowed with a significant portion of the world's coal reserves and, consequently, this natural

resource is used relatively cheaply to supply in more than 75 per cent of the country's energy needs. The largest consumer of coal in South Africa is the electricity supply industry, which uses coal as a primary input to provide for the country's electricity needs. This, however, results in pollution, and with electricity generation from coal being the single largest source of CO₂ emissions, this contributes towards 53 per cent of aggregate national CO₂ emissions. In addition, the use of petroleum products derived from coal contributes another 14 per cent to the national CO₂ levels. It is therefore not surprising that South Africa is the largest contributor towards CO₂ pollution on the African continent.

South African policy makers have a number of policy instruments to their disposal to address this environmental concern; one of which, *viz.* a system of national carbon taxes, might be a possible remedy. However, the environmental benefits gained from this type of taxation could be costly in terms of lower economic growth. This cost will be amplified if the regulations imposed on firms should reduce the overall level of employment and investment in the economy.

The above criticism towards environmental taxation has resulted in a shift in the debate concerning environmental taxation. Rather than being judged as an instrument to control pollution, this type of taxation is currently seen as a revenue-raising tool with uncertain environmental benefits, but with large potential for improving social welfare (Goulder, 1994). Policy makers should therefore use the revenue obtained from environmental taxes to reform the current tax system to achieve certain economic objectives. This possibility certainly seems attractive in the South African context, as the problem of unemployment and the skewed welfare distribution are an even greater concern than that of environmental management.

Because South Africa has a high unemployment rate (which has been the subject of numerous research and policy debates in the country), the notion of a possible "double dividend" that currently features strongly on the European research agenda could also be applicable to the South African market (e.g. Capros *et al.*, 1995). The possibility of achieving such a benefit in the South African context should be investigated.

Therefore, the dual objective of reducing long-term structural unemployment and reducing pollution (e.g. greenhouse gas emission) presents an intriguing opportunity. That is: the double dividend notion presents the possible opportunity for the South African fiscal system to be reformed by switching the burden of taxation from labour as a factor of production to factors of production that contribute towards higher levels of pollution. However, this issue not

without its controversies and has gained a significant amount of interest from economists, environmentalists and policy makers.

The purpose of the research as presented in this paper is to apply a general equilibrium model of the South African economy to determine whether the current structure of the economy would allow the attainment of a double dividend. The general equilibrium model that is applied is a South African version of the generic ORANI model (Horridge, 2001). A 2001 Social Accounting Matrix (SAM) of the South African economy is used as its primary source of data. Because the relative abundance of coal in the South African economy has resulted in relatively low energy costs, we try to establish whether a revenue neutral fiscal reform that introduces a tax on the use of coal as an intermediate input could result in an increase in the overall welfare of South African citizens. The revenue raised is returned to the economy in two different scenarios:

1. A lump-sum transfer to the poorest households in the South African economy.
2. A decrease in the intermediate taxation of those products that are both widely used by the poorest households and relatively labour intensive in the production process. These we have identified as food, agricultural and beverage products.

By comparing these policy shocks with each other, we conclude that a targeted reduction in the price of food and agricultural products holds the highest benefit for the South African economy.

Section 2 describes the broad characteristics of the model that is used, while Section 3 briefly describes the South African labour market. A description of the labour market is deemed necessary because this market has unique characteristics that affect both the choice of model closure and our choice of products that should experience a direct positive benefit from the tax reform. In Section 4 we describe the model closure, and the results of the simulations are summarised in Section 5.

2 MODEL CHARACTERISTICS

2.1 Framework

We use a South African general equilibrium model that reflects the ORANI general equilibrium modelling methodology. It is a comparative-static model, and simulation results are reported as deviations from a base case scenario. The

results do not represent changes over a period of time, but rather differences with respect to the base case at a given point in time. As is described in Section 4, we choose a closure that represents a short-run economic environment, while assuming that the supply of highly and semi-skilled labour is fixed within the South African economy. This assumption reflects the reality of the relative shortage of highly skilled and skilled labour and the abundance of unskilled and informal sector labour in South Africa.

2.2 Database

The main source of data that serves as the basis of the model is a 2001 SAM. The SAM distinguishes between 45 different products and 45 different industries. Each of these industries is allowed to produce only one output. With regard to the production of coal, the database includes the South African coal-mining industry that supplies coal not only to the South African economy, but also to the rest of the world. Although coal is used in the production processes of the major part of the industries in the South African economy, a relatively intensive use of coal is made by four industries, namely:

- 1 the coke and refined-petroleum industry,
- 2 the basic iron-and-steel industry,
- 3 the basic non-ferrous metals industry, and
- 4 the electricity industry.

Within the database distinction is made between four groups of labour:

- 1 highly skilled,
- 2 skilled,
- 3 semi- and unskilled,
- 4 informal labour.

In addition, South Africa's households are divided into 14 different groups according to their income. The original SAM distinguishes between seven different types of government expenditures, 13 different export destinations and 12 different types of fixed investment in the South African economy. However, for the purpose of this study we use aggregated government expenditure, aggregated exports and aggregated investment for the South African economy. The different industries, products and labour groups are summarised in Appendix 1.

