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UNIVERSITY OF CAPE TOWN

**Assessing the Price Impacts on South African
Industry and Households Arising From a 10%
Increase in Fuel Taxes**

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Chapter 1

Introduction

A complex web of laws and industry agreements regulates the South African petroleum industry. Until 1993, the Petroleum Products Act of 1977 forbade the '*publication, releasing, announcement, disclosure or the conveyance to any person of any information or the making of comment regarding the source, manufacture, transportation, destination, storage, consumption, quantity or stock level of any petroleum product acquired or manufactured for or in the Republic*'. As a result, historical industry information and statistics can be difficult to obtain.

In essence, the price of petrol in South Africa can be broken down into two main elements:

⇒ Internationally determined element

This consists mainly of purchasing and transporting the oil and is largely beyond the control of the SA Government, and a

⇒ Domestic element

This includes the levies over which Government exerts control.

These levies are currently:

Fuel Taxes

A tax levied by Government and administered under the Customs and Excise Act

Customs & Excise taxes

A duty collected in terms of the Customs Union¹.

Road Accident Fund Levy

The Road Accidents Fund (RAF) receives a percentage that is used to compensate third party victims involved in motor accidents on South African roads.

¹ This component of the fuel tax does not form part of the fuel taxes that are analysed by this study.

Under the Internationally determined element, the petrol price in South Africa is directly linked to the price of petrol in U.S. dollars in certain international petroleum markets. The specific markets referred to are those 'East of Suez' including, inter alia, the Arabian/Persian Gulf, the Pacific Rim countries and Australasia, wherein crude oil - the major ingredient in all liquid fuels in South Africa - is quoted and paid for in U.S. dollars.

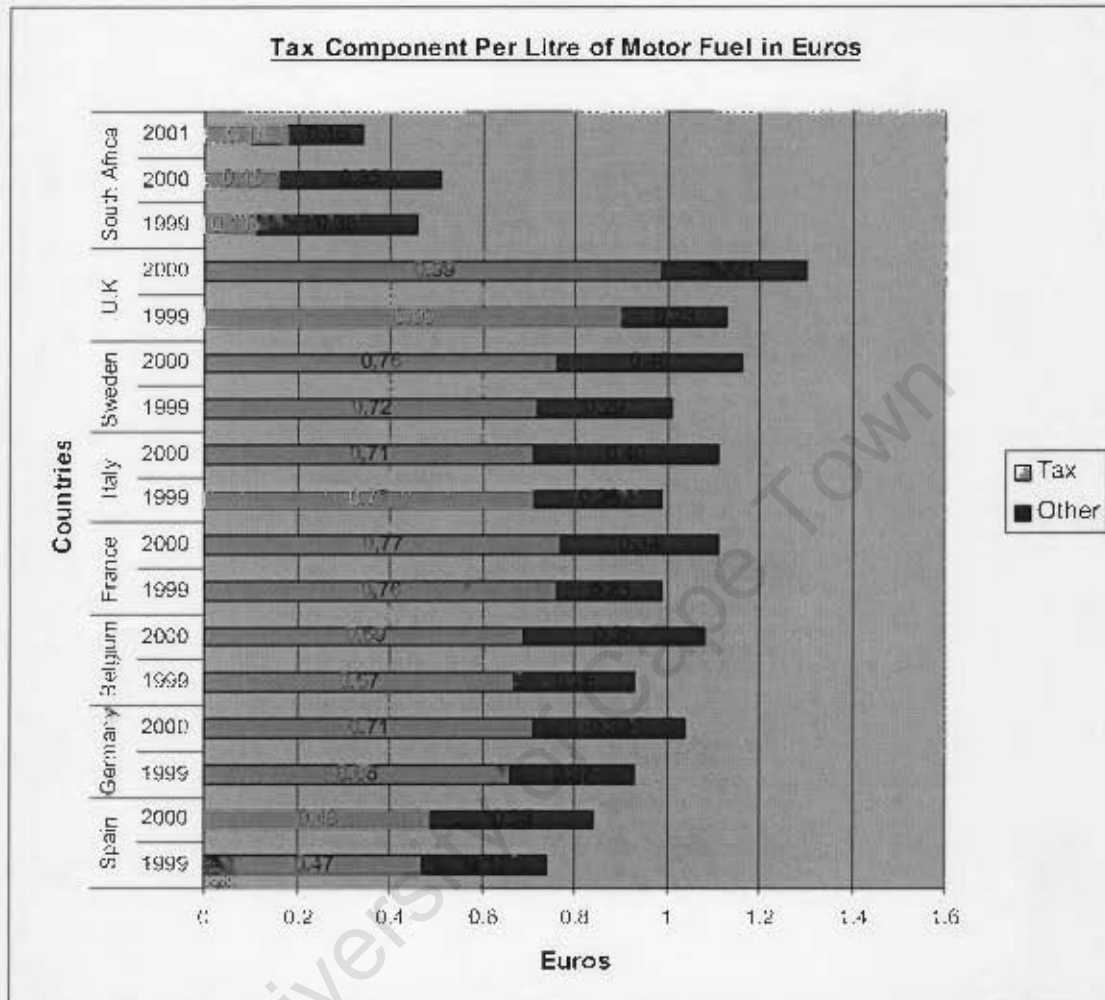
Interestingly, according to the SA Energy Profile (1998:26-27), "*The major components of the petrol price as at May 1997 were the IBLC (39%)² and the fuel tax (36%). From an international perspective, the South African fuel tax is relatively low and in view of petrol's price inelasticity, the government's need for greater tax revenue and the perception that private transport is a luxury item, the tax on the price of petrol was increased by 10c a litre in the March 1998 budget.*"

More recently, in the 2000/2001 year the oil price surged by as much as 160% to \$29/barrel in what was regarded as one of the 5 big oil price shocks of the past 30 years. On top of this, in the February 2000 Budget Speech the South African government announced an increase of 5c/l in fuel taxes to be levied. Considering that these two elements are the most significant contributors to the final cost of petroleum, it is clear that the price of petrol rose rather significantly in this period.

Focussing specifically on fuel taxes, in South Africa, as with certain other countries (e.g. Norway, Germany and Denmark) the fuel price includes a significant tax component, often close to/around 50% of the retail price.

² Refer to Appendix 1 for explanation of what the IBLC (In-Bond Landed Cost) is and how it is calculated

Graph 1.1³



European Prices quoted are for premium-unleaded gasoline

Source: the European Commission Directorate General for Energy

The above diagram clearly supports the SA Energy Profile (1998) assertion with regard to the level of fuel taxes in South Africa compared to other countries.

³ The South African figures represent the fuel price and tax at the 1 January 2000, 2001 and 2002, with the exchange rate being based on the 31 December 1999, 2000 and 2001 Rand: Euro exchange rates.

However, a straightforward comparison such as the one above is misleading unless the objectives behind the levying of fuel taxes in any country are properly understood. In this regard, some general objectives employed by Governments worldwide are:

- 1) To achieve environmental objectives
- 2) To influence consumer behaviour (conserve fuel as it is an expensive commodity)
- 3) As a means of raising revenue for the Government, aligned to the fact that it is an easy tax to collect
- 4) Per the SA Energy quote, to tax the wealthy as only the wealthy can afford cars (redistribution) etc.

These objectives cannot be viewed as mutually exclusive as an alteration of fuel taxes will have an effect on all of the above simultaneously.

The first and second objectives should be seen as highly interlinked. In recent times, fuel taxes, and more specifically, the implementation of carbon taxes on fossil fuels with high carbon contents, have been gaining considerable currency as an environmental tool in many parts of Europe and Australia (OECD, 1993). The idea behind such a tax is specifically to influence consumer behaviour away from the use of such fuels and increase the use of non-polluting sources of energy instead in order to achieve environmental objectives.

Furthermore, with the World Summit on Sustainable Development that was held in Johannesburg, there is a focus on employing more sustainable energy sources instead of depleting the limited source of fossil fuels. One means of conserving the usage of current energy sources is to levy high taxes on it so as to force the consumer to re-consider whether their utility gained from such an energy source is still as beneficial as compared against a more environment-friendly alternative energy source. Thus, the South African Government may insist that higher fuel taxes are needed in order to curb the use of fossil fuels by South Africans.

However, with regard to attempting to utilise high levels of fuel taxes to achieve environmental objectives, the OECD (1993:5) has a fair warning: *“Governments accustomed to taxing energy to raise revenue or for security may contemplate taxing energy to discourage its use, and implicitly, to reduce energy-related pollution...*

...Decisions about incentive taxes should not be made in a vacuum. The wish to use energy taxes as environmental policy tools requires an understanding of the existing array of taxes affecting energy, a profile of energy use, and a profile of energy-related pollution.”

One of the main reasons why Europe has such high fuel tax contents is because of the second objective specifically. The European public transport system is highly advanced, extremely reliable and generally viewed as safe. Furthermore, as it is a means of mass transport, it is therefore capable of reducing the usage of liquid fuel consumption for transport purposes if people can be persuaded to forfeit the use of their own vehicles in favour of such public transportation. The only way to achieve this, aside from ensuring the safety and punctuality of the public transportation system, is to ensure that it is a cheaper mode of transport for the commuter instead of his/her own vehicle. As a result, and with the added benefit of additional revenue for the Government from those who would still rather use their own vehicles, the Governments of Europe have artificially inflated the cost of their liquid fuels by levying high levels of taxation thereon.

In South Africa, the same cannot be realistically said about our means of public transportation. Those who can afford their own vehicles use them to travel everywhere, whilst the poorer Households who cannot afford their own vehicles are forced to use mini-bus taxis, busses and/or trains. The general view is that the public transportation system in South Africa is unreliable, and often questions are asked about safety levels as well. Thus, by comparison to Europe, the reason behind the lower fuel tax content is clear. Fuel taxes in South Africa are levied for revenue purposes, and cannot be assumed to have an element of an incentive tax in them that attempts to convert all South Africans into users of the public transportation system, as is the case in Europe.

Perhaps in the future this may be a realistic assumption, given the move in Gauteng to create the Shilowa Express. Thus super-train is envisaged in part to reduce the congestion and degradation of the roads by enticing commuters to stop using their own vehicles through the provision of an alternate and reliable means of public transport. At the present time though, such an assumption would not be fair in South Africa.

With regard to the third objective, the SA Energy Profile (1998) indicates that the petrol price curve is inelastic, and therefore no matter what level the fuel tax is set at, the Government can be comfortably assured that fuel consumption will only be marginally affected⁴. Aligned to this, is the fact that the highly regulated environment in which South African petrol stations operate facilitates the collection and administering of such a tax. Because of all this, this source of revenue generation is ideal for Government.

The last objective applies more specifically in a South African context. Again, as the SA Energy Profile (1998) article pointed out, there is a perception that private transport is a luxury item, and as such, revenue generated by fuel taxes will be at the expense of wealthier people. This assumption is usually made with regard to fuel taxes, as it is only the wealthy that are generally viewed as being able to afford their own motor vehicles. An analysis of the validity of this assumption is therefore a crucial focal point of this study's assessment of the welfare impact on Households arising from the increase in fuel taxes. This issue is dealt with specifically under the assessment of the type of income Household that will be forced to bear the greatest relative burden of the price impacts, particularly once the indirect effects have been accounted for.

The same article also goes on later to state that in 1997, the main use of liquid fuels was for transport and that the transport sector consumes around 90% of all petroleum products marketed in South Africa. Thus, in an environment of extremely high international fuel prices and increasing fuel levies, the effectiveness of these domestic fuel taxes becomes

⁴ Refer to Appendix I for analysis of fuel tax and fuel price increase compared to fuel consumption levels in South Africa.

questionable, especially as the prices of petroleum products will have an effect on the CPI (Consumer Price Index), and the PPI (Producer Price Index), and consequently on inflation and economic growth. The inflation aspect is of specific concern to the Reserve Bank given their strict inflation targets and the fact that they failed to meet the 2001 targets that were set, mainly because of fuel price shocks.

With regard to the implications, particularly the indirect effects, generated through the levying of fuel taxes, Henderson (Oil Industry Controlled Prices and Customs Adviser: SAPIA⁵ Annual Report, 1998:23-24) raises some valid points:

“...High taxes in this area are common around the world, because the extensive and essential use of fuel makes it a powerful fiscal force. Yet fuel tax is also an extremely sensitive instrument.

Taxes on fuel today (1997/98) amount to more than R16 billion rand a year – which is a sum greater than the contribution to the gross national product of South African mining and commerce together. Fuel taxes represent more than 8 percent of all the money Inland Revenue and Customs and Excise are budgeted to collect from all sources in the 1997-98 tax year.

Fuel taxation, therefore, requires special attention and careful administration. It affects every motorist and every family, not only directly, but by the way the tax impacts on the economic environment. The cost of petrol and diesel affects the business of major fuel users in the economy such as agriculture, fishing, mining and road transport, as well as those in trade, commerce and export manufacturing, and impacts on inflation rates.

‘Clearly so complex and sensitive a tax requires constant monitoring, modifying and sometimes a major re-think in policy...’

An important issue being raised by Hendersen (1998) is that obtaining revenue from fuel taxation comes at a price, and that price is reflected in the increased cost of economic

⁵ SAPIA stands for South African Petroleum Industry Association

activity in the country. Hendersen (1998) highlights in particular the importance of considering the downstream indirect effects associated with fuel taxes. In this regard, it is not only Industry activity that is noted to be affected, but also Household welfare issues that are an important focus of this study as well.

With regard to the latter point, the following extract of an article by Maharaj (2000) highlights this problem: *“Millions of households in the developing world still lack access to safe and reliable energy – and pay high prices for poor quality substitutes (in South Africa, this can be seen as the use of paraffin (which until 2001 attracted VAT⁶) as opposed to electricity) ...*

... The International Bank for Reconstruction and Development this year (2000) published a resource, “Energy Services for the World’s Poor”, to help address this challenge. Its main theme is how a developing country’s government concerned with tackling poverty among its citizens should think about its role in the energy sector. What kinds of energy policy and projects are likely to have the most beneficial and sustainable impact in terms of alleviating poverty? And where should energy policy advisers concerned with promoting development and improving the lot of the poor focus their efforts?”

It is precisely these type of welfare and social development issues that are so clearly a concern at the World Summit on Sustainable Development, not only currently, but also at the Rio Summit held a few years ago.

Clearly therefore, in order to set fuel tax levels, be they increased taxes to generate revenue or carbon taxes for environmental purposes, a Government must be fully aware of the economic and social implications associated with such a decision.

⁶ “VAT on Illuminating Paraffin was zero rated in April 2001 in order to lower the price of this important fuel to the poorer sections of the community” (SAPIA Website – reference number 4)

Unlike the other major elements of the fuel price in South Africa, the tax component of the fuel price is influenced solely by Government policy. If Government were to alter the level of these levies, it would have a direct impact on the price of petrol/diesel and may thus assist South Africa to:

- (a) limit the negative economic and social effects associated with the current high levels of international fuel prices and,
- (b) stimulate economic growth for the future by reducing the cost of economic activity within the country.

It is against this sort of background that this study therefore models a 10% rise in fuel taxes. There is clearly a need to understand the economic and welfare implications arising from raising revenue via fuel taxation. In addition, it is important to assess the validity of assuming that it is the wealthy that will bear the greatest burden when fuel taxes are increased.

The modelled increase is based on the level of fuel taxation in South Africa in 1997. The underlying information source was the South African Social Accounting Matrix (SAM) that was created and developed for the 1997 year by WEFA Southern Africa for the World Bank⁷. From this SAM database, various models have been built, on the basis of slightly differing assumptions. All these models are developed and presented in Chapter 2, along with an analysis of the assumptions underlying each model and the implications thereof on the findings of this study.

