CHAPTER 11

LONG-RUN POLICY SIMULATION RESULTS

11.1 INTRODUCTION

This chapter reports the results of the long-run policy suggestions for the South African economy. As in chapter 11, the effects of the suggested policy proposals on the macroeconomic aggregates and selected industries are analysed and reported. Of particular interest is the effect that the policy will have on consumption, welfare and the competitiveness of the South African economy. Because a certain level of technological innovation is assumed in the second policy simulation, the results will provide important insight into the level of technological innovation that needs to be achieved in order to obtain a positive benefit for both the economy and the environment.

The results of long-run simulation 1 (LRsim1) are reported in section 11.3 and the results of the second policy suggestion (LRsim2) are reported in section 11.4. Because of the importance of the findings in simulation 2, section 11.5 is used to report results of simulations that establish the relationship between technological innovation and the tax that is needed to fund the innovation.

11.2 A FIFTY PERCENT TAX ON COAL: THE LONG-RUN CONSEQUENCES

11.2.1 The macroeconomic results

As is the case in the short-run simulation, the stylised model proposed by Adams (2003) is used to obtain an expectation of the macroeconomic consequences that the tax has on the South African economy in the long run. It is important to note that the capital stock is allowed to change in the long run. Apart from the capital stock, the unskilled and informal sector labour force is also allowed to change. The supply of land, skilled and highly skilled labour is fixed. The assumption with regard to the South African labour market is made to reflect the high level of unemployment of unskilled labour in the country, which seems to be a problem with long-term dimensions.

With reference to equation (17) of the stylised model, the tax on the intermediate use of coal should increase the price of the variable factors of production. This would be the case if the terms of trade decreased or remained constant. The real rate of return is fixed by assumption. The simulation results, however, indicates that the terms of trade will actually increase which results in a decrease in the price of the variable factors of production.

$$RP_V \downarrow = F_F\left(ROR, \frac{1}{TOT \uparrow}, (1+T \uparrow)\right) \quad (17)$$

Because the combination of the terms of trade effect and the fall in the price of the variable factor of production has significant consequences for the South African economy, the effects of these changes are analysed first.

Equation 7 of the stylised model indicates that an increase in the terms of trade results in a decrease in the demand for South African exports.

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

The decrease in the demand for exports should result in a decrease in output (if one assumes that all other demand components remain constant). This is illustrated by equation 1.

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

As indicated in equation 2, the fall in the output will result in a decrease in the demand for the variable factors of production (capital, unskilled labour and informal labour).

$$Y^{FC} \downarrow = F_Y(\overline{F}, V \downarrow) \quad (2)$$

Because the rate of return is fixed (by assumption), the decrease in the use of capital (the variable factor of production) should result in a decrease in investment. This is indicated by equation (8).

$$\frac{I \downarrow}{K \downarrow} = \overline{\Phi} \quad (8)$$

With consumption being a function of GDP at market prices, consumption decreases, as indicated by equation (4).

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

Finally, because of the significant increase in the terms of trade, the price of the fixed factors of production (highly skilled labour, skilled labour and land) also decreases. Although the terms of trade effects were higher in the short-run simulations, the fixed factors of production are a much smaller portion of total production in the long-run simulations and the prices of these factors are therefore much more sensitive to terms of trade changes.

$$RP_F \downarrow = F_{RPF}\left(RW, \frac{1}{TOT \uparrow}, (1 + T \uparrow)\right)$$

The simulation results confirm prior expectations. Table 11.1 reports the results for selected macro-economic aggregates.

Table 11.1: The estimated macroeconomic effects of imposing a 50 percent tax on the intermediate use of coal (percentage changes): Long run

Real GDP	-0.76
Employment	-0.25
Consumption	-2.05
Investment	-1.34
Exports	-0.76
Imports	-0.51
Terms of trade	0.190
Price of exports	0.190
Price of capital	-0.238
Price of highly skilled labour	-2.987
Price of skilled labour	-3.191
Price of land	-1.963

11.2.2 The terms of trade

The terms of trade increase because of the increase in the price of exports. Although the tax policy results in a decrease in the prices of the fixed factors of production, it is not enough to offset the

increase that is caused by the tax on coal. It is therefore not surprising that the products that make intensive use of coal in the production process experience the biggest decline in exports. These industries are the usual suspects - the coke and refined petroleum, basic iron and steel and electricity industries. The fall in the prices of fixed factors of production, however, hold positive effects for the exports of those products that do not make intensive use of coal. The services industries especially benefit from increased exports because of the fall in the prices of highly skilled and skilled labour.