2.3 Model elasticities

The elasticities used in the model are obtained from a combination of econometric estimations and a review of the relevant literature. The lack both of historical data and relevant research material on some of the markets of the South African economy rendered attainment of the true elasticities a difficult task. The procedure followed to obtain the relevant elasticities is briefly described.

2.3.1 *The constant elasticity of substitution (CES) substitution elasticity between different skill types*

Very little (if any) data are available for the estimation of the CES substitution elasticities between highly skilled, semi-skilled, unskilled and informal-sector workers. It is therefore not surprising that the current literature does not provide any insight into the exact values of these elasticities. The uncertainty about the substitution elasticity between different skill types in South Africa is, however, not unique: (Dixon *et al.*, 1980) maintain that considerable uncertainty exists about the extent to which changes in occupational wage relativities influence occupational labour demands in Australia. Despite the uncertainties and difficulties surrounding these elasticities, analysis of the South African labour market indicates that one should not expect a high degree of substitutability between the different types of labour in South Africa, as structural and institutional factors allow little substitution within the labour market. One could therefore assume a low elasticity of substitution for the South African labour market. Given the result for the Australian economy, an elasticity of 0.2 is assumed for the South African model.

2.3.2 *The CES substitution elasticity between primary factors*

A review of current literature on the elasticity of substitution between primary factors in the South African economy has not shed any light on the expected elasticities for the industries included in this study. An attempt is therefore made to estimate these substitution elasticities by following the widely used approach pioneered by (Ferguson, 1965), in which the elasticity of substitution is estimated by making use of conditions of profit maximisation. The elasticities thus obtained for each industry are summarised in Appendix 2.

2.3.3 *The Armington elasticities*

Although Armington elasticities can be estimated separately for each category of demand in the model (i.e. household, investment or import demand), available data can seldom sustain such an attempt. Because of the data inadequacies we

followed (Dixon *et al.*, 1980) and imposed the restriction that the elasticity of substitution between a specific domestic and the imported good is the same for use as an input in the production process, investment or household consumption. (Dixon *et al.*, 1980) defend this assumption by pointing out that most of Australia's major imports are predominantly used in the one end-use category only and that this assumption would suffice for South Africa as well. We therefore estimate the Armington elasticities for the South African industries by making use of a methodology set out by (Reinert & Roland-Holst, 1992) and (Kapusinsky *et al.*, 1996). The elasticities are summarised in Appendix 2.

2.3.4 *Household expenditure elasticities*

Expenditure elasticities are estimated for an "aggregated household" that encompasses the expenditure of the 14 households in the model. It is assumed that these expenditure elasticities are representative of each of the individual households. Despite the lack of data for disaggregated households, sufficient data are available to estimate the expenditure elasticity of the aggregated household for each of the 45 products in the model. The demand function estimated is the common log-linear demand equation that represents household consumption as a function of disposable income and relative prices. The expenditure elasticities are summarised in Appendix 2.

2.3.5 *The foreign elasticity of demand for South African products*

In order to derive and motivate the use of the price elasticities of exports, the methodology behind the ORANI model of the Australian economy has been used. Demand elasticities in the ORANI model are assumed to be -4 for those goods for which Australia does not have sufficient market share to influence the market price. The Centre for Policy Studies at Monash University has indicated that model results do not change significantly if the elasticities increase beyond -4 for those commodities that are highly price elastic.

South Africa's economy is also a small open economy with little pricing power in international markets. Therefore, the price elasticity of -4 has been adopted for all of the industries that are included in the South African version of the ORANI model.

3 THE SOUTH AFRICAN LABOUR MARKET

The unemployment rate in South Africa is exceptionally high and arguably the most pressing concern that faces policy makers. Even according to the conventional (narrow) definition of unemployment, which implies a job-search

test, one in every four adults in South Africa who want work and are actively looking for it, is unemployed. Furthermore, extreme wage inequalities and disparity in the incidence of unemployment exist between different race groups.

While Africans faced unemployment rates of 41 per cent in 1994, the rate for whites was only 6 per cent. The level of unemployment among Africans is one of the highest in the world, and could be the highest, if compared with rates of countries of similar population size. The different skills groups are also pronounced: South Africans with higher education (highly skilled and skilled labour) face an unemployment rate of only 6 per cent, while labour-market participants with only primary education, or less, suffer an unemployment rate close to 40 per cent. This phenomenon could partially explain the labour allocation by race, because there is a huge gap between education and skills levels between race groups.

From the research that has been conducted on the South African labour market, one could conclude that it operates at a level of full employment for skilled and highly skilled labour, while the unskilled and informal-sector labour suffer high levels of unemployment. Although a considerable amount of research has been carried out on the reasons for unemployment, little attention has been directed towards determining whether this unemployment is voluntary or involuntary. The answer to this problem is important for two reasons:

- 1 Research has indicated that the labour-supply function holds important consequences for the success of a double dividend policy. If labour supply is highly inelastic, for instance, wages could increase as result of the policy while employment levels remain constant. This could ultimately result in an increase in the inflation rate and a reduction in the impact of the policy.
- 2 It gives an indication of how the labour-supply curves of the unskilled and informal sector labour should be treated within the model closure. If unemployment is voluntary, it implies a supply-side problem and the labour-supply curve should be treated accordingly. However, if the level of unemployment is involuntary, it implies a demand-side problem.