More specifically though, this study attempts to quantify and understand both the direct and indirect price implications of this 10% increase in fuel taxes on South African Industries and Households. Indirect effects arise because economic entities interact with each other by means of purchasing and selling their products to others. These interactions are not only inter-linked in a very complex manner, but most importantly, they allow for costs incurred by one entity to be passed onto others. This means effectively that

⁷ Refer to Appendix II for data description

additional downstream price impacts will also occur from an initial shock to the economy.

As a result, an analysis of direct effects alone will mean that this complex net of linkages and additional price impacts will be ignored. Moreover, as the aim of this study is to understand the economic price impacts of a rise in fuel taxes, it is therefore important to include as much of these indirect effects as possible so as to obtain as complete and accurate a picture as possible.

With respect to capturing the indirect effects, three models are developed within Chapter 2 in order to provide a more detailed picture of the impact arising from the inclusion of differing indirect effects. The net effect of utilising these different models is that a form of sensitivity analysis is inherently built into the results presented in this study, as these results have to be interpreted based on the assumptions underlying the relevant model.

Further, as more indirect effects are captured, the picture of a given scenario becomes more complete, and consequently enhances the depth of the analysis performed thereon.

The results produced by the different models are presented in two separate chapters: Chapter 3 which analyses the results from an Industry production cost perspective, and Chapter 4, which analyses the results from a Household welfare perspective.

With regard to Industry implications, a key focus remains the importance of capturing as many indirect effects as possible. Fuel taxes impact directly and indirectly on the cost of doing business in South Africa, with the indirect impacts expected to differ depending on the role fuel plays in each sector of the economy. In the case of industry, changing the level of fuel taxes will affect the cost of production, which will ultimately impact on the competitiveness of businesses. The results presented in Chapter 3 therefore aim to provide an important understanding of these price impact effects within the context of the local economy, the real drivers behind these effects and the sectors that are most affected by the increased fuel tax. The results are therefore presented and analysed in terms of the

impact on PPI. As this is specifically weighted towards Industry production expenditure, it is considered the more indicative measure of the impact on Industry arising from a 10% rise in fuel taxes.

On the other hand, from a Household perspective, the focus is on the welfare impacts arising from the increase in fuel taxes. Welfare impacts should always be an important concern of any decision-makers formulating energy policy, particularly with the large proportion of disadvantaged communities living in South Africa. More specifically, the concern of this chapter is whether the increase in fuel taxes will be more beneficial or harmful to these poorer communities. In order to perform this analysis of welfare and price impact distribution effects, Households are categorized according to their income earning deciles. Once again, capturing as many of the indirect effects as possible is important in order to obtain as accurate an idea of the type of income Household that will be affected most negatively by the fuel tax rise. In this instance, the results are therefore presented and analysed in terms of the impact on CPI. As this is specifically weighted towards Household consumption, it is considered the more indicative measure of the impact on Households arising from a 10% rise in fuel taxes.

Finally, a policy-modelling scenario wherein the Agricultural sector is exempted from the direct increase in fuel taxes is presented. This scenario was considered necessary in light of recent calls that were made by the Agricultural sector lobbying Government to exempt them from fuel taxes, as well as Government's positive response to this in 2001⁸. The second scenario involved exempting Households and Government from the direct effects of the fuel tax increase. This scenario is evaluated on the basis of both welfare implications and the ability to minimise the resulting price impacts arising from the fuel tax increase. In both cases, the Industry and Household implications are analysed and presented in order to provide a complete picture of the potential effect on these two groups.

⁸ According to the SAPIA 2001 Annual Report, in July 2001 taxation concessions were granted to diesel users in important primary industries such as agriculture and forestry, mining, coastal shipping (including the NSRI), offshore fishing and mineral exploitation.

Chapter 2

Methodology

Introduction

In recent years, fluctuating fuel prices have become a common phenomenon facing every South African as the Rand weakens/strengthens against the U.S. Dollar, and the U.S. Dollar-based value of oil fluctuates daily in world markets.

As fuel is an essential cog in the productive capabilities of any country, the impact of fluctuating fuel prices can have far-reaching effects on an economy. To illustrate, without fuel, there can be no transport and without transport, people cannot get to work and goods cannot be delivered, and hence production and business in general would be severely hampered.

Taking this further, as fuel prices increase, so the cost of doing business will also be expected to increase. Use of PPI, CPI and CPI (x) figures are all examples of the ways in which countries attempt to measure the impact of various shocks, including fuel price fluctuations, to their economy.

The problem inherent in these figures is that they measure the impact arising from multiple shocks, e.g. currency devaluation, food shortages, labour strikes, oil price changes etc. based on the increased price of each of the individual products used in a selected basket of goods.

Consequently, as the aim of this study is to measure both the direct and indirect effects that result solely from a 10% rise in fuel taxes, the published results of the above figures have not been utilised in this study.

Measuring the direct effects is relatively straightforward, and is essentially similar in nature to the manner in which the PPI, CPI and CPI (x) figures are calculated.

Measuring the indirect effects however, is somewhat more difficult and requires the development and use of economic models, as unlike the direct effects calculation, there is no straightforward calculation that has been universally accepted. The models available to measure these indirect effects differ in terms of certain key economic assumptions that have to be made in developing such models, and consequently the results produced will also vary accordingly.

To overcome this problem, three economic models are utilised in this study. The reason behind this is simply to allow for a comparison and understanding of the reason behind the differing results produced by each model, whilst simultaneously assessing the impact – in terms of results - of making certain assumptions. The result is effectively the presentation of an inherent sensitivity analysis under certain assumptions.

This chapter thus aims to provide an understanding and critique of each of the models utilised in this study to ensure that the results produced are fully understood in light of the assumptions and inherent limitations underlying each of the models.

1. Types of Models Available

In this section, the Direct effects model is developed and presented in order to be able to isolate and assess the direct effects of the rise in fuel taxes. Then, in an attempt at capturing and assessing the overall (direct and indirect) effects, an Input-Output model and SAM-based models are similarly developed and presented.

1.1 Direct Effects Model

When fuel taxes are increased by 10%, the consumer's first concern is how much more it will now cost them to fill up their vehicles. If it were assumed that when fuel taxes were increased fuel prices were the only commodity that was impacted upon, then this economic impact can be measured as:

$$\text{Equation 1} \quad \Delta E_i = \left[\begin{array}{c} 0.1 * F_i \\ E_i \end{array} \right]$$

where

i = a specific Industry or Household category

F = Total fuel tax paid by the specific Industry/Household to Government

E = Total expenditure by the specific Industry/Household (before the 10% fuel tax increase) on all Industry/Household purchases

% ΔE = Percentage increase required in E as a result of the 10% rise in fuel taxes in order to retain real income

The following Table is an example of the database that provides the information that enables the above calculation to be performed:

Table 2.1
Direct Cost Information Database

	Demand		Other Demand	Gross Output
	Manufacturing	Agriculture		
Industries	350	600	950	1900
Fuel Tax	150	75		
Other	400	325		950
Total	900	1000	950	

Reading down the column (e.g. agriculture), the information in **Table 2.1** above highlights the amount that the agricultural industry spends on fuel taxes in relation to its total expenditure. It is therefore possible, with regard to this study, to accurately assess what the direct impact of a 10% rise in fuel taxes will be for each individual industry.

As a specific example, the direct impact of the agricultural industry from a rise in fuel taxes by 10% per **Equation 1** will be:

$$\frac{0.1 * \text{Agriculture fuel tax amount}}{\text{Agriculture Total Expenditure}} = \frac{0.1 * (75)}{1000} = 0.75\%$$

This is interpreted as the agricultural sector having to suffer a 0.75% increase in their overall expenditure in order to afford the same amount of fuel as before the 10% fuel tax increase.

One problem with this model though is that the assumption that a rise in fuel taxes will affect only the price of fuel is not entirely true. Even though it is only fuel taxes being increased in this study, a rise in these taxes will increase the price of fuel, which in turn, and to varying degrees, will increase the cost of all products and services that then utilise fuel as an input (e.g. agriculture). This in turn, will also increase the downstream cost of all products and services that then utilise these affected products and services as their

inputs ('knock-on' effects), which leads to yet another series of downstream cost increases being created.

Thus by capturing the direct effects suffered by a *specific* economic group only, this model is in effect capturing only the first component in the above series of effects, and none of the resulting 'knock-on' effects.

More specifically, as this model fails firstly to capture the associated impact of the fuel tax increase on intermediate good purchases, other indirect price impacts that are even further downstream e.g. potential wage increase impacts required to compensate employees for cost of living increases, also cannot be captured.

As a result of the underlying assumption made in developing this model, it is only capable of analysing the impact of changes in an economic group in isolation to the impact that these changes may have on other economic groups, and as is clear from the above description, the series of 'knock-on' effects are a direct consequence of this economic interaction of all groups within the economy.

Thus, the precise reason why this model is incapable of capturing these 'knock-on' effects is its inability to capture the entire range of relationships between all sectors of the economy.

As Roukens de Lange (1989b: 21) points out, this can be a major problem: "*Often economic analyses and calculations are carried out which do not treat the economy as a whole and which may result in partial and potentially flawed insights. To evaluate the quantitative impact on all aspects of the economy of alternative policies, economic forces and events, it is necessary to have an adequate economic model structure that covers the entire economy.*"

Clearly therefore, any model that purports to be even mildly capable of covering the entire economy must at the very least be able to capture the entire range of relationships between all sectors of the economy.

1.2 Input-Output Methods

In this regard, the use of Input-Output methods has become widely accepted for appraising the incidence of energy taxes. Because Input-Output Tables provide the capability to capture, and if necessary, isolate the complex Industrial relationships within an economy that are responsible for the 'knock-on' effects mentioned earlier, they have become the traditional database for models requiring industrial detail.

Moreover, it is also worthwhile noting that Input-Output methods are the one alternative that have already been refined specifically for tax impact analysis, with Rose & Stevens (1988) having utilised an Input-Output model to examine the provisions of the Tax Reform Act of 1986 relating to the oil and gas industry in the U.S.⁹

Labandeira & Labeaga (1999) also notes that Input-Output analyses are well suited to assessing the effects of, amongst others, a carbon tax levied on fossil fuels (coal, lignite, natural and manufactured gas and liquid fuels in this exercise) on the relative prices of industry outputs.

More specifically, *"Input-Output analysis has been most recently used to estimate the price effects of carbon taxation in Australia (Cornwell and Creedy, 1996), Britain, the USA (1996) and Germany (Proops, Faber and Wagenhals, 1993). The preceding studies employed an Input-Output demand model to calculate the CO₂ intensities for each industrial branch – i.e. the carbon contents of their products – which allows for a straightforward computation of the price changes after carbon taxation."* (Labandeira & Labeaga, 1999: 310)

⁹ Bahl and Shellhammer (1969) discuss the range of uses for the Input-Output model to evaluate tax incidence and other tax effects.

The aforementioned carbon tax studies are very similar to this study in that their aim is to assess the price effects of an increase in fuel taxes on the economy. The intensity with which each industry utilises fuel will ultimately influence the price effects that an increase in fuel taxes will have on the economy as a whole.

From the discussions thus far, it is clear that an Input-Output model, as advocated by most energy incidence studies, is the best model available at this point for analysing the price effects on industry as a result of an increase in fuel taxes. However, before getting to the detail of the model itself, one has to first understand the database from which the model is derived in order to be able to interpret the results produced by the model.

1.2.1 Input-Output Tables

The link between being able to capture inter-industry relationships and thereby capturing the 'knock-on' effects that they generate from a shock to the economy can best be understood from the following explanation by Parikh & Bailey (1990: 168):

“In order to produce output, an industry requires certain primary inputs, e.g. labour of various skill types, capital equipment etc., and in addition requires a number of the goods produced elsewhere in the economy as intermediate inputs. Unlike the capital equipment at the disposal of the industry, these intermediate inputs are totally used up during the production process. For example, to produce furniture, the manufacturer must purchase inputs from other industries, such as wood, nails, electricity, paper and packaging, and transportation services in addition to the primary inputs necessary for the production process. In turn, these demands for the aforementioned intermediate goods (wood, nails etc.) give rise to demands by these other industries for intermediate inputs (e.g. fuel by the transportation industry) in order to produce said intermediate inputs (wood, nails etc.) as required in the original industry (furniture), and so on.”

1.2.2 Developing the Input-Output Price Model ¹⁰

Bearing this type of relationship in mind, the distribution of sector i's value as traditionally recorded in the Input-Output Table is mathematically represented as:

$$\begin{aligned}
 &P_1X_{11} + P_1X_{12} + \dots + P_1X_{1j} + \dots + FD_1 = P_1X_1 \\
 &P_2X_{21} + P_2X_{22} + \dots + P_2X_{2j} + \dots + FD_2 = P_2X_2 \\
 &: \\
 \text{Equation 2} \quad &P_nX_{n1} + P_nX_{n2} + \dots + P_nX_{nj} + \dots + FD_j = P_nX_n \\
 &: \\
 &Tax_1 + Tax_2 + \dots + Tax_n + 0 = Tax_{tot} \\
 &\frac{VA_1 + VA_2 + \dots + VA_n + 0 = VA_{tot}}{P_1X_1 + P_2X_2 + P_iX_{ij} + \dots + P_nX_{nn} = PX}
 \end{aligned}$$

where $i = 1, 2, 3, \dots, n$,

Tax_i and VA_i represents payments to taxes, labour, capital and other costs,

P_i represents output prices and X_i represents output quantities.

The key to the price model relates to the fact that the data in the Input-Output Table, which is presented in nominal values, is made up in its most basic form of (price x quantity), and that the row and column totals balance.

As pointed out by Bulmer-Thomas (1982), output (X values) somehow needs to be removed from the scenario. In the price model the interpretation of Equation 2 is that the value of output produced per the first column (say P₁X₁) is made up of

$$P_1X_{11} + P_2X_{21} + Tax_1 + VA_1 = P_1X_1.$$

To remove the output values from the system, the entire column *j* is divided by the respective output value X_j. This now effectively makes X=1 under this model. This also leaves the following for the first two columns (reading each column separately)

¹⁰ Refer to Appendix IV for the detailed background and development of the Input-Output price model equation presented here.

$$\begin{bmatrix} P_1 a_{11} & P_1 a_{12} \\ + & + \\ P_2 a_{21} & P_2 a_{22} \\ + & + \\ \frac{Tax_1}{X_1} & \frac{Tax_2}{X_2} \\ + & + \\ \frac{VA_1}{X_1} & \frac{VA_2}{X_2} \\ = & = \\ P_1 & P_2 \end{bmatrix}$$

where $a_{ij} = \frac{X_{ij}}{X_j}$, or simply put, this represents the application of the standard Leontief assumption of fixed consumption coefficients under the price model.

Let

$$P = [P_1 \quad P_2 \quad \dots \quad P_n]$$

$$Tax = \begin{bmatrix} \frac{Tax_1}{X_1} & \frac{Tax_2}{X_2} & \dots & \frac{Tax_n}{X_n} \end{bmatrix} \text{ and}$$

$$VA = \begin{bmatrix} \frac{VA_1}{X_1} & \frac{VA_2}{X_2} & \dots & \frac{VA_n}{X_n} \end{bmatrix}.$$

In matrix form this then becomes

$$PA + Tax + VA = P.$$

Where A is the normal coefficient matrix.

Now let $V = Tax + VA$

After re-arranging, we obtain

$$\begin{aligned} P - PA &= V \\ \Rightarrow P [I - A] &= V \\ \Rightarrow P &= V [I - A]^{-1} \end{aligned}$$

The impact of an increase in fuel taxes can therefore be found via:

Equation 3
$$\Delta P = \Delta v' [I-A]^{-1}$$

Where
$$\Delta v' = \left(\frac{\Delta tax_1}{X_1} \right)$$

with the $\Delta v'$ vector at this point only capturing the change in the fuel tax experienced by Industry accounts.