11.2.3 Consumption

The fall in aggregate real consumption is large. Analysis of this decrease indicates that it is the result of a fall in nominal income, which is not offset by the fall in consumer prices.

Consumer prices fall because of the fall in the prices of the fixed factors of production. It is clear from the simulation results that the increase in the prices of the variable factors of production (capital and unskilled labour), plus the addition of the tax, is not enough to offset the decrease in the price of the fixed factors of production (land and skilled labour). As a result, the aggregate consumer price decreases (0.32 percent). Despite this, nominal income of households decreases. The wages of the highly skilled and skilled labour fall, while the number of unskilled and informal sector labourers that are employed decrease.

The fall in aggregate consumption is reflected by a fall in consumption across all households. There are, however, distributional effects, as the high-income households experience a bigger decrease in the prices of their consumer basket than that of the low-income household. Table 11.2 reflects the change in consumption and consumer prices for the different households.

Table 11.2: Changes in real consumption and consumer price baskets of household groups

Income group	Decrease in consumption	Decrease in consumer price basket
D0	-2.40467	0.025136
D1	-2.31492	-0.06677
D2	-2.21489	-0.169
D3	-2.1458	-0.23948
D4	-2.09769	-0.28851
D5	-2.08094	-0.30556
D6	-2.05287	-0.33413
D7	-2.06117	-0.32569
D8	-2.07802	-0.30853
D91	-2.05345	-0.33354
D921	-2.04272	-0.34446
D922	-2.02634	-0.36112
D923	-2.0045	-0.38332
D924	-1.94226	-0.44655

11.2.4 The effect on the demand for coal

The domestic demand for coal decreases with 1.13 percent. As is the case for the short-run simulation results, the fall in the demand for coal is mostly the result of a decrease in output of the industries that make significant use of coal in the production process (the coke and refined petroleum industries, the basic iron and steel industries and the electricity industries). Because of the lack of alternative sources of energy, there is no substitution effect and the considerable high level of taxation results in a relatively small decrease in the use of coal. It is debatable whether this small decrease could result in a positive environmental benefit. It does, however, serve as further motivation for the allocation of sufficient investment in research, development and technological innovation in order for the South African economy to be less dependant on coal as a primary source of energy.

11.2.5 Industry specific results

It is evident from the macroeconomic aggregates that the tax policy has negative effects on the South African economy over the long term. The industries that are most affected by the tax on coal are those industries that are highly dependant on coal in the production process. These industries experience a decline in both the domestic and the foreign demand for their product. Table 11.3 reports the decrease in the demand components of the coke and refined petroleum industry, the basic iron and steel industry, and the electricity industry.

Table 11.3: The change in the demand components of selected industries

	Intermediate demand	Household demand	Export demand
Coke and refined petroleum	-0.58	-1.26	-2.42
Basic iron and steel	-0.83	0	-6.56
Electricity	-1.24	-1.6	0.13

The level of investment in these industries also fall significantly with the investment expenditure of the coke and refined petroleum industry falling by 4.13 percent. Investment in the basic iron and steel industry falls by 8.02 percent and the electricity industry experiences a fall in investment of 1.34 percent.

11.3 A FIFTY PERCENT TAX ON COAL THAT IS USED TO FUND TECHNOLOGICAL CHANGE

The results of the simulations that assume a short-run closure indicate that there is a need for technological innovation in order to reduce the dependence of the South African economy on coal. The simulation results above confirm that this would also be the case over the long run. The results of the long-run simulation indicate that the proposed tax policy will raise intermediate tax revenue of R 5.94 billion per year. In the simulation results that are reported below, it is assumed that this revenue is used to subsidise investment in technological innovation to reduce the use of coal by 50 percent. This level of technological innovation is found to be the lowest level of technological improvement that would negate the negative effects of the 50 percent tax in terms of economic growth welfare and employment. Although technological innovation that reduces the use of coal by 30 percent would already have positive effects on economic growth, it would not negate the

negative effect that the tax on coal has on employment and welfare of the society. A technological innovation that reduces the use of coal by 40 percent would have positive effects on economic growth and welfare but it would not negate the negative effects of the tax policy on employment. The result of a technological innovation that reduces the use of coal by 50 percent is reported below.