In one of the few papers addressing this problem, (Kingdon & Knight, 2001) described their attempts to determine whether unemployment in South Africa is voluntary or involuntary. They came to the conclusion that it is very likely that most of the unemployed workers are involuntarily so and would accept formal sector jobs at the going wages. They also stated that it would be remarkable if the unemployed in South Africa would choose to remain deprived, but that it appeared as if limited opportunities for entering into the informal sector provided no real alternative to unemployment. These findings are confirmed by studies that analyse the reasons for unemployment, and one can conclude that

the unemployed in South Africa are not voluntarily so and that they do not obtain a higher level of utility because less labour is supplied. In fact, most studies indicate that the unemployed would readily work at real wages lower than the current wages in the labour market. Once again, this is especially true for the unskilled labour force and it seems as if the elasticity of labour supply for the unskilled labour is high.

4 MODEL CLOSURE

4.1 The economic environment

Against this background a suitable closure was established to test the effects of a revenue neutral coal tax on the South African economy. The features of South African factor markets were considered in the closure, as well as the economic variables that have to be evaluated in the experiment. This includes variables such as coal consumption, labour absorption and the welfare of the South African society.

The closure adopted to test the effects of a revenue neutral tax on coal in South Africa can be classified as a short-run closure within the ORANI methodology, even though it is assumed that the supply of highly skilled and skilled labour are fixed. This assumption is made to reflect the realities of the South African labour market described above. A realistic closure for these two components of the South African labour market would therefore be to exogenise the real wages for these two groups and to assume that the unskilled and informal sector employment would change in the face of a policy shock, while real wages remain constant.

Because of the significant unemployment rate among unskilled and informal sector workers, it is assumed that capital and land remain fixed within the model (short-run assumption) and that the price of capital and land will adjust in the face of any policy shocks. This assumption allows firms to change the number of unskilled and informal sector workers in their employment to adjust output. Although a lower wage for unskilled labour should result in a lower cost of labour, it should also result in lower income to households who supply the unskilled labour.

With regard to the macroeconomic aggregates, it is assumed that government and investment spending are fixed (unless some theory needs to be adopted regarding their behaviour). To allow analyses of the effect of the policy shocks on welfare as well as on the competitiveness of the South African economy, consumption expenditure and the trade balance are endogenous in the model.

Apart from the above, all technical change and shift variables are exogenous. This assumption allows for the evaluation of the economic effects of the introduction of the revenue neutral tax on the intermediate use of coal in the absence of any technological improvements in the economy. Finally, all tax rate variables are exogenous, and the tax rate on the intermediate use of coal, food, agricultural products and beverages can be shocked to determine the effect of such a shock on the South African economy.

4.2 The policy shocks

The first policy shock that is simulated with the South African CGE model is a 50 per cent increase in the tax rate on the intermediate use of coal across all industries in the South African economy. The tax increase of 50 per cent is chosen to get a clear indication of the economy-wide effects of such a tax. Of particular interest will be the effect of such a tax on the demand for coal, consumer welfare, competitiveness, employment and GDP growth. It must also be determined what the change in government revenue will be as result of the policy change.

The second policy proposal is a revenue neutral shock in which a 50 per cent tax on coal is introduced, but the revenue from the tax is redistributed as a lump-sum transfer to the households in the three lowest income groupings of the model (D0, D1, D2).

The third policy proposal is a revenue neutral shock in which a 50 per cent tax on coal is introduced along with a revenue neutral cut in intermediate taxation of food and agricultural products. The revenue raised by the tax on coal is redistributed by reducing the cost of those products that constitute the bulk of the consumption expenditure of the poorest households in South Africa. A comparison between the expenditure patterns of the poorest household groups (D0) and those of the richest (D924) in South Africa reveals that the poorest households spend nearly 50 per cent of their income on food and agricultural products, while it constitutes only about 10 per cent of the total expenditure of the richest households.

Apart from the potential impact of cheaper food and agricultural products on the poorest households, a tax that reduces the cost of these products should directly result in a decrease in the tax burden on labour. These industries are relatively labour intensive and contribute towards 12.5 per cent of the unskilled employment in South Africa and 6.5 per cent of total employment. Only the gold-mining sector employs more unskilled labour than the agricultural sector.

The results of the policy shocks will indicate whether these policy proposals can result in a double dividend for the South African economy. This will be the case if the net result of the policy shock would be both a decrease in pollution levels and, simultaneously, an increase in welfare. Other economic variables that are of interest are the change in the level of unskilled and informal sector employment and the effect that these proposals will have on South Africa's external competitiveness.