$(I-A)^{-1}$ is the standard Leontief inverse. The 'A' matrix is known as the matrix of technical, input-output, or direct input coefficients, whilst $(I-A)^{-1}$ captures both the direct and associated indirect effects that will arise from a shock to the economy. The indirect effects captured by $(I-A)^{-1}$ will therefore only be those effects arising because of interactions between the accounts included in the $(I-A)^{-1}$ matrix. Under this model, this is only the Industry accounts.

ΔP is the overall change in price that results from increasing fuel taxes by 10%

1.2.3 Limitation of Input-Output models

Despite obvious superiority over the direct effects model as an economic tool, it should however be noted that the Input-Output Table, and hence model's, focus upon inter-industry relationships alone means that this model is also limited as an economic modelling tool. Simply put, Input-Output models fail to provide sufficient detail of inter-relationships with and between other economic groups that exist outside of the industrial sector, e.g., wage interactions with Households or Government, in the same manner as industry inter-relationships are captured.

As a result of this, Input-Output models provide only a partial record of the flow of income within the economy, i.e. detailed flows within the industrial sectors, but no indication of the relationships and flows between the other economic groups which purchase industry products as well as provide inputs to industry e.g. in the form of labour.

More specifically, this model does not take into account demands by factors to maintain real wages. Unless payments to factors rise, which in turn will also impact on product prices again, real wages will decline as a result of the increase in fuel taxes. The model therefore assumes that workers accept real wage declines, which is clearly an unrealistic situation to assume in a South African context.

Clearly therefore, Input-Output models are not detailed enough outside of industry to provide the necessary framework for considering the full impact of changes in the economy.

As a result, there has been a noticeable shift of interest from the basic Input-Output Table to a more extended version thereof - the Social Accounting Matrix (SAM).

1.3 SAMs and SAM-based Models

A SAM is merely an extension of the Input-Output Table framework developed by Leontief in the 1930's. The only difference relates to the focus being extended beyond inter-industry flows of expenditures and receipts to a wider range of institutions including Households and Government, and identifying separately the sources of consumption and capital formation. Households are usually aggregated into meaningfully distinct groups which can be used to focus on their economic position, for example their sources of income, sector of employment, expenditure and savings decisions, tax burdens and receipts of transfer payments. In this regard, the SAM used in this study allows for a grouping of Households into 10 different income-earning categories.

As Pyatt & Round (1985) point out, the development of SAMs was motivated in part by the desire for a unified framework that reconciled the Input-Output accounts with macro-economic accounts. Unlike an Input-Output Table, a SAM is regarded as being able to comprehensively record the interactions between all components of the economy, at a point in time, by integrating data from the national accounts with data on transactions between Industries, Households and other agents. The SAM is therefore able to provide detail and a more complete economy-wide policy perspective as opposed to the Industry-

only perspective offered by Input-Output accounts. As a result, a SAM also allows for economic analysis to be extended beyond Industry accounts so as to provide information about commodities and people as well.

In fact, according to Roukens de Lange (1989), any SAM-based model can basically be seen to represent the structure of the South African economy in 3 major respects:

- In the first place, it handles inter-industry financial flows on the same basis as the Input-Output Table of the South African economy. This allows the SAM database to be used to calculate the relative effects of alternative economic patterns on different industrial sectors.
- In the second place, the SAM provides data on income and expenditure for the various income categories within these groups. This allows for the creation of a model that can investigate the income distribution and private consumption expenditure effects of economic policies across these various income groups.
- In the third place, the SAM deals with financial flows in the economy as set out in the national accounts. This allows the relationships between saving and capital expenditure, tax and government spending, imports and exports, deficits and balance of payments, to be explored.

To reinforce the inherent value of the second point mentioned above, Pyatt & Round (1985:1-2) have noted that *“The framework for data and models must recognise the central importance of people, not commodities, if it is to best serve the interests of policy design. While most would agree that output growth is a necessary condition for sustained improvement in living standards, it is also generally recognised that economic policy must simultaneously concern the distribution of benefits arising from growth, to the point where faster growth overall may be sacrificed for the sake of faster growth in the living standards of particular groups, especially poverty groups...”*

...The SAM approach serves to emphasise the fact that the distribution of employment opportunities and living standards in a society are inextricably interwoven with the structure of production and the distribution of resources.”

The usefulness of the SAM in the case of this study is the specific need to incorporate Household activities, in addition to assessing the price effects on Industry output, in order to evaluate the distribution of the price burden across the different household income categories arising from an increase in fuel taxes. It is the SAM and SAM-based model's ability to allow for an in-depth analysis of this latter issue that results in it being invaluable to this study.

In order to reinforce this, McGrath (1987), in his critical report on South Africa's SAMs, highlighted 2 general goals of all SAMs:

- The first is expanding the present national accounting system to incorporate data on income distribution. As such, SAMs *“provide a holistic framework from within to view an economy and its internal relationships”* (CEAS, 1986: 4). In this sense the SAM provides a method by which the national accounts can be transformed from a documentation of production statistics to a statement of what the economy is like as a generator of incomes, making the living standards of the different socio-economic groups the focal point of the exercise. However, the structure of production, and commodity balances, still have to play an important part in this framework, for they are a part of the setting in which living standards are determined. To achieve this goal the social classes that are chosen must have relevance to questions relating to the distribution of income.

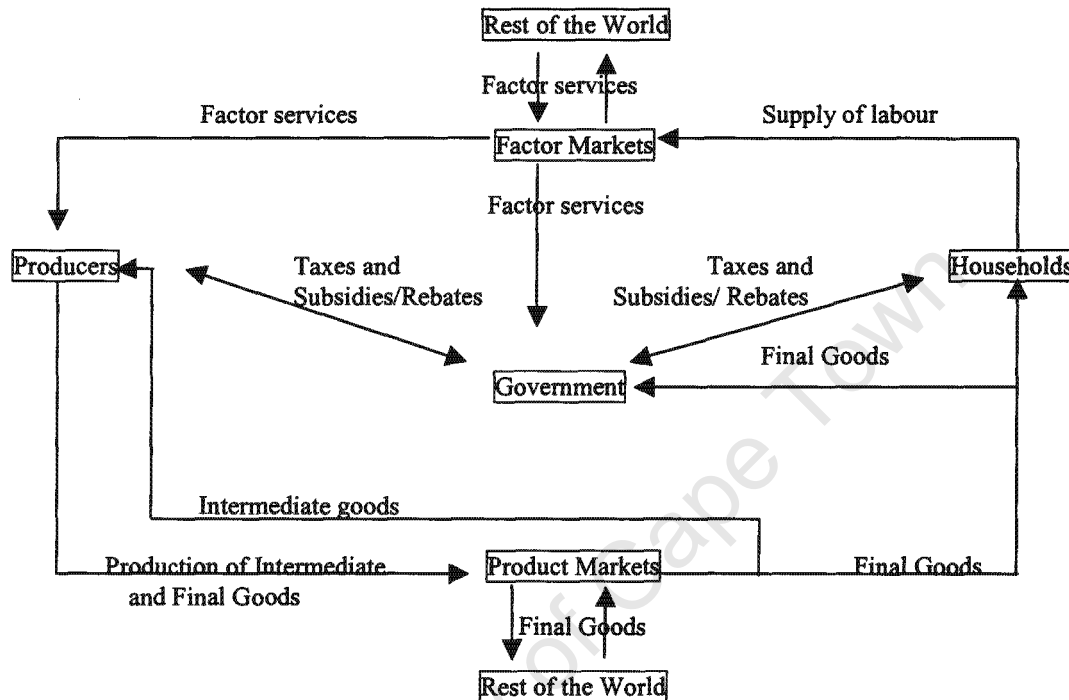
- The second major aim is the *“provision of a planning tool which permits the evaluation of the potential impacts of policy changes and development programmes on various socio-economic groups”* (CEAS, 1986: 4&5). King (1985) was the first to point out that the SAM provides a statistical basis for the creation of a plausible economic model. In this capacity *“...they provide not only the Government but also*

the private sector and independent researchers with instruments that can be used to determine the extent of the problems, and also to search for appropriate solutions to these problems..." (McGrath 1987: page 303)

- A third subsidiary purpose, as was also initially put forward by King (1985), concerns the organisation of information. In this latter capacity the *"construction of the SAM can provide a test of the consistency of data from various sources, and can be used to identify areas in which improvement is necessary, and lead to a subsequent need to reform the existing data system"* (CEAS, 1986:5).

With regard to the achievement of these goals, it is essentially the matrix format of the SAM database, as with the Input-Output database, that facilitates the capturing of both the multitude and magnitude of indirect linkages between all the sectors in the SAM. As noted before, where the SAM differs from the Input-Output Tables is that these important linkages include not only inter-industry, but also the relationship between income and consumption, consumption and production and finally, production and income, more commonly known as the circular flow of income. The following diagram provides a visual description of this flow:

Diagram 1
Illustration of the Circular Flow of Income



The above diagram can be interpreted as follows:

- ⇒ As a random starting point, Producers create products and services, which are then sold in the Product Market.
- ⇒ Some of these goods and services are purchased by other Producers as inputs to their products and services, whilst the remainder of the goods and services are sold to Households and Government.
- ⇒ Households purchase these goods and services with the salaries and wages that they earn by providing their factor¹¹ services in the Factor Market to Producers. These salaries and wages are yet another input cost for products sold in the Product Market, and therefore have an impact on product prices.

¹¹ Households, factors and employees are used inter-changeably throughout the study depending on the model being employed. Under the traditional input-output model, factors (or labour) are essentially one of the inputs into the production process. Under the Partial SAM-based model, factors are viewed more specifically as employees supplying labour. Finally, under the full SAM-based model, households are viewed as both the suppliers of these employees/labour, as well as consumers in their own right.

- ⇒ Government utilise the income earned from taxes levied on Producers and Households to purchase goods and services in the Product Market, and factor services in the Factor Markets.
- ⇒ The Rest of the World segment reflects the imports and exports transactions that can occur with regard to transactions involving either products or factor services that are not taken up by Producers, Households or Government.

Clearly the problem with the Input-Output Table is that it only provides detailed information on the link between producers and the product market component of the above structure, and considers all the other components as part of the Rest of the World segment.

By facilitating the extension of analysis beyond the production accounts to include issues of income distribution, price transmission, employment and poverty alleviation, a SAM provides a more complete picture of the economy than the Input-Output Tables with its inherent bias towards production (Vogel, 1994).

Bearing this in mind, the Social Accounting Matrix (SAM) therefore allows for the inclusion of Household flows into the model.

1.3.1 Using a SAM database to endogenise Households and Governments

The Input-Output Table discussed earlier is now expanded to include a separate Household income row and expenditure column (Consumer Demand (F)):

Table 2.2¹²

Illustrative Example of a Simple SAM Database

	Intermediate demand		Consumer Demand (F)	Other Demand (FD*)	Gross Output (X)
	Manufacturing	Agriculture			
Manufacturing	150	500	200	50	900
Agriculture	200	100	400	300	1000
Households	300	300			600
Fuel Tax	150	75			
Other (VA)	100	25			350
Total	900	1000	600	350	

The figures above represent values in R millions. As the SAM is merely an extension of the Input-Output Table, total expenditure is still equal to total income in the table above. Thus, like the Input-Output Table, the SAM is always balanced, with all income and expenditure accounted for.

The only difference really is the inclusion of accounts that are non-industry, e.g. Households as above. The above Table assumes only one factor and one Household for simplicity sake, although in reality this will be substantially disaggregated. As illustrated and discussed under **Diagram 1**, Household income and expenditure are clearly linked.

Bearing this in mind, the additional column and row can therefore be interpreted as follows:

- ⇒ Household income represents the Rand flows to factors (employees) in the form of wages and salaries as payment for their labour services, whilst
- ⇒ Household expenditure represents the Rand flows from consumers to Industry in the form of Household purchases of Goods and Services from Industry,

¹² Simple SAM example obtained from lecture notes on SAM-based models of Lawrence Edwards (Department of Economics, UCT). Refer website reference number 7.

For this reason, we can therefore use the SAM to capture the interaction between Industries as well as Households.

More specifically, under the SAM value-based model,

⇒ a change in the exogenous variable

⇒ will lead to a change in factor incomes due to the increase in output required

⇒ which will lead to a change in Household expenditure

⇒ which will lead to a change in Industry output levels

with this cycle repeating itself from point 2 until the new output equilibrium level is attained. The change in the exogenous variable is usually a once-off shock, and in the case of this study, it is the 10% increase in fuel taxes.

Under the SAM price-based model, this interaction can be viewed as

⇒ a change in the exogenous variable – in this case a fuel tax increase

⇒ will lead to an increase in Industry product prices

⇒ which will lead to an increase in Household expenditure to purchase the same amount of goods

⇒ which will lead to a demand by employees for compensatory wage increases

⇒ which will lead to an increase in Industry product prices as an input cost has increased

with this cycle repeating itself from point 3 until the new price equilibrium level is attained.

The only difference between the two types of models is that the direction of the impact of the exogenous change filtering through the economy reverses from the value-based to the price-based models.

The point to note however from all of the above is that Households do have an impact on Industry prices regardless of whether it is the price-based or value-based SAM model. The original argument put forward earlier for considering Households to be exogenous was that Households tend to purchase goods for 'final' consumption, which is still true.

However, it is the manner in which Household are able to affect Industry prices, not the reason for their consumption of goods, that supports the treatment of Households as an endogenous account instead of an exogenous one.

It is for this reason that ‘closing’ the model with respect to Households is commonly accepted. Effectively, the Household sector is moved from the exogenous column and placed instead inside the technically inter-related Table (inverse). Consequently, the inter-relationships that Households have with each other and the various Industry accounts that have also been endogenised thus far can now be captured.

Based on all the above, **Equation 3** is adapted¹³ to include Household accounts as reflected below:

Equation 4 $\Rightarrow \Delta P = \Delta v' [I-A]^{-1}$

The $\Delta v'$ vector now captures the change in the fuel tax experienced by both Industry and Household accounts,

ΔP is still the overall change in price that results from increasing fuel taxes by 10%, with the added impact of the Household accounts which have now been included into the model, and

$(I-A)^{-1}$ is now an $[(n+1) \times (n+1)]$ square matrix which includes both Industry and Household accounts

More specifically, in the SAM-based model inverse¹⁴ there are three general categories

- (a) Industries
- (b) Factors, and
- (c) Households.

¹³ Refer to Appendix V for details of how this detail is mathematically derived and adapted

¹⁴ Refer to Appendix V section 1.2 for an interpretation of the SAM-based price model inverse

The Industry row values reflect the impact on prices in each column arising from a R1 increase in the price of (a) to (c) above. In the full SAM-based model, the full circular flow effects are incorporated, i.e. the direct price impact on the Industry, the effect this has on downstream industries and their subsequent effects on the Industry as well, the impact these price increases have on the expenditure of Households which feeds back into the cost of labour and thus the price of output.

The Labour row (included as part of the Household income row above) reflects the direct and indirect impact of a R1 increase in the price of labour on the price of the products. With regard to the SAM model this includes the Household effects. In the Input-Output model this only includes the Industry effects.

Finally, the Household row reflects the impact of a R1 increase in the cost of the consumption bundle per Household on each product price.

By pre-multiplying the Household columns of the SAM Leontief inverse by the price vector one is in effect now capturing:

- (a) the impact on Household expenditure arising from the increase in price of products and
- (b) the impact on Household expenditure arising from the direct fuel cost impact on expenditure as this is past through the system in the form of higher wages demanded.

Issues surrounding the Households and Government accounts

Any further doubts regarding the inclusion of Households within the set of exogenous accounts should be eased by Millar & Blair (1985: page 25) pointing out that because of the direct linkage between earned income and consumption, and between consumption and output, the Household sector is the one final demand sector that is most often moved inside the model.