11.3.1 Macroeconomic results

The simulation results indicate that technological innovation has a positive effect on the South African economy. The effects of the tax changes should be the same as in the first long-run simulation, but, the technological change introduces significant positive effects to the economy, which offsets the negative effects of the tax policy.

Because of technological change, it is difficult to obtain a prior expectation of the movements in the macroeconomic aggregates, and the results are therefore reported in Table 11.4. These results are then used, along with the stylised model, to obtain economic insight into the effect that the policy shock has on the macroeconomic aggregates.

Table 11.4: The policy simulation effect on the macroeconomic aggregates in the SA economy

Real GDP	1.248
Employment	0.020
Consumption	0.918
Investment	-0.408
Exports	0.824
Imports	-0.496
Terms of trade	-0.205
Price of exports	-0.205
Price of capital	0.168
Price of highly skilled labour	1.816
Price of skilled labour	1.705
Price of land	-2.243

As was the case in the first long-run simulation, highly skilled labour, skilled labour and land are assumed to be the fixed factors of production, while capital, unskilled labour and informal sector labour are assumed to be the variable factors of production.

Because it is assumed that the rate of return and the real wages of unskilled and informal sector labour are constant, equation (17) indicates that the tax increase and negative terms of trade effect will result in an increase in the real price of the variable factor of production. The simulation results indicate that the terms of trade effect is indeed negative.

$$RP_V \uparrow = F(\overline{ROR}; \frac{1}{TOT \downarrow}; (1 + T \uparrow)) \qquad (17)$$

Equation (15), which relates the prices of the fixed and variable factors of production is also affected by the technological change. It is evident that the effect of technological change on the price of the fixed factors of production is ambiguous, and it depends on whether the change in the price of the variable factors of production is bigger than the technological change. The results summarised in Table 11.4 suggest that the technological change is bigger than the change in the price of the variable factor of production, which implies that the price of the fixed factor of production increases (highly skilled labour, skilled labour and land).

$$RP_v^{S_V} \uparrow = \frac{A \uparrow}{RP_F^{S_F} \uparrow} \qquad (15)$$

Equation (14) indicates that the simultaneous increase in the fixed and the variable factors of production will have a positive effect on the employment of the variable factors of production if the price increase in the fixed factors of production is higher than the price increase in the variable factors of production. The results in Table 11.4 suggest that this is indeed the case, as the use of capital and unskilled labour increases.

$$\frac{V \uparrow}{\overline{F}} = \frac{RP_F \uparrow}{RP_V \uparrow} \qquad (14)$$

The increase in the employment of the variable factor of production and the technological innovation increases GDP at factor prices (equation 2).

$$Y^{FC} \uparrow \times A \uparrow = F(\overline{F}, V \uparrow) \qquad (2)$$

As indicated by equation (3), the increase in GDP at factor costs implies an increase in gross domestic product at market prices.

$$Y^{MP} \uparrow = Y^{FC} \uparrow + \overline{Y} \uparrow^{TAX} \qquad (3)$$

The trade balance is fixed by assumption, although there are changes in both the import and export component of the trade balance. Because economic activity increases, final consumption expenditure will also increase (equation 4).

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

Government consumption expenditure is fixed by assumption, while investment expenditure decreases. The decrease in investment expenditure is the result of the increase in the use of capital, while the rate of return for investment is fixed (equation 8).

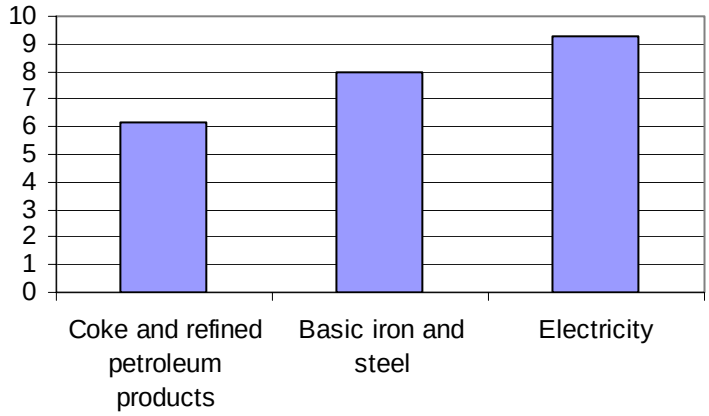
$$\frac{I}{K} = \Phi \qquad (8)$$

It is evident that the technological innovation leads to an increase in economic growth, which results in an increase in consumption. Investment decreases slightly, however, because of the fall in the use of capital. The decrease in the use of capital is countered by an increase in the use of labour. This should be seen as a positive result for the South African economy because of the high levels of unemployment that persist in the country.