5 RESULTS

5.1 A 50 per cent tax on coal

We use a stylised model (Adams, 2003: Appendix 3) that represents the underlying theory of the CGE model to explain the macro-economic results of the simulation. From equation (15) in the said appendix we expect an increase in the indirect tax on coal to increase the cost of low-skilled and informal-sector labour (variable factors of production). This result will be strengthened by a negative terms of trade effect, which occurs in the denominator.

Equation (14), which relates the price of the variable factors to that of the fixed factors (capital, land, highly skilled and skilled labour), indicates that the increase in the price of the variable factors should result in a decrease in the price of the fixed factors. The increase in the price ratio between the price of the variable factor and that of the fixed factor implies that the quantity of the variable factor that is employed will decrease (Equation (13)).

The decrease in the quantity employed of the variable factor will result in a fall in output, which will result in a fall in gross domestic product at market prices.

If the trade balance increases, the consequence will be a decrease in aggregate consumption.

$$Y^{MP} \downarrow = C \downarrow + \bar{I} + \bar{G} + (X - M) \uparrow \quad (1)$$

Given the negative terms of trade effect and the positive trade balance, our simulation results confirm the expected macroeconomic outcomes. The simulation results for selected macroeconomic variables are reported in Table 1.

Table 1: The estimated macroeconomic effects of imposing a 50 percent tax on the intermediate use of coal (percentage changes)

Real GDP	-0.099
Employment	-0.028
Consumption	-0.632
Exports	0.388
Imports	0.144
Price of capital	-2.029
Price of land	-0.052
Price of highly skilled labour	-2.299
Price of skilled labour	-2.162

Because we assume that foreign prices remain unchanged while the nominal exchange rate serves as numeraire, the negative terms of trade effect can only be the result of a fall in the price of exports. This is evident because of the fact that the prices of capital, land and highly skilled and skilled labour will fall. This fall in the price of primary factor inputs is not offset by the increase in the price of intermediate goods in the manufacturing of exports. The result is that the price of exports falls, which results in an increase in exports and a decrease in the terms of trade.

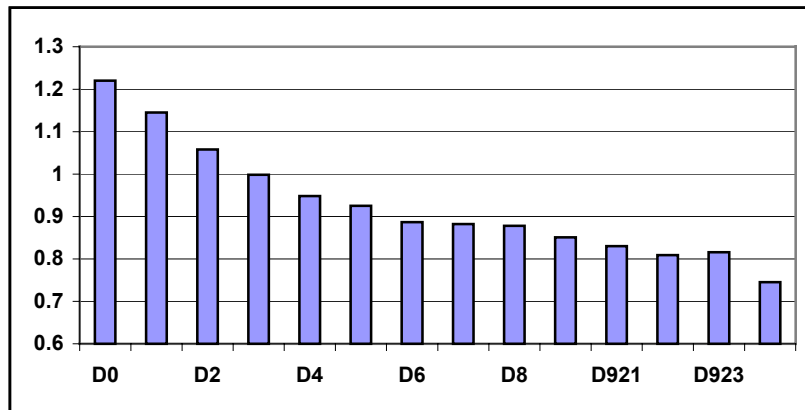
Apart from the effect of the tax on the macroeconomic aggregates, it is evident from the simulation results that the coke and refined petroleum industries, the basic iron-and-steel industry and the electricity industry will suffer most under the proposed policy change, as they are the industries that rely most on coal as an input into the production process. Although aggregate exports increase as result of the fall in the aggregate export price, the industries mentioned above experience a significant fall in their exports. The exports of the coke and refined petroleum industries fall by 3.15 per cent, those of the basic iron-and-steel industry by 6.50 per cent and those of the electricity industry by 7.48 per cent.

Despite the positive effect of the tax on the competitiveness of the South African economy, it has a negative effect on the aggregate welfare of the South African society as such, as well as on the welfare distribution of the society. Table 1 indicates that consumption decreases as result of the tax. The simulation results also indicate that the consumption of the households in the lowest income groups will decrease more than that of the households in the higher income groups.

An analysis of the change in the real consumption of the households indicates that the households in the higher-income groups experience a larger decrease in

their consumption basket than that of the lower-income households. This is the result of the relatively high weight that capital-intensive products carry in the consumption basket of the high-income households (compared to the lower-income households) (Figure 1).

Figure 1 Percentage change in the household consumption according to income groups



Finally, the effect of the tax on coal on the demand for coal seems to be relatively small. The domestic demand for coal falls only by 1.39 per cent. Although this could result in some reduction in the levels of pollution, it seems as if the cost of this benefit could be high (in terms of employment loss, etc.). With no attractive alternative energy source available, this result should be expected.

5.2 A 50 per cent increase in the tax on coal, accompanied by a lump-sum payment to the households in the lower-income groups of the South African market

The result in Simulation 1 indicates that the tax on coal raises revenue of R5.044 billion for the government in the form of indirect taxes. The second policy simulation evaluates the effect of a lump-sum transfer towards the households in the lowest three income groups of the South African economy. The revenue for the transfer is obtained from the tax on coal.