A very real concern however is that the idea of fixed consumption coefficients (i.e. expenditure pattern of consumers remains unchanged regardless of income level

category) is not reflective of economic reality; R100 more a month will be spent differently by a consumer earning R500 a month as opposed to a consumer earning R50 000 per month. As a result, the Household sector has been broken-down into 10 income categories, with the top decile being further decomposed into 5 categories due to the large values involved in the top decile group. This is possible because the underlying SAM database contains this level of detail in its value flows for Households.

Thus deriving fixed consumption coefficients for each of these sub-categories can be considered more realistic as the expenditure pattern of a consumer within a specific income group will not be expected to differ significantly from the expenditure pattern of the rest of their income group. However, it should be noted that whilst this allows for different consumption patterns to exist, there is still an inherent assumption that income elasticity is 1. This is an accepted limitation of the model.

Finally, this study has also opted to endogenise the Government sector. The only exception in this regard is the fuel tax row, which has been retained as an exogenous account as it is used to introduce the 'shock' to the economy in the form of the increased fuel tax.

Government (excluding the fuel tax line) has therefore been mathematically 'endogenised' into the system in the same way as Households were above, below the last Household row and to the right of the last Household column. However, unlike Households, Government has been retained as a one row and one column addition to the model and not decomposed into component departments.

The argument for 'endogenising' Government relates again to the issue of trying to get closer to capturing the full flow of income through the major groups within the economy. In this regard, Government is involved to an extent in the production process by means of purchasing inputs from Industry (e.g. expenditure on goods/services by Government in order to meet defence or health care needs of the country) very much as Households do,

and influencing Industry production via policy decisions, whilst also earning income, via taxation, of not only Industry, but also Households via personal income tax¹⁵.

However, assuming fixed expenditure coefficients may seem somewhat unrealistic given the different spending patterns within the various Government departments. In this regard, endogenising Government as a single row and single column should effectively be seen as the coefficients representing a more average expenditure pattern for Government as a whole. This, it is submitted, compensates somewhat for this assumption. Another consideration in keeping Government so aggregated is that Government as a whole earns income from tax collection, which is pooled and then distributed to the various Government departments for expenditure in terms of the Budget allocation each year.

Thus, as each department of Government does not earn its own income, disaggregating the Government sector in the model into departments would not reflect economic reality either.

Further, and as is the case with Households, an increase in the value of production in one or more sectors will lead to a change (here an increase) in the amounts earned and spent by Government as a whole for 'final' consumption. In other words, as with Households, even though Government tend to purchase goods for 'final' consumption, the amount of their purchases is related to their income from taxation, which depends on the value of outputs of each of the sectors. Once again, it is not the nature of the purchase being made, but rather the manner in which Government can impact on prices within the economy.

¹⁵ This explanation implicitly assumes that Government in the face of increased costs of consumption will raise taxes to maintain real expenditure constant. This places further upward pressure on prices in the economy. Such an assumption is clearly heroic and is not the underlying reason behind this argument. Government income and expenditure is explained here in order to understand how Government transacts with Households and Industry.

Overall the inclusion of Government as an endogenous sector would appear unrealistic. However, as stated, the aim of this study is to assess as much of the indirect effects generated within the economy, it is considered a necessary assumption to endogenise Government.

Consequently, the endogenised accounts within the SAM-based model developed in this study consist of Industry, Household and Government sectors.

The impact of an increase in fuel taxes is still found simply via an adaptation of **Equations 3 and 4** detailed earlier:

Equation 5¹⁶
$$\Delta P = \Delta v' [I-A]^{-1}$$

However, the only difference in the above equation is that the $\Delta v'$ and the Inverse vectors now include the Industry, Household and Government accounts and therefore model not just the Industry accounts as defined in **Equation 3**.

1.4 Partial SAM-based Model

This model is an attempt to exempt Households and Government from the direct effects of the rise in fuel taxes, whilst still capturing the indirect effects of increasing wages in order to compensate these Factors for the rising costs of living associated with increasing product prices. This model is essentially a hybrid of the traditional Input-Output and full SAM-based model, and is still represented by an adaptation of **Equation 5**:

Equation 6
$$\Delta P = \Delta v' [I-A]^{-1}$$

The only difference between this model and the full SAM-based model is that $\Delta v'$ only includes changes in fuel taxes for the Industry accounts.

¹⁶ Refer to the development of Equation 6.1 in Appendix V

The reason behind the development of this hybrid model is to provide a more accurate reflection of Industry price impacts. The Input-Output model does not contain sufficient interaction with entities outside Industry, whilst the full SAM-based model contains more linkages than is required in order to isolate the requisite Industry price impacts. Thus, as this model captures the downstream impacts of Household and Government demanding higher wages to compensate for the increased Industry prices that they face in the Product market, this model is seen to provide a middle-ground of results between the other 2 models.

1.5 Common limitations of Input-Output and SAM-based models

Finally, as with the transition from Input-Output Tables, the transition from a SAM database to a SAM model requires certain assumptions to be made about the nature of economic relationships. These assumptions have been discussed during the development of the Input-Output model, and as the SAM-based model is merely an extended version thereof, it is important at this stage to obtain a more detailed understanding of the consequences of these assumptions that are equally inherent in both models.

2. Assumptions made in developing the Input-Output and SAM-based Models

As Roland-Holst & Sancho (1995:36) points out: *“the SAM approach is particularly useful for analysing price formation and cost transmission mechanisms in economies with institutional rigidities¹⁷. In these economies factor prices need not conform to the neoclassical paradigm and are implicitly indexed to commodity prices or cost-of-living effects. Of course, no real-world economy is purely neoclassical or purely structural, but by analysing the structural components in isolation, we can gain additional knowledge about the transmission mechanism for prices and its implications for policy and welfare.”*

This statement serves to highlight that despite SAMs being a very powerful instrument for economic analysis, it certainly is not without its limitations. This is due to the number of assumptions required in order to develop a SAM-based model. These standard assumptions are thus very important to consider when drawing conclusions from the model's results, as the results obtained provide only a guide to what the final outcome will be, and may differ somewhat if the underlying assumptions were to be relaxed. The following is a discussion of some of the standard assumptions - and thus limitations - required to construct any SAM/Input-Output model:

- a) SAMs are essentially modelling a dynamic economy in a static manner. Thus, as McGrath (1987) points out, at best the SAM is a snapshot of the economy at a specific point in time only. This inherently assumes that there have been no major structural changes to the economy between the base year that the SAM purports to represent and the time when it is actually completed and ready for use as a database. As Wang & Mullins (1988) points out, this is a valid assumption in the short-run (less than 5 years), but not for the long term.

¹⁷ This is the case in South Africa as wage increases do compensate for the full inflation effect

To illustrate the fact that this specific limitation is not as limiting as it seems, Pyatt & Round (1985:8) points out that the real value of a SAM is that *“more than anything else, a SAM is a generator of agenda for decisions: about what the facts are, about the priorities for improved information, and about the repercussions that a particular course of action might have. In this sense an underlying dynamic for change emerges from the static matrix of numbers. This in itself is a reason for not worrying too much about how bad the basic data are since, as Fell and Greenfield point out, either the SAM will not be used or the process of using it will create the forces for improvement.”*

The latest available South African SAM is the 1997 RAS update¹⁸. The fact that this SAM is not constructed entirely from raw data clearly exacerbates the above limitation somewhat. However, this SAM is the latest database available. Furthermore, because all economic agents (particularly households) with the exception of Industry have been constructed from the latest available raw data, the 1997 SAM can still serve to provide realistic insights of the effects of rising fuel taxes. For the purposes of this Thesis, this model has therefore been considered adequate.

Roukens De Lange (1989b: 22) supports this latter point when he says: *“...It certainly remains good for illustrative purposes and for developing applications while awaiting improved data input at a later stage...”* Whilst Roukens De Lange was referring to an earlier SAM database for South Africa, his words nevertheless still hold true for the version used in this particular study.

¹⁸ Refer Appendix II for more details of RAS update techniques

- b) The standard Leontief assumption of linear fixed relationships is assumed.

A SAM can only be used as a model if it is assumed that all its behavioural relationships contain constant marginal and average propensities or coefficients. This is a reasonable assumption to make when modelling the effects of small shifts in the direction of economic policy, and the result will most probably have negligible effects on the structure of production, factor payments and the distribution of household incomes.

More substantial policy changes will however start to affect factor prices, production techniques, patterns of demand, propensities to invest and import, etc. and will require a fully articulated general equilibrium model with production functions, demand functions for goods and factors, market clearing procedures investment functions, etc, to model the behavioural relationships in the economy.

This latter scenario is not the case here. It is the effect of a minor shock that is being modelled, with a view towards assessing its impact on the *current* structure of the economy. In addition, there is no shift in policy designed to achieve any of the changes mentioned above. In this regard, the standard Leontief assumptions are reasonable.

With regard to a SAM-based price model, one of the main assumptions is that prices are responsive to costs, but not to activity levels, i.e. fixed quantity, but flexi-price model. Per Roland-Holst & Sancho (1995), the justifying assumption here is generalised homogeneity and fixed coefficients in activities. (*See Consequences of fixed production coefficients below*)

- c) Due also to their use of fixed linear relationships, SAMs do not allow for substitution¹⁹ of items when quantities and/or relative costs change of items currently being used. Clearly, this may result in the final effects being overstated to a degree.

This is a common problem with all general equilibrium models. The only way of overcoming it is to develop a computer-generated general equilibrium model (CGE) that is capable of relaxing the Leontief fixed co-efficient assumption that is the root cause of the problem. However, CGE models also have their own problems, and whilst such a model may provide a slightly better indication of the final effects, the standard SAM-based model is still considered sufficient for this study.

- d) A note of caution relevant to this particular study needs to be made. What is reported in the SAM as fuel tax is the revenue collected on fuel tax. Certain rebate systems may already be in place and, as a result, the data in the SAM may not reflect what is supposed to be paid by industries, households and other institutions. A 10% increase in the fuel levies as collected by the revenue service may therefore bias price increases downwards for those industries that have some sort of special deal.

Of course, it is very difficult to determine what each industry and household should be paying as this depends on the usage of the various forms of fuel, and that data is typically not available in a ready format. Hence the note of caution.

2.1 Consequences of fixed production coefficients

Wiese *et al* (1995) and Labandeira & Labeaga (1999) both highlight the fact that in Input-Output and SAM models, with their inherent assumptions of fixed production coefficients and fixed consumption shares, the tax is entirely shifted forward, with the price rise proportional to total (direct and indirect) energy use. Labandeira & Labeaga (1999:311) goes on to say that this is “*a very strong and unlikely premise in that it does*

¹⁹ This is the normal issue of economic substitution – when the price of a price-sensitive product rises, but the price of its substitute does not, the substitute becomes relatively cheaper, and therefore under normal circumstances the substitute product would be used in production/consumption instead. This is not possible under the models utilised in this study as the inherent assumption is that even if such a price situation existed, no such substitution could occur under these models.

not allow for effects such as changes in factor prices and pre-tax prices of goods. Moreover, it is assumed that no substitution takes place in production following the introduction of the carbon tax, which is obviously related to the incidence presumption.”

Labandeira & Labeaga (1999) thus concludes, much like Wang & Mullins (1988) as above, that the results of such models should only be taken as a short-term approximation to the impact of taxes on inputs. Wiese *et al* (1995) supports this by saying that although such models may yield a great deal of insight, considerations of tax incidence are limited by the simplifying assumptions that allow for only very limited supply-demand interactions.

Due consideration must however also be given to the fact that despite the aforementioned criticisms of the Input-Output model, Labandeira & Labeaga (1999) still considered the Input-Output model to be valuable enough to be employed in his study into carbon tax incidence.

Wiese *et al* (1995) on the other hand went on to utilise a CGE²⁰ model. This however was mainly because Wiese *et al* (1995) also intended to investigate the effects of subsequent expenditure by government of the extra fuel tax revenue. As this can affect the existing income distribution structure, as well as also influencing input choices even more, the inability of Input-Output and SAM models to capture substitution effects rendered them inadequate in such a scenario.

However like Labandeira & Labeaga (1999) with his Input-Output model, a SAM-based model, despite its limitations is sufficient for the purposes of this study.

In a way, Roukens de Lange (1989b: 22) supports this when he says that despite its limitations, “... a SAM based model of the economy is still very valuable as a link

²⁰ Computer generated equilibrium model. Refer section 1.5 below for further details on CGE's

providing quantitative information in the process of evaluating economic and fiscal policies.”

Finally, King (1985) highlights some important considerations to bear in mind in SAM-related studies:

“Clearly no SAM can ever be constructed to answer questions except in the broadest sense. Specialists in any particular subject may have a much better idea of specific consequences, based on their accumulation of intimate knowledge, than a SAM alone could provide. But no one since Thomas Jefferson and his contemporaries can be a specialist in everything. A SAM can be used to bring out what is likely to be important in any given context and, therefore, to order the consultation of specialist knowledge to the occasion... The great advantage of a SAM is that one can select for any occasion those parts of it to be aggregated and those parts where detail is to be preserved.”

3. CGE (Computer Generated Equilibrium) Models

Unlike SAM-based and Input-Output models, CGEs allow for price *and* quantity to be able to simultaneously fluctuate. As a result, far less restrictive constraints need to be placed on the type of scenario being modelled.

Wiese *et al* (1995) highlights the fact that computer generated equilibrium models have a long history in tax incidence analysis. He goes on to state that these models overcome many of the limitations of Input-Output and SAM-based analysis by allowing for producer input and consumption expenditure substitutions, requiring fewer restrictions on elasticities, allowing for non-linearities, and explicitly modelling supply-demand interactions. Such models are therefore able to analyse the backward shifting of a tax on factors of production, as well as subsequent effects through the alteration of input combinations and the mix of final output.

However, whilst these types of models are useful because of their flexibility, CGEs are extremely expensive to develop both in terms of price and time. For the purposes of this study, it is therefore felt that the cost necessary to create such a model far outweighs the benefits that it could potentially provide.

CHAPTER 3

Analysis: Industry

Introduction

As has been mentioned, fuel taxes are an easy means of raising extra revenue without the administrative and collection hassles and costs that are usually associated with other such fiscal earners. In a Time magazine article Joffe (2000:32) points out:

“A gasoline tax that rises with the cost of the product is a wonderful way to make money for the powers that be. Demand for fuel is inelastic in the short-run, so Governments cash in... Rising energy prices are a wondrous windfall for the state; no need to fight nasty battles in Parliament in order to raise direct taxes on income or investments...”

However, there is a cost attached to this easy collection that extends beyond the direct effect of everyone just paying more at the filling station. Fuel taxes are an indirect tax, and thus have important and far-reaching consequences. For this reason, the levying of fuel taxes for whatever purpose should not be done in a vacuum.

This chapter therefore aims to assess as much of these consequences as possible for South African industries. Use is made of the direct effects model, as well as Input-Output and SAM-based models, with the results obtained from each of the models being compared against each other in order to highlight the impact on overall price increases attributable to the differences underlying each of the models.

A sectoral impacts analysis is then performed in order to ascertain which sectors are most affected by the fuel tax increase. Each individual sector's price impact is specifically analysed in terms of the role that all Industry sectors play in contributing to its price impact. Again, this is done under each model, and is used to provide further insight into the downstream multiplier role that certain sectors play when different economic linkages are accounted for.

1. Measuring the Costs Associated with Increasing Fuel Taxes

The following extract from a Fleming Martin Research Report (2000:3) highlights the effect that increasing oil and fuel prices have on PPI and CPI(x) or headline CPI:

“An analysis of the breakdown of ppi and cpi(x) inflation shows that the upward trend in consumer inflation, as well as the disparity between the different measures of consumer inflation, relate primarily to the influence of a number of ad hoc events including the hike in international oil prices. If fuel is excluded from the cpi(x) then the rate falls from its current level of 8,0% year-on-year in July 2000 to 7,1% year-on-year. Similarly, if oil (as opposed to the effects of an increase in fuel taxes by 10%) is excluded from ppi inflation, the rate falls from 8.6% year-on-year in July 2000 to around 5.8% year-on-year. The remaining components of cpi(x) and ppi remain relatively subdued, rising in most cases at less than 6% year-on-year.