11.3.2 Terms of trade

There is a decrease in the terms of trade, which is the result of a fall in the price of exports. The significant tax on coal is offset by a number of factors that allow the price of exports to decrease. These factors include the technological innovation that reduces the cost of producing basic iron and steel, coke and refined petroleum products and electricity. Apart from the technological change, the fall in the price of land also contributes to the decrease in the price of exports. Figure 11.1 shows the increase in the exports of selected industries as a result of the change in the price of exports.

Figure 11.1: Increase in exports of selected industries

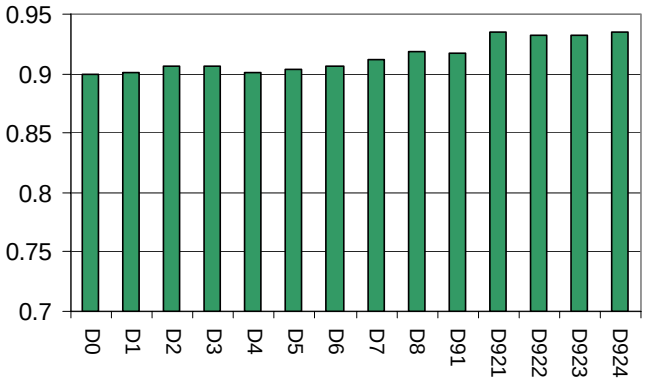


Apart from the increase in exports, there is an increase in imports. The increase in imports is the result of the increased economic activity, and it is especially the imports of transport equipment that experience a significant increase in imports (5.18 percent).

11.3.3 Consumption

The increase in real consumption is the result of an increase in the nominal income of households, which is partly offset by an increase in the prices of consumer goods. The nominal income of households increases as a result of the increase in the real wages of the highly skilled and skilled labour force. Apart from the increase in real wages, the increase in the employment of unskilled and informal sector labour also contributes towards the increase in nominal income. The policy proposal does not have a positive effect on the distribution of welfare although, consumption across all households increases by roughly the same magnitude. Figure 11.2 reflects the increase in household consumption across all households.

Figure 11.2: Change in household consumption after the policy shock



A breakdown of household consumption indicates that the use of electricity will increase significantly across all household income groups. Apart from this, households will also increase their expenditure on television sets and furniture. Table 11.5 summarises the change in individual household consumption and consumer prices.

Table 11.5: Changes in real consumption and consumer price baskets of household groups

Income group	Increase in consumption	Increase in consumer price basket
D0	0.899	0.378
D1	0.900	0.377
D2	0.905	0.372
D3	0.905	0.372
D4	0.901	0.376
D5	0.903	0.373
D6	0.906	0.371
D7	0.911	0.365
D8	0.919	0.358
D91	0.917	0.360
D921	0.935	0.342
D922	0.931	0.345
D923	0.932	0.345
D924	0.935	0.342

11.3.4 The effect on the demand for coal

The demand for coal decreases with 13 percent, which is the result of a decrease in intermediate demand (16.64 percent) and household demand (0.71 percent). Foreign demand for coal increases by 4.34 percent. The decrease in the intermediate and household demand for coal constitutes a decrease in the domestic demand for coal of 18 percent. This is a significant decrease in comparison with the decrease that was experienced in each of the policy simulations where technological change was held constant. In contrast to the previous policy proposals, the decrease in the demand for coal is not the result of a decrease in the output of the coal intensive industries – it is the result of the improved technology. The industry that bears the brunt of this policy proposal

is the coal industry. The demand for the coke and refined petroleum industry's product increases by 2.26 percent, the demand for electricity increases by 1.47 percent and the demand for basic iron and steel increases by 4.48 percent.

The 18 percent decline in the domestic use of coal represents an improvement in the environment.

11.3.5 Industry specific results

The industry that experiences the biggest decline in final demand is the coal industry, which constitutes a decline in domestic use of coal and an increase in exports. The 13 percent decline in the demand for coal is accompanied by a 17 percent decline in employment within the coal industry. The decline of the coal industry is offset by increases in the output of the coke and refined petroleum industries (2.26 percent), the basic iron and steel industries (4.48 percent) and electricity industries (1.47 percent). The increase in these industries is accompanied by an increase of employment in these industries.