The stylised model in Appendix 3 indicates that the intermediate tax will increase the cost of the variable factor of production. The simulation results indicate, however, that this policy will also have a positive terms-of-trade effect that slightly offsets the effect of the tax increase on the cost of labour. With reference to the stylised model, the results of the policy shock are, in summary, that:

- 1 The tax increases the cost of the variable factor of production.

- 2 The increase in the cost of labour results in a decrease in the cost of the fixed factor of production.
- 3 The relative factor price movements result in a fall in the employment of the variable factors of production.
- 4 The decrease in the employment of the variable factor of production results in a fall in GDP.
- 5 The fall in GDP is reflected by a fall in exports (not surprising if one takes into account the positive terms of trade effect). Consumption, however, increases as result of the lump-sum transfer to the households at the lower end of the income distribution.

Table 2 reports the effects of this policy simulation on selected macroeconomic variables.

Table 2 The estimated macroeconomic effects of imposing a revenue neutral tax on the South African economy (percentage changes)

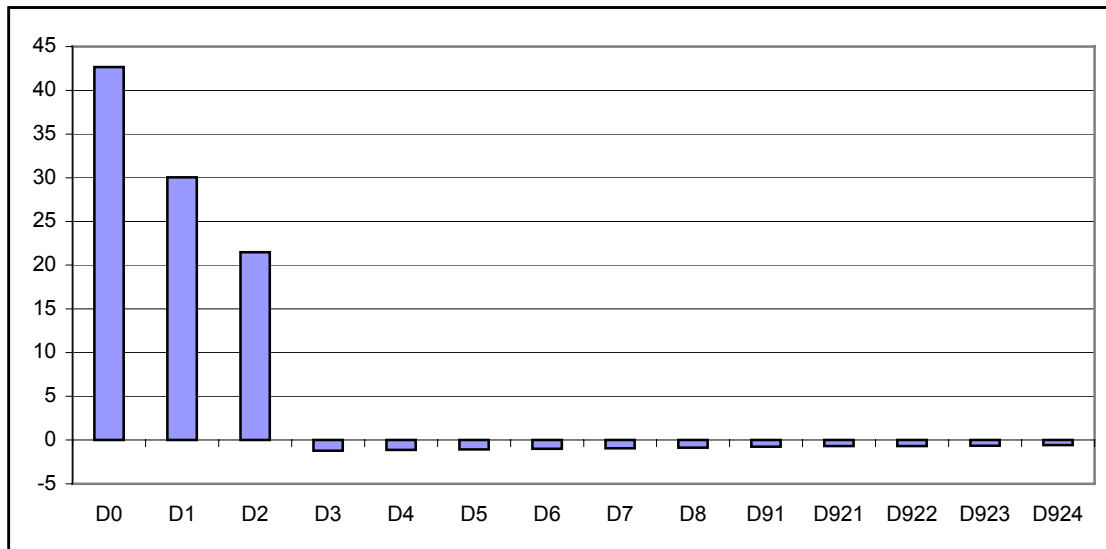
Real GDP	-0.019
Employment	-0.203
Consumption	1.612
Exports	-1.868
Imports	-0.028
Price of capital	-0.265
Price of land	-0.745
Price of highly skilled labour	-0.549
Price of skilled labour	-0.209

It is evident that this policy will have a positive effect on welfare in South Africa, although it will result in a loss in competitiveness, being the result of an increase in the domestic price of South Africa's exports. This increase is brought about by the tax on coal. Although the price of the fixed factors of production falls (as is the case in Simulation 1), the decrease is not big enough to offset the increase brought about by the additional tax on coal. As a result, exports fall across all industries except coal and other mining.

It is significant that the agricultural, food and beverage industries are among those that experience the biggest fall in exports. The fall in the exports of these industries can be explained by the small amounts of capital and skilled labour employed by them, which explains the relative price increase of the (unskilled) labour-intensive products.

Not surprisingly, the lump-sum transfer towards the lower-income group of households results in an increase in aggregate consumption of the three low-income household groups, despite the slight increase in consumer prices. Figure 2 reflects the positive effect of the policy on South Africa's welfare distribution.

Figure 2 Change in household consumption expenditure after lump-sum transfer



An analysis of the low-income household expenditure patterns after the policy shock indicates increases in their expenditure across all consumer goods. However, because the prices of relative capital-intensive goods fall relative to those of labour-intensive goods, expenditure on capital-intensive goods increases relative to expenditure on other goods. This includes expenditure on television sets (92 per cent), furniture (76 per cent) and commercial services (94 per cent). The consumption of the other household groups, which do not receive the lump-sum transfer, falls as result of the increase in consumer prices.

The effect of the policy proposal on the domestic demand for coal is once again small - the domestic demand for coal decreases by 1.31 per cent. This small decrease, despite a relatively high tax shock is, once again, due to the lack of a feasible alternative to coal as an input in the production processes.