It is clear that the outlook for the international oil prices is extremely important in determining the outcome for both consumer and producer inflation, especially, if the inflation target range is to be achieved by 2002.”

One problem with the above report is that an increase in fuel taxes has a once-off effect on prices, not an inflationary effect in the true sense i.e. recurring price increases. Further, this report has looked at what constitutes the PPI and CPI(X). The PPI and CPI(X) measure the price changes of a bundle of goods, each of which are weighted according to their level of consumption or use in production. The fuel price is treated as one of the goods included in the bundle. The problem with this method of calculating the PPI and CPI is that it assesses the direct effects of fuel price rises, whilst ignoring the indirect effect that the price of fuel has on the other bundles. Thus the reduction in CPI(X) by 9 percentage points (to 7.1%) when fuel is excluded is probably an underestimation of the true impact the rising fuel price has had on CPI(X) and PPI. This study on the other hand aims to be able to least capture and quantify these indirect effects.

The specific question being posed in this section is what are the implications for PPI figures attached *solely* to the increase in fuel taxes as opposed to the overall oil/fuel price increases evaluated above? In an attempt to answer this question, this study, inter alia, simulates the effect that a once-off 10% rise in fuel taxes will have on PPI figures. Different types of models – each of which were discussed in the methodology chapter - are used in order to achieve as accurate a result as possible.

Furthermore, this attempt at estimating the total effects impact arising from an increase in fuel taxes is also considered valuable to Government. It provides an indication of the extent to which future Government policy decisions aimed at increasing fuel taxes will in fact impact on Government's ability to ultimately achieve its inflation target range of under 6%.

In order to balance out this cost-side analysis of raising fuel taxes, it is important to first note the value of the fuel tax (which, in the Graphs below, includes the Equalisation Fund²¹ and Road Accident Fund contribution, as well as the Customs and Excise charges²²) as a revenue generator for Government.

The graph below provides a time line analysis of the real revenue (in terms of the 2000 year values) generated for Government via the fuel tax. It should be noted however, that the increase in fuel tax revenue in this graph is due to a combination of both rising fuel taxes over time, as well as the increase in the number of vehicles and vehicle owners, who as a result, increase the demand²³ for fuel as well.

As has been noted and calculated in Appendix I, fuel is price inelastic. This means that overall, a rise in fuel tax will result in a rise in revenue as the percentage change in fuel consumption will be less than the percentage change in the fuel price.

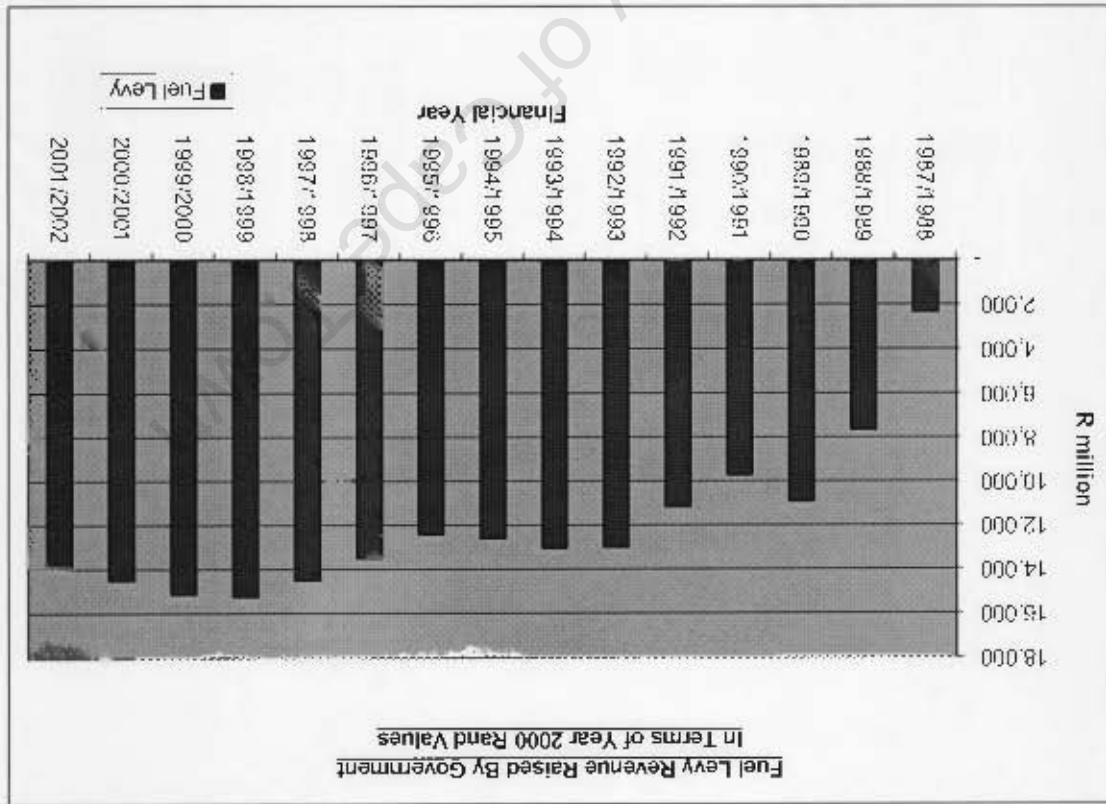
²¹ The Equalisation Fund was removed in 2000.

²² These components add 16.5c per litre to the fixed fuel tax for petrol in 1989, and 22,3 c per litre for diesel, when the fixed fuel tax price was 86,6c per litre and 76.1c per litre for diesel. In this study, only the customs and excise charge of 4c per litre for diesel and for petrol should be excluded from the fuel tax. Refer to Appendix I for more details on these price elements.

²³ Refer to Appendix I for sales volumes of fuel over time as well as the calculations supporting the price inelasticity of fuel

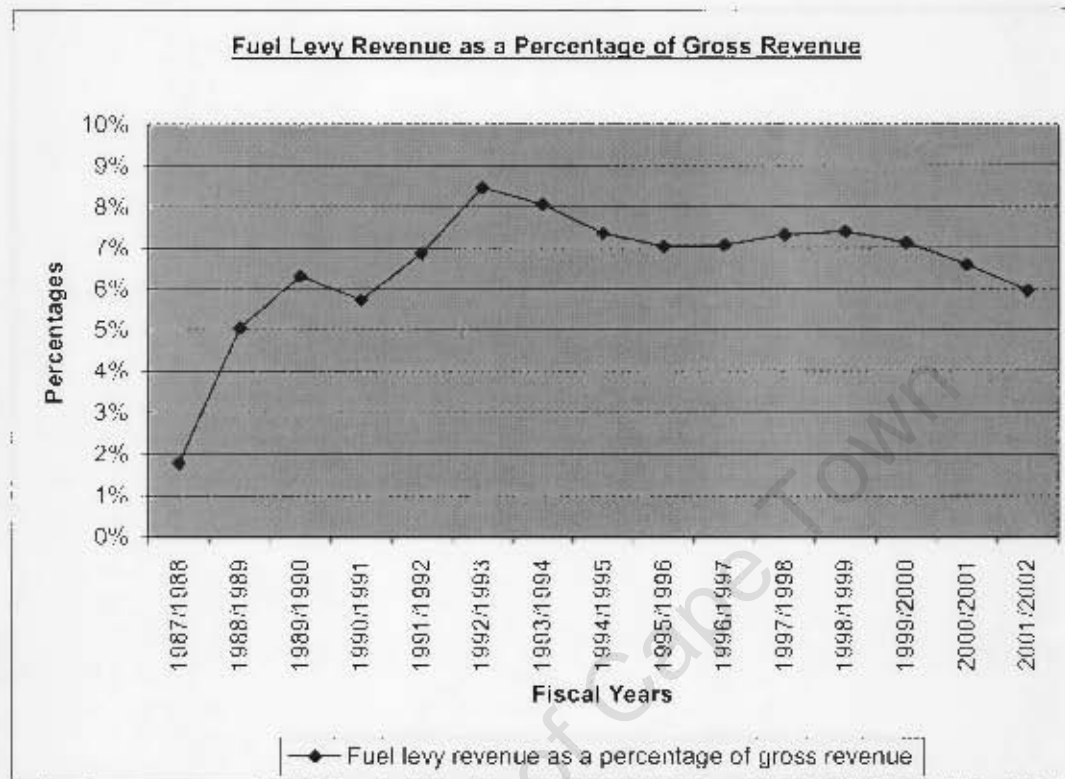
In absolute terms, the revenue generated is also large. Per the 2002 Finance Ministry's Budget Review document²⁴, it has consistently over the years been the second largest domestic tax (goods and services) revenue generator after VAT, and 4th largest overall after Persons & Individuals tax, and Companies (other than mining) taxes. In all, **Graph 3.2** perhaps best represents the increased reliance that Government has placed on the fuel levy as a revenue generator over the past few years:

Even when adjusted for inflation, there is still an overall increasing trend in real revenue raised from the fuel levy. As the fuel levy is only one component of the overall fuel price, determining by how much Government would be able to increase the fuel levy, and hence also the overall fuel price by, and whether this increase would be exceed inflation for the year or not.



Graph 3.1

Graph 3.2



The declining percentage contribution experienced in 1999/2000 to 2001/2002 may be somewhat misleading. This decline can be attributed firstly to the oil price shocks that have resulted in the price of fuel spiking during this period. As a result, Government has been careful about increasing the level of fuel tax levied per litre of fuel by too large an amount in order to minimise the massive fuel price increases that consumers have been forced to bear in this period²⁶.

In addition, the Equalisation levy – which was at 8c per litre for diesel and petrol at the time – was scrapped in February 2000²⁵, whilst in July 2001 taxation concessions were granted to diesel users in important primary industries such as agriculture and forestry, mining, coastal shipping (including the NSRI), offshore fishing and mineral exploitation. The change also brought down costs of running railway diesel locomotives²⁶.

²⁵ Refer Appendix 1 – Tables of fuel price components

²⁶ Refer SAPIA 2001 Annual Report on the SAPIA Website – website reference number 4

Moreover, SARS has been striving in recent years to become more efficient in its tax collection methods, and this has resulted in greater fiscal revenue being collected. This was noted in Parliament by Finance Minister Manuel, who as a result has been able to reduce personal income tax rates in his 2001 and 2002 Budget speeches. Despite these additional rate reductions, personal income tax has continued to grow as a contributor to the fiscal revenue coffers, and is still almost double that of the second largest fiscal generator – VAT. Thus the tax collection methods of SARS can be seen to be highly improved and effective, resulting in greater fiscal income from this sector.

Consequently, a combination of all the above factors has led to the fuel levies contribution to gross revenue diminishing in percentage terms. However, as per **Graph 3.1**, the absolute collection amounts in real terms have, in general, continued to increase over time, albeit in ebbs and troughs on an annual basis. Overall therefore, the fuel levy provides Government with quite a substantial amount of income, and is thus an important revenue-generating tool for Government.

Having established the importance to Government of the revenue generated by fuel taxes, the focus now returns to the question of what is a fair estimate of the associated cost in terms of price impacts experienced throughout the economy? More specifically, and as was mentioned earlier in this section, is the traditional method of including only direct effects in PPI a fair reflection of the full cost attached to an increase in fuel taxes?

2. Methodology

2.1 Direct Effects

The direct effects, as discussed in chapter 2, is a measure that compares the additional amount that a motorist (or any other economic group) will have to pay for fuel after the increase in fuel taxes, relative to their total expenditure on all items before the fuel tax increase. Recall from **Equation 1** that these effects were calculated for each of the endogenous accounts as follows:

$$\Delta E_i = \left[\frac{0.1 * F_i}{E_i} \right]$$

where

F = Total fuel tax paid by the specific Industry to Government

E = Total expenditure by the specific Industry (before the 10% fuel tax increase) on all Industry purchases

ΔE = Percentage increase required in E as a result of the 10% rise in fuel taxes

In essence, this is the extra amount that each Industry will have to pay to maintain their direct purchases of fuel at the same level as before the fuel tax increase.

2.2 Direct and Indirect Effects

Recall also from Chapter 2 that the overall (direct and indirect) effect of the 10% increase in fuel tax on each endogenous account is calculated as follows per **Equation 3**:

$$\Delta P = (\Delta v') (I-A)^{-1}$$

where

$\Delta v'$ = row vector of the change in the fuel tax (10% of the value in the original fuel tax line in the SAM) across all endogenous accounts.

$\Delta P/P$ is then calculated in order to convert the results into percentages, where P represents the total expenditure of the relevant Industry before the fuel tax increase.

With regard to Industry, the focus is on attempting to calculate the impact on PPI figures when the indirect effects of a rise in fuel tax were included. The overall effects are calculated in 3 different ways in an attempt to simultaneously assess the extent of influence that certain components of the economy has on Industry PPI figures. All 3 utilised the above equation, with the elements of v' changing, whilst the make-up of the 'A' matrix in $(I-A)^{-1}$ also differs between the models.

Input-Output Model

The row vector $\Delta v'$ and the 'A' matrix under this scenario consists solely of Industry accounts. As Government and Household groups are completely **excluded** from the 'A' matrix, the indirect effects impacting on Industry prices do **not** include any effects caused by interactions between Industry and the aforementioned groups.

The results obtained from this model therefore reflect only the impacts arising from Industry transactions with each other. That is, purchases of inputs from other Industries and sales of final products to other Industries as input into their production process, with all surplus going to an exogenous stand-alone grouping known as Final Demand. This exogenous grouping plays no role in influencing the price impact multiplication within the Industry accounts, and is therefore the way in which a shock to the economy is usually introduced into this model.

Partial SAM-based model

Under this scenario, there is a move towards including the effects on PPI that arise because of wage interaction between Industry and the Household and Government groups.

Households and Government are effectively deemed to be exempted from the direct effects of the rise in fuel taxes. Simply put, the direct effects and associated downstream

effects arising from the increased direct expenditure of Households and Government on fuel are excluded. However, the indirect effects (the impact on expenditure arising from increased product prices) that Households and Government pass on to Industry through increased wages are still included.

In order to achieve the direct effects exemption accorded to Households and Government, the row vector $\Delta v'$ does not include any changes in the fuel tax for these two entities' accounts.

As a result, only the Industry accounts are retained under $(I-A)^{-1}$. The influence of Household and Government wage interaction with Industry is now captured, whilst the transmission of the direct effects suffered by these groups through this wage interaction is effectively excluded.

Full SAM-based Model

The 'A' matrix in this model includes all the endogenous accounts, i.e. Industry, Households and Government, thereby capturing not only the interactions between each of these groups, but also the effects of each of these groups interacting with themselves.

Under this model, the row vector $\Delta v'$ now includes any changes in the fuel tax experience by the Household and Government accounts. As a result, the direct effects suffered by these two groups are now also captured, along with the associated downstream effects of this additional impact being passed onto Industry via higher wage demands.

Consequently, the effects that arise from

- a. Industry transactions with each other,
 - b. wage payments to employees as compensation for work performed during the production process,
 - c. payments to Government in the form of taxes,
- as well as the resulting loop of effects that arise as
- d. Households purchase goods and services and
 - e. transfer the price impacts that they suffer onto Industry via demands for higher wages to compensate for the potential loss in their real wages,
 - f. whilst Government also purchases Industry goods and services and
 - g. receive income from Industry via taxes, VAT and other such duties
- all contribute to the overall price effects within the economy, and are all captured under this model.