11.4 THE RELATIONSHIP BETWEEN THE TAX ON COAL AND TECHNOLOGICAL INNOVATION

The result of the second long-run simulation (LRSim2) is exciting, as well as daunting. It implies that the tax revenue that is raised from a 50 percent tax on coal needs technological innovation that reduces the use of coal by 50 percent in order for the policy proposal to have positive effects on economic growth, welfare and employment. In order to determine whether the "one-on-one" relationship between the tax increase and technological innovation holds across tax proposals of between 10 and 50 percent, simulations were performed that tested the effect of a 10, 20, 30, 40 and 45 percent increase in the tax rate on coal and an improvement in technological innovations of the same magnitude. Table 11.6 summarises the effects of the policy proposals on economic growth, consumption and employment.

Table 11.6: Tax and technological innovation: The effect on selected macroeconomic aggregates (percentage changes)

Simulation	Tax proposal	Innovation	Effect on economic growth	Effect on consumption	Effect on employment	Tax revenue (R billions)
LRSim3	10	10	0.18	0.016	-0.014	R 1.511
LRSim4	20	20	0.39	0.11	-0.019	R 2.803
LRSim5	30	30	0.64	0.29	-0.015	R 3.881
LRSim6	40	40	0.92	0.561	-0.0018	R 4.746
LRSim7	45	45	1.083	0.728	0.008	R 5.097

The results summarised in table 11.6 indicate that a tax proposal, which funds a technological innovation that reduces the use of coal with the same amount as the tax increase, should have unambiguous positive effects for economic growth and consumption. This result is not applicable for the effect on employment - it is only when a tax increase of 45 percent funds a technological improvement that reduces the use of coal by 45 percent that the economy obtains a positive dividend for employment as well. Although it is highly unlikely that such a one-on-one relationship will be pursued, it is clear that the percentage change in the technological innovation that is funded by the tax increase will have to be higher than the proposed increase in the tax rate. Table 11.7 reports the effects of combinations of tax and technological increases which is higher than the suggested tax increase.

Table 11.7: Tax and technological innovation: The effect on the economy

Simulation	Tax increase	Technological innovation	Economic growth	Consumption	Employment	Demand for coal	Revenue
LRSim8	10	10	0.18	0.016	-0.014	-2.54	R 1.511
LRSim9	10	15	0.35	0.238	0.003	-3.70	R 1.641
LRSim10	20	20	0.39	0.11	-0.019	-5.09	R 2.803
LRSim11	20	25	0.57	0.35	0.0007	-6.29	R 2.887
LRSim12	30	30	0.64	0.29	-0.015	-7.67	R 3.881
LRSim13	30	35	0.83	0.56	0.0070	-8.91	R3.911
LRSim14	40	40	0.92	0.56	-0.0018	-10.30	R 4.746
LRSim15	40	45	1.08	0.72	0.008	-11.64	R 5.097
LRSim16	50	50	1.24	0.91	0.029	-13.00	R 5.394
LRSim17	55	50	1.20	0.80	0.0076	-13.05	R 5.726

These results confirm that the technological change that the tax revenue will fund should be higher than the tax increase in order to obtain positive benefits for employment up to a level of a tax increase of 50 percent. At this level a one-on-one relationship between the tax increase and the technological innovation results in a positive employment benefit. From this level the technological innovation can be less than the tax increase for the policy to result in a positive benefit for employment and the environment. Not surprisingly it is also clear that high levels of technological and tax change, holds the highest benefit for the environment.

11.5 CONCLUSION

The results from the long-run policy simulations indicate that technological innovation is a necessary development for South African policy makers to obtain a sustainable environmental policy. The result of the first simulation, in which the tax policy is unable to significantly reduce the demand for coal, prompts the introduction of technological change as part of the policy recommendation.

The assumption that the introduction of an environmental tax could induce positive technological change is consistent with the Porter Hypothesis of technological change. The introduction of the tax provides both an incentive to the polluting industries to reduce their use of coal as well as revenue

that could be used to fund research and development projects to achieve the relevant levels of technological efficiency.

The results from the policy simulations that assume certain levels of technological change indicate that a combination of environmental tax and technological changes will hold positive benefits for the South African environment, economic growth, consumption and unemployment.