5.3 A 50 per cent increase in the tax on coal, and a decrease in the intermediate taxation of food and agricultural products

In the third policy simulation the revenue raised through the tax on coal is returned to the economy by reducing the intermediate tax rate on food and agricultural products. The increase in revenue allows a 4 per cent reduction in

the intermediate tax rate on food and agricultural products. Because the aggregate effects of the intermediate tax are ambiguous with regard to labour and capital, the simulation results of the terms-of-trade effect and the prices of capital and labour are used to explain the macroeconomic effects of the tax. Our simulation results indicate that the policy proposal results in positive terms-of-trade effects and that the prices of both labour and capital fall. The fall in the price of labour results in an increase in employment and subsequently an increase in GDP.

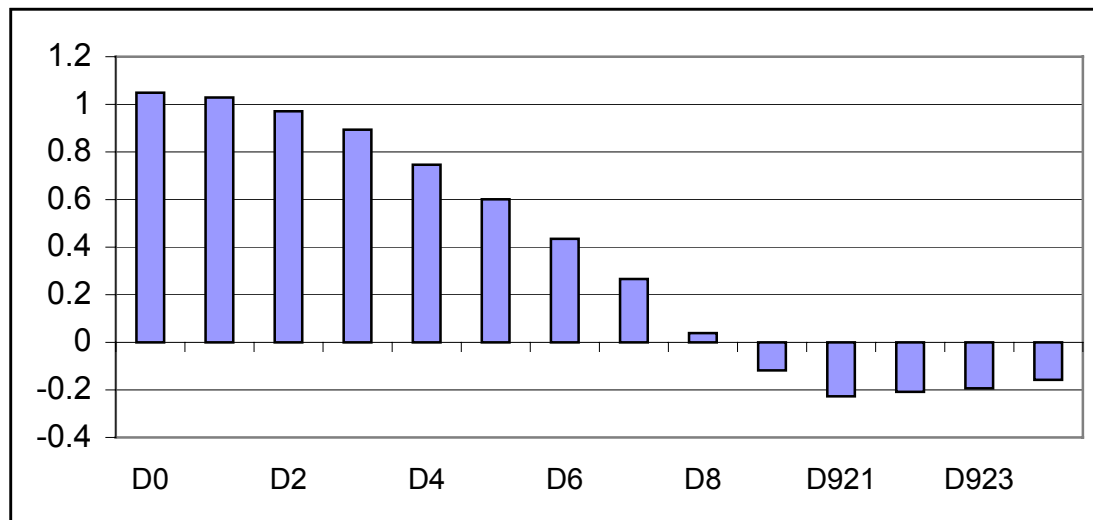
Table 3 summarises the simulation results of selected macro-economic indicators.

Table 3 The estimated macroeconomic effects of imposing a revenue neutral tax on the South African economy (percentage changes)

Real GDP	0.0195
Employment	0.0677
Consumption	0.1569
Exports	-0.39121
Imports	-0.15142
Price of capital	-0.63919
Price of land	0.24210
Price of highly skilled labour	-0.94751
Price of skilled labour	-0.53043

As in the case of the second policy simulation, the positive terms-of-trade effects are the result of an increase in the price of exports. This increase is the consequence of the intermediate tax on coal, and it is evident that the decrease in the price of food and agricultural products is not enough to offset these price hikes.

Despite the fall in exports, aggregate consumption increases as result of the reduction in food and agricultural product prices. As is illustrated in Figure 3, the policy proposal also has a positive redistribution effect.

Figure 3 Change in household consumption expenditure

The lower-income households experience an increase in their levels of consumption because of a significant decrease in consumer prices. This is not surprising if one considers that food and agricultural products represent nearly 50 per cent of the consumer basket of the low-income households.

The effect of the tax on coal on its domestic use remains small – a 1.43 per cent reduction. Once again, the effectiveness of the tax is hampered by the lack of a feasible alternative source of energy whatever in the South African economy.

6 DISCUSSION

The three policy simulations highlight a few important points that policy makers should consider before implementing a tax on energy resources in South Africa:

6.1 The environmental effect

All three the simulations have indicated that a significant tax on coal will have a positive environmental effect through a reduction in the use of coal. The reduction is, however, small and has to be determined whether such a decrease is sufficient to justify the environmental tax proposal. Because there are but a few energy substitution possibilities existing in the South African economy, policy makers should consider establishing alternative energy sources first, before venturing towards energy taxation.

6.2 The effect on welfare

The results from Simulation 1 have indicated that a tax on coal will have negative effects on South African welfare, and close consideration should be given to the manner in which revenue is returned to the economy. If the revenue is used to increase government savings (or repay government debt), aggregate consumption will decrease. The tax will also have negative distributional effects, as the households at the top end of the income distribution will benefit from the fall in the price of capital and the subsequent fall in the price of capital-intensive goods.

Simulations 2 and 3 indicate that positive welfare and redistribution results could be achieved if the revenue is returned to the economy by means of a lump-sum transfer to the poorest households, or by a reduction in the intermediate tax of products that are both labour intensive and represent a significant portion of household expenditure. The procedure of revenue return will, however, have important trade-balance effects.