In addition, the following loops:

- a. Households transacting with each other and Government through income taxes payments and the receipt of subsidies and rebates,
 - b. as well as payments to Household employees and by default therefore to other Households,
 - c. as well as Government departments transacting with each other much as separate divisions of the same companies could be expected to
- are also all captured under this model.

3. PPI – Capturing Industry Direct vs. Overall (Direct & Indirect) Effects

3.1 Assessing the Overall PPI Impact

In Chapter 2, the deficiencies with regard to measuring only the direct effects of a rise in fuel taxes were discussed. Recall that an increase in prices in one industry – in this case fuel taxes – affects the prices not only in that sector, but also all the other sectors that buy from and ultimately sell to it as well.

As has been mentioned, the method/model to be employed for evaluating this total effect of a rise in fuel taxes is not clear-cut, and to counter this problem, three slightly differing models have been employed. Clearly, an inherent advantage of this approach is that it allows for an assessment of the effects of including/excluding certain economic groups²⁷ under the same modelling scenario.

In this regard, the table below provides a summary of the estimated impact on overall PPI²⁸ attributable to the direct effects of the fuel tax increase as against the differing overall effects.

Table 3.1
Overall PPI Impacts per Model

Model	Overall increase in PPI figures
Direct Effects	0.05%
Input-Output Model	0.09%
Partial SAM-based Model	0.20%
Full SAM-based Model	0.46%

²⁷ Refer Chapter 2 for detailed discussions on calculation of 'A' Matrix and $(I-A)^{-1}$ matrices under each model.

²⁸ PPI is calculated according to each Industry's share of total Industry production. That is, an Industry's total output is weighted in terms of its proportional share of total Industry output per the SAM database. In this context, PPI should be interpreted as Product Price Index, as Gross Operating Surplus and wages have been excluded from the weightings to ensure consistency of the Index across all models.

As is to be expected, the overall effects – which include the direct effects - are much greater than the direct effects alone. What is interesting however is the vast magnitude of this difference, which at the extreme, differs by up to a multiple of almost 10. This difference can be explained by two underlying impacts:

- Firstly, the magnitude of the downstream impacts arising from the fuel tax increase which the direct effects fail to capture, and
- more specifically with regard to the models capturing the indirect effects, the differences in the assessment of the indirect effect impact that is a consequence of the inclusion/exclusion of certain economic groups under the different models.

Input-Output Model

Under the Input-Output model, wherein the direct effects and only the indirect effects of Industry interactions with each other are captured, the effect on PPI is double that of the direct effects alone. This means that the magnitude of indirect effect generated by Industry interactions with each other is as large as the direct effects that Industry suffers. This is now the first concrete indication that the true magnitude of the indirect effects is at least as substantial as the direct effects.

Partial SAM-based Model

The result of 0.20% is significantly different from the direct effects figure, as well as the Input-Output figure, which is an indication that the effect of Industry interactions with Household and Government can also have quite a substantial impact on PPI. The PPI effect is more than double that of the Input-Output model effect (which includes the direct effects as well), serving to highlight the growing magnitude of the indirect effects as more economic linkages are accounted for.

This result can best be interpreted as the scenario wherein employees are only being compensated for the indirect effects arising from increasing industry prices. That is, the rise in Industry prices cause wages to rise in order to maintain real wages. This **now** in turn has an impact on the production cost of goods and services, and sets off another round of indirect effects.

This model does not cater for the price impact arising from the direct and associated downstream indirect effects that employees suffer when they consume fuel directly. As employees are not being compensated for this cost under this model, they will therefore still experience a real wage decline overall.

Full SAM-based model

Unlike the Partial SAM-based model, the full SAM-model includes the full impact of Industry, Household and Government interaction with and amongst each other, and not merely Industry and its interaction with Government and Households. More specifically, the direct and associated indirect effects that Households and Government suffer are now also captured under this model.

Under this full SAM-based model, the inclusion of the Household and Government direct effects as well as the two additional linkages that are captured extend the loop through which the indirect effects generated under this model have to flow, and therefore help to magnify the downstream impact of these effects, resulting in the larger PPI result. Consequently, the impact on PPI of 0.46% is once again more than double that experienced under the Partial SAM-based model.

In this scenario, complete wage increases have occurred to maintain the real wage of employees. The direct effects suffered by Industry are captured, the indirect effects on wages and Industry prices as a result of wage increase demands by employees to maintain real wage purchasing power are captured, along with the initial and downstream effects of Household and Government transferring their direct costs incurred onto Industry prices in the form of demands for higher wages.

Once again, the indirect effects arising from the capturing of additional linkages has resulted in a doubling of the PPI impact, illustrating yet again, that the direct effect magnitude is not a fair proxy for the magnitude of the overall effect arising from an increase in fuel taxes.

3.2 Conclusion

The results serve to highlight the differing magnitude of indirect effects that can potentially be generated depending on the economic linkages that are chosen to be captured within a model.

Moreover, because the Input-Output model fails to capture the impact that increased wage costs are likely to have on product prices, the results produced by this model are seen to be a severe underestimate of the true overall impact that can be expected when such costs are included under differing assumptions.

In this regard, the Input-Output result of 0.09% is woefully inadequate against the Partial SAM-based model result of 0.20%. The difference between the two figures is simply that the latter figure now captures the price impact of wage increases demanded to retain product price purchasing power. This is a clear indication that the Input-Output model on its own is not necessarily the strongest model available for providing the best indication of the true impact on Industry arising from an economic shock.

Moreover, the magnitude of the indirect effects being generated under each of the SAM-based models also differs substantially. This can be attributed in part to the differing manner in which the wage cost impact is captured, along with the inclusion of additional economic linkages as discussed earlier.

With regard to the wage cost impact, there are two aspects that need to be considered:

- (1) The fuel tax raises industry prices, which reduce the real wage, and raises the cost of living for Households. These effects are passed through the system in both models, however,
- (2) real Household income may/may not be affected because Households consume fuel and may/may not be able to pass this increased cost onto producers in the form of higher wages.

The way in which the second aspect is dealt with depends on the modeller.

In the Partial SAM-based model, it is submitted - and therefore modelled – that the impact arising from the second effect probably would not be passed onto Industry. This then would appear to be similar to the Input-Output model, the difference being however that the Partial SAM-based model still captures the indirect effects that changes in producer prices have on real wages and real Household income and the transfer of these back into the system.

In the full SAM-based model however, the transfer of the direct increase in the cost of Household consumption (due to fuel price increases) onto wage increases and thus product price increases is captured in order to obtain the complete picture of the impact on the economy from a rise in fuel taxes.

It should however be noted that these two simulations (Partial SAM-based and full SAM-based) differ substantially in terms of their economic intuition. In both cases product price increases result in compensatory increases in nominal wages and thus nominal Household income. In the former case, Households who suffer reduced real incomes because they consume fuel directly do NOT demand increased wages as compensation. In the second case (full SAM-based) they DO.

It is important to establish this difference directly as it involves important assumptions regarding the way in which factors demand wage increases. The Partial SAM-based model best reflects the existing wage bargaining scenario in South Africa to maintain real wages. The latter may be more difficult to justify, but is nevertheless presented in order to understand the full flow-through implications of a rise in fuel taxes.

Consequently, as the aim of this chapter is to assess the impact on PPI of a 10% rise in fuel taxes, it is considered that, due to its ability to capture all relevant Industry-related relationships (including those with Households and Government) whilst excluding the direct effects and the associated downstream effects suffered by Household and Government, the Partial SAM-based model provides the most realistic measure of the impact of a rise in fuel taxes on PPI, with the real result lying somewhere between the Partial and full SAM-based models results.

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4. Direct and Indirect Effects on a Sectoral Basis

Having analysed on an overall basis the differing impact that the indirect effects could have on PPI, the next step involves assessing the impact of the indirect effects on the various sectors that make up Industry. The purpose behind this is two-fold:

- To ascertain which sector is impacted upon the most – under each model – by the rise in fuel taxes, and
- To enable the identification of the influential drivers behind the impact suffered by each sector under each of the models.

It is believed that the above information will permit a more informed scenario analysis to be performed later on as the modelling will be performed based on the results of the findings above as opposed to arbitrary situations.

It is also important to be aware of the sectoral classifications used, and the basis on which these classifications were made, in order to fully appreciate the results produced. This crucial information is therefore presented in the Table below:

Table 3.2
Sectoral Classifications

Sectors	Industries included in the sector	ISIC Codes
1. Agriculture	Agriculture	11-13
2. Mining	Gold Mining	23
	Coal Mining	21
	Other	22,24,25,29
3. Agricultural Resource Intensive	Food	301-304
	Beverage	305
	Tobacco	306
	Leather	316
	Paper	323
4. Mineral Resource Intensive	Coke & Refined Petroleum Products	331-333
	Non-metallic Minerals	342
	Basic Non-ferrous Metals	352
	Textiles	311-312
	Wearing Apparel	313-315

5. Unskilled Labour Intensive	Footwear	317
	Wood & Wood Products	321-322
	Furniture	391
	Plastic Products	338
	Glass & Glass Products	341
	Other Transport Equipment	384-387
	Other Industries	392
	Building Construction	51
	Civil Engineering & Other Construction	52-53
6. Knowledge Intensive	Basic Chemicals	334
	Other Chemicals & Man-made Fibres	335-336
	Metal Products excl. Machinery	353-355
	Machinery & Equipment	356-359
	Electrical Machinery	361-366
	Professional & Scientific Equipment	374-376
	Printing, Publishing & Recorded Media	324-326
	Rubber Products	337
	Basic Iron & Steel	351
	TV, Radio & other Communication Equipment	371-373
	Motor Vehicles, parts and accessories	381-383
7. Services	Wholesale & Retail Trade	61-62
	Catering & Accommodation Services	63
	Transport & Storage	71
	Communication	72
	Finance & Insurance	81-82
	Business Services	83
	Medical, Dental & Other Health & Vet Services	93
	Other Community, Social & Personal Services	97-98
	Other Producers	99
8. Utilities	Electricity, Gas & Steam	41
	Water Supply	42

The sectoral groupings selected are based on the ISIC (Production) Krause Classification of Manufactures (Tsikata²⁹, 1999). The Knowledge Intensive sector is however a combination of the Technology Intensive and Human Capital Intensive groupings proposed by the said ISIC system.

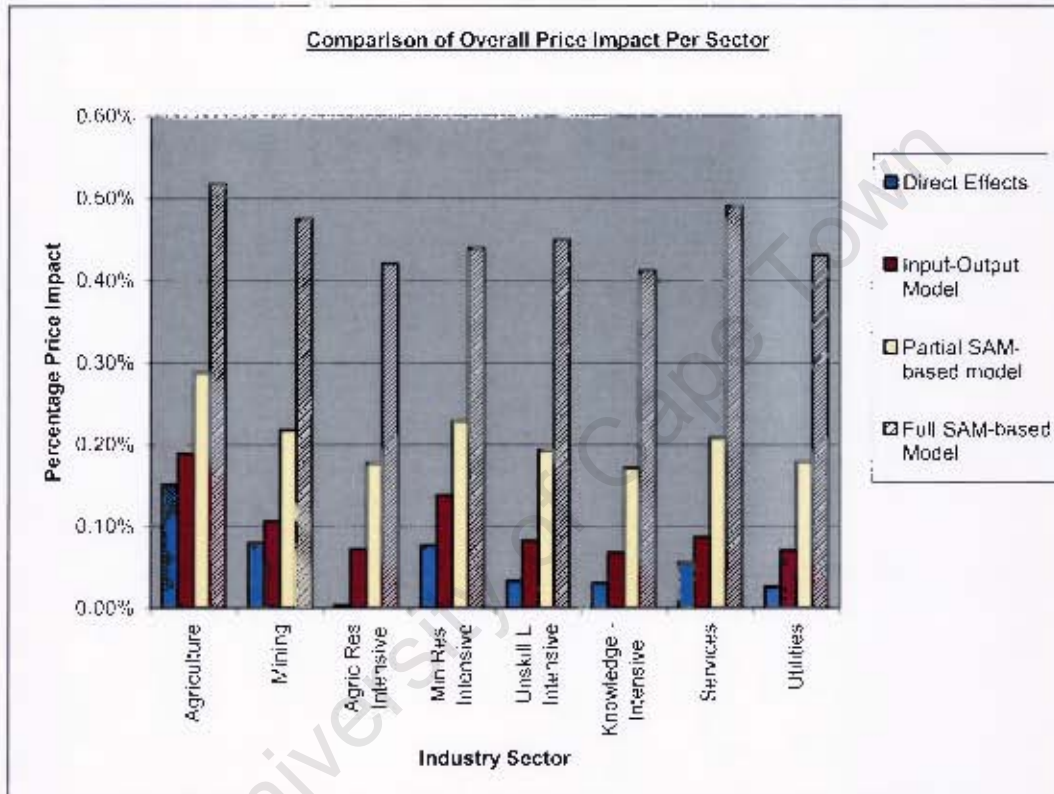
Services, Mining, Agriculture and Utilities are additional sectoral groupings that are used. Standard groupings were made with regard to the remaining available industries.

²⁹ This classification system was obtained from Annex 3

4.1 Brief Analysis by Sector

In a similar manner as the overall impact on PPI, **Graph 3.3** below illustrates the magnitude of the overall effects suffered by each sector under each of the three models, in comparison to the direct effects:

Graph 3.3



Sectoral Overview

Briefly, the agricultural sector suffers the greatest direct effect, followed by the mining sector, mineral resource intensive and then services sectors. The agricultural-resource intensive suffers almost no direct effects at all.

From an overall viewpoint, **Graph 3.3** is useful in terms of providing some initial insight into highlighting the influential sectoral drivers behind the overall price impact produced under each model, as well as the price impact suffered by each sector as a result of the increase in fuel taxes.

It is important however to recall, with regard to the indirect effects, that each sector not only consumes fuel directly (direct effects), but also transacts with the other sectors in the economy. The first sector is therefore influenced by the costs incurred and passed on by other sectors as well. This then is how the indirect effects suffered by a particular sector can arise from interactions with other sectors.

Going further, each sector relies in differing degrees on the other sectors within the economy for both inputs for their products and as markets for their output. The overall effect suffered by any particular sector reflects the final result of this input-output reliance on other industries. As each sector relies on other sectors in differing degrees, so the indirect effects will differ across sectors, and it is assumed, not relate to the direct effects that a sector itself suffers.

Finally, as has been shown already, the inclusion of different economic linkages under a model designed to capture the overall price impact of a shock to the economy can also have significant implications on the magnitude of the indirect effects that it generates.

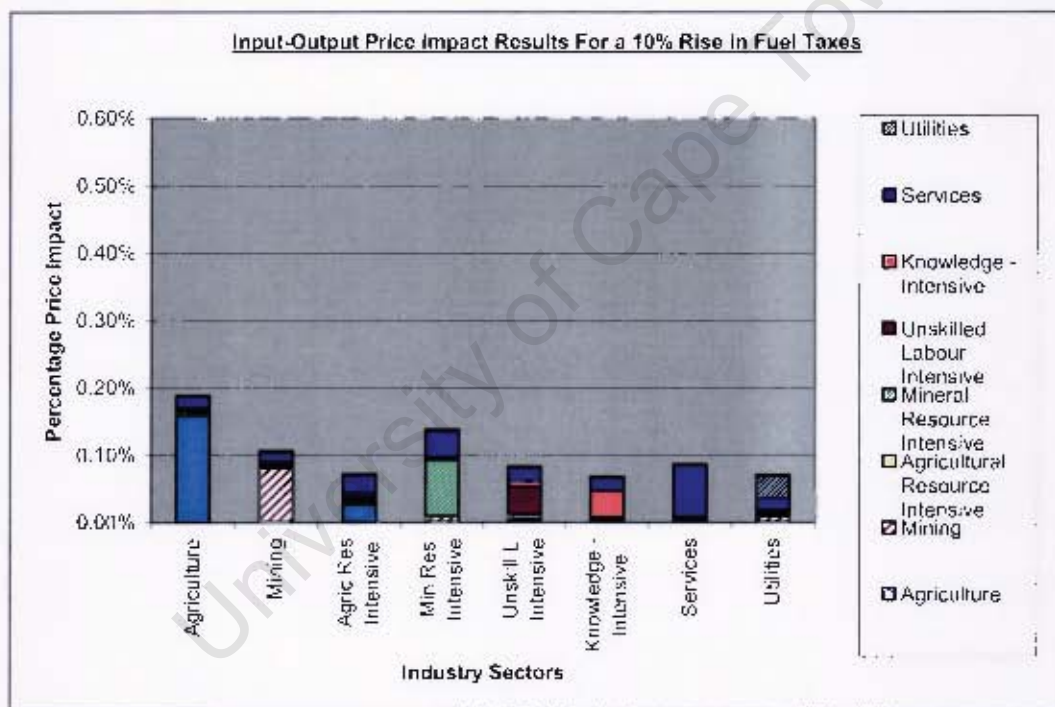
Bearing all this in mind, the information produced by **Graph 3.3** is clearly not detailed enough for a detailed analysis to be performed on the overall price impact suffered by each sector under each of the 3 models. As a result, the price impact effects of each sector as reflected in **Graph 3.3** have been decomposed into the elements that make-up their price impact.