6.3 The effect on South Africa's competitiveness

The simulation results indicate that the policy proposals have significant terms-of-trade effects, which influence South Africa's export performance. Because the tax on coal results in a decrease in the price of the fixed factors of production, a policy that does not return the revenue to the economy would actually have a positive effect on South Africa's exports, as the price of exports falls. The fall in the price of exports can be contributed to two factors. The first is the fact that the tax on coal is not directly raised on the export product, but on the intermediate use of coal. Although the intermediate tax could raise the export price, its inflationary effect on export prices is less severe than it would be if the tax were directly levied on exports. The second is that the significant fall in the price of the fixed factors of production offsets the inflationary effects of the tax increase. It seems as if South Africa's biggest export products are intensive in the use of unskilled labour and the use of land.

However, if the tax revenue is returned to the economy in order to obtain some welfare effects, the decline in the price of the fixed factors of production is not pronounced, and the price of exports increase. Because of this, aggregate exports will decrease. The simulation results indicate that lump-sum transfers to households have more severe effects on the competitiveness of the South Africa economy than a reduction in the taxes of food and agricultural products. Reasons for this are that the lump-sum transfer to the lower income households results in an increase in the demand for products which is relatively capital, land and skilled labour intensive. The increases in the demand for these factors result

in an increase the prices of the factors of production that is used in the industries that produce these products.

7 THE EFFECT ON EMPLOYMENT

The results of the first two policy simulations indicate that the policy proposals will have a negative effect on employment of the unskilled and the informal-sector labour in South Africa. The negative effect on employment is especially pronounced in Simulation 2. This is the result of the big increase in the terms of trade in Simulation 2, which results in a significant fall in exports.

The simulation results indicate that a policy proposal that reduces the cost of food and agricultural products will have a positive effect on employment (unskilled and informal-sector labour) because these industries are primarily labour intensive.

8 CONCLUSION

Our analysis indicates that an increase in the tax on coal will have positive, albeit marginal, environmental benefits for South Africa. Such a tax would, however, have negative consequences for the South African economy in the form of lower levels of employment, consumption and economic growth. Although the analysis indicates that a revenue raising tax (that is not returned to the economy) could have a positive effect on South Africa's exports, it seems that a policy that returns the revenue to the economy could increase the prices of exports and decrease exports. It is therefore important that the revenue from such a tax be disbursed in a manner that will reduce the negative effects thereof.

In conclusion, we therefore extend our analysis by testing two alternative simulations. Firstly, we make use of the revenue that is raised by the tax on coal to institute a lump-sum transfer to households at the lower end of the income distribution and, secondly, to decrease the tax on food and agricultural products, which are both labour intensive and an important component of (lower-income) household budgets. We find that both these policy proposals have positive welfare effects. The policy proposal that targets the prices of food and agricultural products will also have a positive effect on employment and less of a negative effect on South Africa's competitiveness and a positive effect on economic growth.

The analysis focuses on the economic consequences of a tax on coal and does not investigate the administrative feasibility of the tax. Although the

introduction of a new tax would invariably result in some administrative costs we are of the opinion that the policy proposals should fall within the scope of the South African Revenue Service's (SARS's) abilities to raise intermediate taxes in the economy. A lump-sum transfer to households should fall within SARS's ability to raise income taxes.

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APPENDIX 1 Breakdown of database used in the analysis

1.1 The different types of industries and products of the model

Industry	Abbreviation	Industry	Abbreviation
Agriculture, forestry and fishing	Agric	Metal products, excluding machinery	MetProd
Coal mining	Coal	Machinery and equipment	Macheq
Gold and uranium ore mining	Gold	Electrical machinery	ElecMach
Other mining	Othmin	Television, radio and telecommunications equipment	Telv
Food	Food	Professional and scientific equipment	ProfEq
Beverages	Bev	Motor vehicles, parts and accessories	MotVeh
Tobacco	Tob	Other transport equipment	OthTrnsp
Textiles	Text	Furniture	Furn
Wearing apparel	Wear	Other industries	OthInd
Leather and leather products	Leath	Electricity	Elect
Footwear	Foot	Water supply	WatSup
Wood and wood products	Wood	Building and construction	BuildCnst
Paper and paper products	Paper	Civil engineering and other construction	Civil
Printing, publishing and recording media	Print	Wholesale and retail trade	WhSale
Coke and refined petroleum products	Coke	Catering and accommodation services	CatAcc
Basic chemicals	BasChem	Transport and storage	TranspStor
Other chemicals and man-made fibres	OthChem	Communication	Com
Rubber products	RubProd	Finance and insurance	FinIns
Plastic products	PlastProd	Business services	BusServ
Glass and glass products	Glass	Medical, dental and other health services	MedDent
Non-metallic minerals	NonMetMin	Other community services	OthComServ
Basic iron and steel industries	BasIrSt	Other producers	OthProd
Basic non-ferrous metals	BasNFer		

APPENDIX 2

2.1 Elasticity of substitution between capital and labour in the South African economy

Industry	Elasticity of substitution	Industry	Elasticity of substitution
Agric	0.74	MetProd	0.91
Coal	0.38	Macheq	0.77
Gold	0.42	ElecMach	0.66
Othmin	0.29	Telv	0.83
Food	0.34	ProfEq	0.77
Bev	0.28	MotVeh	0.66
Tob	0.66	OthTrnsp	0.91
Text	0.66	Furn	0.58
Wear	0.78	OthInd	0.66
Leath	1.02	Elect	0.26
Foot	0.81	WatSup	0.173
Wood	0.38	BuildCnst	1.05
Paper	0.36	Civil	0.91
Print	0.61	WhSale	0.74
Coke	0.28	CatAcc	0.5
BasChem	0.83	TranspStor	0.66
OthChem	0.27	Com	1.45
RubProd	0.85	FinIns	0.34
PlastProd	0.73	BusServ	0.29
Glass	0.72	MedDent	0.35
NonMetMin	0.69	OthComServ	0.66
BasIrSt	1.01	OthProd	0.66
BasNFer	0.81		

Source: Own calculations

2.2 Estimated Armington elasticities

Product	Armington elasticity	Product	Armington elasticity
Agric	0.318	<i>MetProd</i>	0.85
Coal	1.423	<i>Macheq</i>	1.07
Gold	No imports	ElecMach	0.94
Othmin	0.94	Telv	0.91
Food	1.14	ProfEq	0.99
Bev	0.68	MotVeh	0.71
Tob	0.73	OthTrnsp	1.37
Text	1.24	Furn	0.75
Wear	0.68	OthInd	0.43
Leath	1.83	Elect	0.94
Foot	0.94	WatSup	No imports
Wood	0.37	BuildCnst	1.57
Paper	1.37	Civil	2.84
Print	0.42	WhSale	0.94
Coke	0.47	CatAcc	0.94
BasChem	0.56	TranspStor	1.17
OthChem	0.71	Com	0.94
RubProd	1.00	FinIns	0.94
PlastProd	0.94	BusServ	0.98
Glass	0.35	MedDent	1.05
NonMetMin	0.94	OthComServ	0.58
BasIrSt	0.94	OthProd	0.65
BasNFer	0.94		

Source: Own calculations

2.3 Household expenditure elasticities for the household consumption commodities distinguished within the model

Product	Expenditure elasticity	Product	Expenditure elasticity
Agric	0.99	<i>MetProd</i>	0.86
Coal	1.72	Macheq	0.72
Gold	0	ElecMach	0.03
Othmin	0	Telv	2.24
Food	0.96	ProfEq	1.2
Bev	1	MotVeh	1.2
Tob	0.05	OthTrnsp	1.41
Text	0.43	Furn	1.85
Wear	0.25	OthInd	0.19
Leath	0.89	Elect	0.89
Foot	0.89	WatSup	0.62
Wood	0.65	BuildCnst	0
Paper	1.11	Civil	0
<i>Print</i>	0.75	WhSale	0.81
Coke	1.62	CatAcc	0.9
BasChem	1.69	TranspStor	1.68
OthChem	1.17	Com	2.31
RubProd	0.35	FinIns	1.84
PlastProd	0.71	BusServ	1.28
Glass	0.83	MedDent	1.83
NonMetMin	0.89	OthComServ	0.72
BasIrSt	0	OthProd	0.72
BasNFer	0		

Source: Own calculations

APPENDIX 3**A Stylised Macro Model Useful for Analysing Results from a CGE model such as GTAP*****Levels equations***

$$Y^{MP} = C + I + G + (X - M) \quad (1)$$

$$Y^{FC} = F_Y(L, K) \quad (2)$$

$$Y^{MP} = Y^{FC} + Y^{TAX} \quad (3)$$

$$P^C C = P_{GDP}^{FC} Y^{FC} \times \Omega \quad (4)$$

$$\frac{C}{G} = \Gamma \quad (5)$$

$$M = F_M(Y^{MP}, RER) \quad (6)$$

$$X = F_X(-RER) \times Y_W \quad (7)$$

$$\frac{I}{K} = G_I\left(\frac{ROR}{ROR^{REQ}}\right) \quad (8)$$

$$RER = \frac{P_{GDP}^{MP}}{(\phi P_w)} \quad (9)$$

$$P_{GDP}^{MP} = P_{GDP}^{FC} (1 + T) \quad (10)$$

$$TOT = \frac{1}{\{F_{TOT}(X) \times P_w\}} \quad (11)$$

$$\frac{P^C}{P_{GDP}^{MP}} = \frac{1}{F_{PGDP}(TOT)} \quad (12)$$

$$\frac{K}{L} = F_{KL}\left(\frac{RP_L}{RP_K}\right) \quad (13)$$

$$RP_L^{S_L} = RP_K^{-S_K} \quad (14)$$

$$RP_L = F_{RP_L}\left(RW, \frac{1}{TOT}\right), (1 + T) \quad (15)$$

$$RP_K = F_{RP_K}\left(ROR, \frac{1}{TOT}\right), (1 + T) \quad (16)$$

Source: (Adams, 2003)