4.2 Detailed Analysis of Make-up of Sectors Impacts

This section is therefore aimed at analysing the main contributors to a particular sector's overall price impact. This will help to not only understand the influential drivers behind a sector's price impact, but also identify the sectors that have the strongest impacts on downstream price increases. The Graphs to be presented in each section below illustrate the results of this decomposition exercise.

Input-Output Model

Graph 3.4



Recall that when direct effects were considered, the agricultural sector suffered the greatest direct effect, followed by the mining, mineral resource intensive then services sectors. From the above Input-Output graph, it is clear that agriculture is still the most affected sector, followed this time however by mineral resource intensive and then the mining sector. The unskilled labour intensive and services sectors are the next sectors to suffer large impacts.

An obvious effect of incorporating the Industry indirect effects is that the sectors identified as being the most affected have changed positions.

From **Graph 3.4** above, the intra-industry effects are clearly the most dominant influence in the overall price impact suffered by any sector under the Input-Output model. Before continuing however, it is important at this point to reiterate the general idea - as discussed in Chapter 2 - behind the expectation of large intra-industry effects. Recall the following example of $[I-A]^{-1}$ as calculated:

Table 3.3
Illustrative Example of an Input-Output model Inverse

	Manufacturing	Agriculture
Manufacturing	1.41	0.78
Agriculture	0.35	1.30

Remember that the rows above represent the impact of a R1 increase in prices for a particular industry – in this case brought about by a rise in fuel taxes. Reading across the row, a R1 increase in agriculture will result in the total price of agriculture rising by R1.30 and that of manufacturing by R0.35. The R1 in the R1.30 for agriculture is due to the direct effects of the tax increase. The R0.30 is due to the rising cost of all inputs used in the production of agriculture. The R1.30 therefore captures the total direct and indirect effects on agriculture arising from an initial R1 increase in the price of agriculture.

Under this model, it is only the downstream impacts arising from the inter-industry purchases and sales that account for the difference in magnitude of PPI figures between the direct effects results and the results of this model.

In this regard, a good example is the agricultural resource intensive sector which – recall – failed to suffer much direct effects of its own. The drivers behind this sector’s price impact under the Input-Output model are the agricultural sector and the services sector. The influence of the agricultural sector is to be expected, for as the agricultural resource

intensive sector's name would suggest, there is a strong link between the two sectors. That is, the agricultural resource sector relies heavily on the agricultural sector for the majority of its inputs. This is more obvious when one considers that industries such as food are included in the agricultural resource intensive sector.

Regarding the food industry, it is interesting to note the difference in ranking of the food industry in terms of price impact suffered. Under the direct effects model, the food industry was barely affected (3rd last)³⁰, yet, as the inter-industry effects are captured, food now becomes the 10th most affected industry. This clearly is the one of the main reasons behind why the agricultural resource intensive sector has now suffered a much larger impact than under the direct effects model. Effectively, the food industry appears to be more influenced indirectly than directly through a fuel tax rise, illustrating the importance yet again of capturing as much of the indirect effects as possible before drawing any conclusions.

The influence of the services sector is also interesting. Not only does the services sector exert a fair influence over price impacts suffered by the agricultural resource intensive sector, but it does so relatively consistently over all the other sectors as well. In fact, the services sector is second only to the intra-industry effects (again except for the agricultural resource intensive sector). The extent of influence of this sector over the mineral resource intensive sector is the reason why the latter sector is more affected than the mining sector under the Input-Output model than was the case under the direct effects model. In fact, aside from its own direct effect, the services sector impacts on the mineral resource intensive sector the most, followed by the agricultural resource intensive sector. This again is the reason behind why this latter sector has swapped places with the services sector itself when compared to the direct effects results.

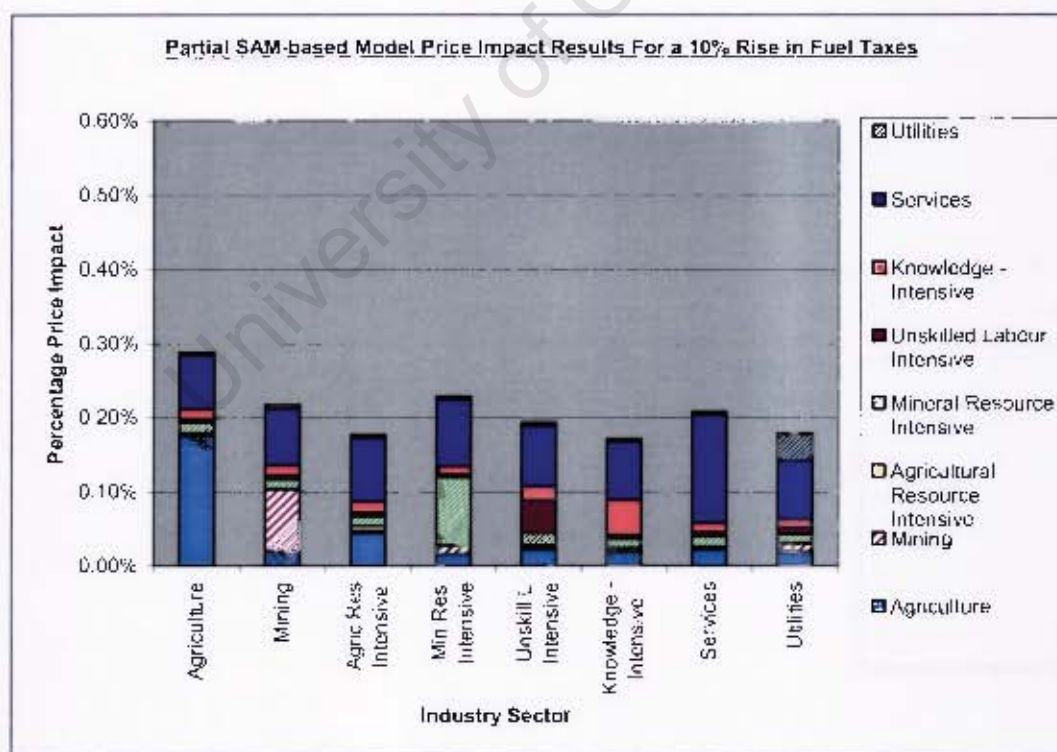
³⁰ Refer to Appendix III for a ranking of Industries under each model in order of the price impact suffered under each model.

The main industry driver behind the services sector is the transport industry, which is consistent with the direct effects model. However, because the inter-industry linkages are captured under the Input-Output model, the transport industry's link with the food industry can now be clearly seen. This is reflected not only by the increase in relative price impact suffered by the food industry under the Input-Output model, but also by the increased influence of the services sector over the agricultural resource intensive sector when the indirect effects are captured.

Thus, the Input-Output model has helped to provide proof of the long accepted belief that transport costs and food prices are linked, illustrating yet again the importance of accounting for indirect effects alongside the direct effects.

Partial SAM-based Model

Graph 3.5



It is worth noting at this point that the Input-Output model is the model that quite a few studies advocate and employ when attempting to assess the indirect effects of any

changes/shocks to the economy (Casler & Rafiqui (1993), Labandeira & Labeaga (1999) and Gale (1995)). Consequently, it is viewed as a valuable exercise just in itself to compare the influential sectors reflected under this model to those obtained under the Partial SAM-based model.

As illustrated in **Graph 3.5**, the obvious result of including the Industry linkages with employees is quite clearly the increased influence of the services sector over the other sectors. More specifically, the influence of the services sector is now larger than the agricultural sector's influence over the agricultural resource intensive sector, is as influential as the direct (intra-industry) effects in the mineral resource intensive sector, and is in fact, larger than the direct effects for the unskilled labour intensive and utilities sectors. Overall, the sectors that were most affected under the Input-Output model remain the same ones as under the Partial SAM-based model, although there is very little to separate the unskilled labour intensive and the services sector for 4th and 5th spot.

Graph 3.5 highlights the magnified influence of the services sector, along with a slight increase in influence by the agricultural, mineral resource and knowledge intensive sectors.

The inclusion of the Industry linkages with employees has clearly increased the relative contribution of the services sector to the price impact suffered by all sectors - to the extent that the overall PPI impact suffered by each sector has increased by approximately 0.10%. The amount by which the service sector's influence was magnified, relative to any other sector, and the increased overall impact on each sector's PPI figures, clearly indicates that the services sector has the most influential of all Industry linkages with both Industry and the rest of society.

Viewed from another angle: Transportation services - which under all three models thus far is consistently the industry the most strongly affected by fuel taxes - falls under the services sector, and a rise in the cost of services has just been shown to have a significant effect on the other sectors of the economy.

Under the Partial SAM-based model, the price impact suffered by the food industry is still relatively important, but it has fallen to 12th from 10th under the Input-Output model. The Financial services industry however has catapulted from 25th under the Input-Output model to 7th under the Partial SAM-based model. As this is another industry in the services sector, this provides some sort of explanation behind the increase in influence exerted by the services sector. These changing rankings also highlights the fact that different modelling approaches can have a significant effect on the relative price impacts experienced by the individual industries. Consequently the choice of modeling technique is extremely important.

Effectively though, the inclusion of increased wage costs impacting on product prices in order to compensate employees for increased product prices associated with the fuel tax rise, has increased the influence of the services sector over other sectors. Another important finding to note, is that aside from certain industries, e.g. Transport, agriculture, mining etc, the ranking in terms of the relative price impact that an industry suffers under each model appears to be constantly changing as different economic linkages and indirect effects are being captured.

Despite the fact that these aforementioned linkages do not appear to alter the *relative* impact that each sector suffers under each model, the relative impact suffered by the majority of the underlying industries that make-up each of these sectors seem to be constantly changing around as different economic linkages are accounted for. Yet again, this illustrates the importance of capturing as many economic linkages and indirect effects as possible within a model before drawing any conclusions.

Getting back to the services sector, intuitively the extensive use of human capital in the services sector would also hint at the fact that the inclusion of the possibility of increasing wage costs under the Partial SAM-based model would result in larger indirect effects impacting on this sector. This is as a result of its role in the circular flow of income being more closely related to Households as opposed to only the product markets which are the sole focus of the Input-Output model.

The following Table best illustrates this point as the services sector is shown to be a significant link in the circular flow of income from Industry to employees through its payment to labour relative to other sectors:

Table 3.4
Analysis of Payment to the Different Categories of Production Labour³¹

	Agric	Mining	Agric. Resource	Mineral Resource	Unskill labour	Knowledge Intensive	Service	Utilities
W&S high	3%	10%	23%	31%	15%	31%	27%	30%
W&S med	12%	18%	31%	25%	18%	28%	52%	19%
W&S low	83%	71%	44%	42%	55%	39%	11%	42%
W&S inf	2%	2%	1%	1%	12%	1%	11%	8%
Payment to labour by sector	5 373	22 188	11 417	5 890	24 294	35 102	119 328	6 136
Percentage of total payment to labour by Industry ³²	2%	10%	5%	3%	11%	15%	52%	3%

As a result, the inclusion of higher wages to compensate employees for increased product prices associated with the rise in fuel taxes will be expected to have the largest impact on the services sector because of its large share of payments made to labour relative to other industries. The increased wages suffered by the services sector in order to compensate employees as above will lead to the price of services increasing, and thereby set off another round of these effects until a new equilibrium point is reached.

As mentioned already, the Partial SAM-based model results are approximately 0.10% *per sector* larger than the Input-Output model results where these employee linkages were

³¹ Figures obtained from the SAM database.

³² This is calculated as the payment made to labour by the sector divided by the sum of all payments made to labour by all the sectors. That is, row 4 amount divided by the sum of row 4.

completely excluded. Consequently, the indirect effects suffered by all sectors, including mining, are much larger due the increased influence of the services sector.

Under the Input-Output model, mining was the least affected as regards indirect effects. An explanation of this was offered by Townsend & McDonald (1998), who established that the mining sector has the smallest backward and forward multipliers³³ of all sectors. The forward linkages in this model generate the price increases. A price increase in one sector does not directly affect the upstream industries (backward linkages) but does affect the downstream industries that use the affected product as an input. Because mining output is generally exported as raw material, it is not really used downstream at all, hence the small forward linkage. The less a product is linked to the rest of the economy the less of an impact it will have on prices. Further, because of its small backward linkages mining can also be expected to experience very little impact from the indirect effects arising from the few sectors that it does rely on for inputs.

Townsend & McDonald (1998) go on to point out that the value of the mining sector actually relates to its role in the balance of payments, and not its linkages to other sectors of the economy. Hence, in this regard, the small indirect effect result is to be expected.

However, under the Partial SAM-based model, mining is no longer seen to be the least affected sector in terms of indirect effects impacts. This therefore represents a contradiction of the aforementioned Townsend reference as to the reason for mining suffering the least indirect effects of all.

The crucial point to be noted is that the difference between the results produced by the Input-Output model and the other models being employed in this study can have very important implications. In this regard, Vogel (1994) notes that research has demonstrated that the concentration on production linkages in an Input-Output model may produce

³³ According to Townsend & McDonald (1998) backward linkages for a particular sector, i , show the extent to which output from other sectors is used as an input for sector i . Thus the stronger the backward linkage, the greater the stimulation of economic activity, within these sectors, from an increase in output from sector i . Forward linkages for a particular sector i show the extent to which its output is used as an input by other sectors.

misleading policy descriptions, particularly with respect to the potential contributions of the agricultural sector. The Townsend & McDonald (1998) reference with regard to mining is a specific case in point that highlights this very problem.

The increase in effect on mining once Households are endogenised reflects the impact of the employment of labour in mining, which is an important input in the production process. Much like the services sector scenario, the rising nominal wage will consequently be expected to push up the price of mining output.

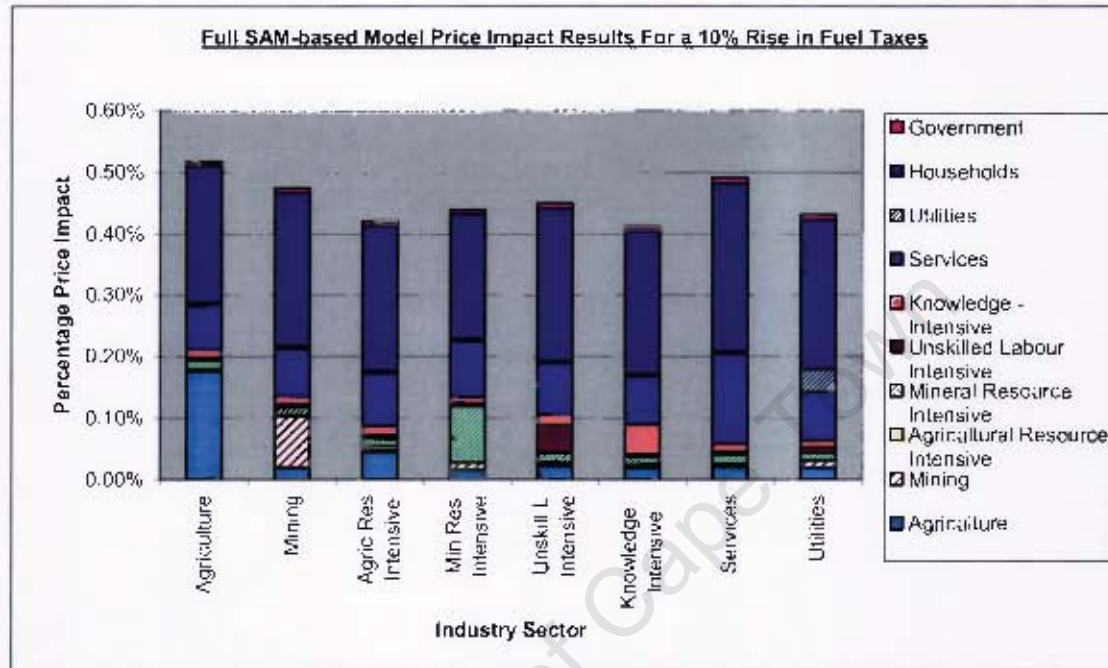
Bearing this problem in mind, and more specifically Vogel's (1994) reference to the agricultural sector's contribution, it is interesting to note the more influential role that the agricultural sector plays in the price impact suffered by all other sectors under the Partial SAM-based model than was the case under the Input-Output model. This is because agriculture:

- a) is at the start of the production process for many industries – a fact supported by this sector having the largest direct (intra-industry) effects of all the sectors under the direct effects model, and
- b) it has relatively influential downstream linkages - as indicated by this sector's increased influence over the price impact suffered by other sectors.

A rise in its price will therefore have strong impacts downstream. This has been clearly illustrated under the Partial SAM-based model where the crucial employee linkages with Industry were captured. The influence of agriculture on the other sectors became more apparent in the graphic make-up of this model's results (**Graph 3.5**) than was the case in the Input-Output model's **Graph 3.3**. As Townsend & McDonald (1998) note, there is much research evidence in this regard to suggest that agriculture has extensive forward linkages with the rest of the economy. This is supported here by the fact that no other sector, not even the services sector, is able to exert any significant influence close to the direct effects that the agricultural sector suffers from.

SAM-based Model

Graph 3.6



As this model incorporates the full circular flow of income throughout the 3 major groups – Industry, Government and Households - the results of the downstream effects generated by this model would be expected to be larger than the Partial SAM-based model. The addition of the latter two sectors would also have suggested this. This is akin to the inclusion of downstream effects – when moving from the Direct effects to the Input-Output model - and the capturing of employee interaction via wage increases with Industry – when moving from the Input-Output model to the Partial SAM-based model. At each step of the way, the above all resulted in higher PPI figures.

However, unlike the results produced by the previous models, the full SAM-based model results are significantly larger *per sector* as reflected in **Graph 3.6**. It is clear though that the 10 % increase in fuel tax only raises overall industry prices by between 0.4 % and just over 0.5 %. Moreover, whilst the agricultural sector remains the most affected sector of all, the services sector now becomes the next most affected, followed by mining and then unskilled labour intensive. Aside from mining now only being the 3rd most affected sector

instead of 2nd under previous models, the mineral resource intensive sector has shifted from being the 3rd most affected under previous models, to being the 5th most affected.

The contribution of the services sector to each sector's price impact is as large as under the Partial SAM-based model. Under this model, the sector suffers a larger price impact as Households and Government are now able to transfer their total increase in the cost-of-living onto producers via wage demands, as opposed to only increased product prices under the Partial SAM-based model.

Under the full SAM-based model though, this influence is dwarfed by the Household contribution to each sector's price impact. However, despite this, the services sector still contains extensive linkages within the economy, and therefore can still play a significant role in the price impact suffered by other sectors. A fuel tax increase for this sector can have significant impacts both upstream and downstream as was witnessed under the Partial SAM-based model.

In fact, under this model, the two most affected industries are service sector components – Transport – once again, and Financial Services, illustrating yet again the shifting impacts on the underlying industries making up these aggregated sectors. Agriculture interestingly enough has fallen from 2nd under the Direct effects and Input-Output model, to 3rd under the Partial SAM-based model, to 4th under the full SAM-based model. Thus, it appears that whilst agriculture does overall appear to suffer a large price impact as a result of the increased fuel taxes, as more economic linkages are captured, so the *relative* impact suffered by the Agricultural industry diminishes. The absolute impact does however increase significantly.

As has been consistently found, the new sector – Households - is strongly affected as a result mainly of the direct (intra-industry) effects, as well as partially because of the large share of expenditure spent on consumption goods - as opposed to savings, which are not affected by fuel taxes. The direct tax on Households also has a large impact on all sectors. This is as a result of cost increases being transferred to Industry via wages or Gross Operating Surplus (GOS) increases. Due to the fact that wages and GOS account for a

significant share of the price (between 25-60 % of gross output), as the costs are transferred so the impact on prices rises significantly.

More specifically, from **Graph 3.6** it is clear that the largest contributor to price increases in all sectors comes from Households. Recall that the Household component reflects the total effect of Households passing their initial increase in their cost of living onto Industry. Fuel taxes directly raise the cost of living for Households through their consumption of fuel. As mentioned, this increase is then passed down onto Industry via increased wages, which then in turn feeds into increased Industry prices. This in turn sets off the next cycle as the price increases are passed onto (a) other industries, (b) households via their consumption bundle and (c) government via its consumption bundle.

The whole cycle through which the price impacts travel can be best understood in terms of the following step-by-step breakdown:

- ⇒ Households' direct effects are passed onto Industry via wage increases,
- ⇒ which are then passed onto other Industries
- ⇒ who in turn also suffer their own direct effect increase
- ⇒ all of which are now passed back to Households via the increased price of Industry outputs,
- ⇒ and again passed back onto Industry & Households in the next round of effects through the same set of wage and product price increases,

This cycle is repeated many times until a new equilibrium level is reached, consequently the price impact generated can be expected to be quite significant.

In summary though, the total Household impact is relatively large as Households are affected directly via relatively large increases in expenditure on fuel and the indirect effects generated as detailed above.

The impact of the other sectors is small by comparison. This is partly because fuel taxes constitute a smaller part of their costs, but also because the downstream linkages are relatively low by comparison. The starting point of their cycle is the direct cost suffered

by Industry as a result of the initial rise in fuel taxes, which impacts on their product price, which in turn impacts on the purchasing power of Households, which only then in turn leads to the wage cycle mentioned above. Note, where Industry is concerned, the loop begins with Industry, and then leads to the Industry and Household cycle detailed above. As the starting point differs from the cycle listed above, namely the lack of the initial Household direct effect being passed on to Industry first, the Industry impact is expected to be lower than that suffered by the Households.

Government is essentially a pseudo Industry sector, one which derives its income via taxes and incurs expense via payments to employees, subsidies or handing out of contracts for work to be performed by Industry. It is best viewed as a medium through which funds are received via taxes and are re-distributed in the economy. For this reason, one can see in the make-up of the price impact that Government suffers, that each Industry contributes a part to the price impact, and as with all the other sectors, the services sector and Household sectors dominate this price impact. This indicates that Government may have extensive upstream linkages – i.e. Government is impacted upon by what happens in the rest of the economy, and even though it can influence policy matters in the economy, Government ultimately bears the financial impact of those policies as well, through the impact suffered by the other components of the economy.

Moreover, the rise in fuel taxes also represents income for the Government sector which collects the fuel taxes, much more than the increase in direct expense that it suffers, and hence the low direct effects that Government suffer. Government also has a very small impact on the price impact suffered by other Industry sectors and Households.

In short, the downstream linkages of Government are very low, as indicated by the small contribution to other sectors' overall price impacts. However, because Government itself is a large consumer of other products, the price impact of price changes in other sectors will be relatively large on Government.

CHAPTER 4

Analysis: Households

Introduction

“Governments tax energy to raise revenues, largely because energy is convenient to tax, and because demand is relatively inelastic, permitting the raising of revenues without significantly eroding the tax base...

...No tax however, is purely revenue raising or purely an incentive tax. A tax levied to raise revenues is likely to affect price and hence demand, while a tax levied to change behaviour generally does so by affecting prices and hence raising revenues. The existence of this continuum may facilitate the use or adaptation of existing taxes to further a number of newly important policy goals.” (OECD, 1993: 15&20)

Whilst the above quote would initially lead one to think of the impact of rising fuel taxes on Industry, it is in fact another economic group that should be the first to spring to mind – Households.

As illustrated in the circular flow diagram as presented in Chapter 2, Households play a pivotal role within the economy as both consumers and suppliers of labour to Industry – i.e. they are both consumers and inputs into the production process.

Moreover, as Government is interested in improving the living conditions under which the poor are forced to live - as indicated by the creation of projects such as the RDP and the recent introduction of the Skills Development Levy for funding the upgrading the skills of workers in the work place - an important consideration is whether the fuel tax increase is conducive towards realising this objective. More specifically, will the fuel tax increase raise income inequality and push people further into poverty in contradiction to Government’s objective? Government appears to have realised this problem when the 2002 Budget announced the zero-rating of the VAT levied on paraffin, this despite an

overall increase in the taxation of diesel and petrol, whilst the 2003 Budget left the fuel levy untouched from its prior year level.

Whilst these overall decisions may have more to do with the fact that oil prices and the weakening Rand/Dollar exchange rate had significantly increased the price of fuel over the past 2 years, the elimination of paraffin taxation points toward Government recognising that fuel tax increases may not be in line with their welfare objectives. Paraffin is used mostly by the disadvantaged communities living in informal settlements in South Africa for heating, cooking and lighting (paraffin lamps) purposes due to their lack of access to electricity (Myolisi, 2000). As such, by eliminating the level of paraffin taxation whilst leaving the other fuel taxes unchanged, Government may be indicating that it views this means of revenue generation (VAT on paraffin) as being non-aligned with its goal of income equality (i.e. taxation thereof would clearly hurt the poor the most).

Bearing all this in mind, as well as the historic levels of income disparity in this country, it should be clear that the impact of rising fuel taxes on the different income-earning Households needs to be understood before any further adjustments are made to the current level of fuel taxes.

In this regard, in order to determine which income Household is hurt the most by a fuel tax increase it is necessary to quantify by how much the tax raises the cost of living, i.e. the actual price increase impact, for each income Household. These results will then be used to generate the distributional profile of the impact of rising fuel taxes across the various income Households.

This chapter also employs a variety of methodologies to estimate this price impact of the fuel tax increase. Again, this is done in order to provide a more solid understanding of the implications of the differing results from each model, whilst in this chapter, it also allows for an international comparison of results with a similar U.S. study.

Finally, the results of the SAM-based model employed are decomposed in order to identify the driving/influential sectors behind the indirect effects suffered by each of the various income Households. This not only provides some insight into the drivers that are mainly responsible for the final price impact a Household suffers, but also permits a more informed scenario analysis to be performed, wherein the impact from these sectors is limited in an attempt to limit the overall price impact endured within the economy.

Literature analysis

Unlike the Industry impacts arising from an increase in fuel taxes, the distribution of the price impact burden across income Households is not as well documented.

It is anticipated that the impact from a rise in fuel taxes will be significantly multiplied when Household effects are fully accounted for. As was found in Chapter 3, the inclusion of additional economic linkages within a model will lead to additional downstream effects being captured. The price impact arising from these additional effects will not only affect the extent to which overall prices differ across models, but also the distributional profile of these price impacts across Households. As this study will show, such implications are usually not adequately dealt with by certain overseas fuel tax studies, mostly because the commonly employed Input-Output models utilised in these studies fails to endogenise Households and therefore fails to capture these additional effects.

Examples of such studies include Labandeira & Labeaga's (1999) investigation into the effects of Carbon Taxation on Spanish Households. Their investigation dealt with the levying of an additional fuel tax, a Carbon Tax, which is similar in nature to this study in that it also has the effect of increasing the fuel tax charge. In his study, Labandeira & Labeaga (1999) established that a Carbon Tax burden would be distributed according to income across the various Spanish Households, i.e. the larger the income of the Household, the higher the burden borne by that Household.

Labandeira & Labeaga's (1999) carbon tax findings with respect to Households are supported by similar findings in other studies dealing with the effects of rising fuel taxes, namely that of Casler & Rafiqui (1993), Herendeen (1974) and Hannon (1975) in the U.S. All these studies found that the price impact from a rise in fuel taxes would be distributed roughly in proportion to each Household's income category. That is, the higher the income level of the Household, the larger the relative price burden the Household is forced to bear.

It is submitted however, that the results obtained from these studies provide only a partial picture of the overall price impact suffered by all components of the economy due to the fact that the Input-Output models utilised focussed solely on inter-industry relationships, whilst Households are treated as an exogenous sector. Households are included only as final consumers of Industry products and all other linkages between the two entities are ignored. More specifically, the Input-Output model does not account for wage (factor payments) demands by factors in response to price increases arising from the initial fuel tax increase.

A good example of such Input-Output studies is Casler & Rafiqui (1993), who in his paper "Evaluating Fuel Tax Equity: Direct and Indirect Distributional Effects", utilised an Input-Output model to assess the impact on different income Households of a rise in energy taxes, with one category of such taxes being gasoline taxes. As Casler & Rafiqui's (1993) detailed results were published for this category of taxation, his methodology and findings are presented, as well as replicated for South Africa, in order to contextualise the differences not only in the techniques that this study employs, but also the differences in distributional profile across the two countries. A consequence of all this is that a new 'model' – the Direct Consumption Effects model – is introduced in this chapter.

Casler & Rafiqui's (1993) methodology involved looking at the *different* energy sources consumed by each Household and the effect of a tax being added onto each one. This was simulated by means of raising the price of the Input-Output row of the relevant energy

source by an amount equal to the increased tax charge, typical of other such studies that utilise Input-Output models.

Unlike Casler & Rafiqui (1993) and other such Input-Output studies, there is no need to alter the price of a specific fuel in order to analyse the effect that such a tax rise will have on the economy. The SAM database employed in this study contains a specific 'Fuel Levy' line that can be altered to simulate the 10% tax increase and thereby isolate the effects of a fuel tax rise. This is not a methodological difference, but merely a refinement of the technique employed by Casler & Rafiqui (1993).

Further, this study is considered an advancement on the work done in the studies mentioned above, as it not only replicates Casler & Rafiqui's (1993) work for comparative purposes, but also goes further and attempts to account for the effects of higher wage demands by factors to compensate for price increases experienced by the various Households.

Finally, despite the absolute price impact borne by each income Household being interesting from a welfare point of view, it is rather more difficult to translate these absolute results produced per income Household category into a distributional profile that can be compared across the different models in this study. For this reason, an interpretative technique called Regressivity Analysis has been adopted from Casler & Rafiqui (1993) in order to ascertain exactly which income Household suffers the greatest relative (as opposed to absolute) price impact burden under each model.

Regressivity Analysis Technique³⁴

In their paper, Casler & Rafiqui (1993) looked at, amongst others, the extent to which a tax on energy was regressive across Household income categories. This was done in order to establish the manner in which an increase in energy taxes would be distributed

³⁴ On its own this method of identifying regressiveity holds no value. It is merely a method of simplifying the data in order to facilitate an easier and clearer interpretation.

across the various income Households, and from a welfare point of view, which income Household thus bore the greatest relative burden.

The regressivity calculation involves using the highest income Household's price impact percentage increase as a common denominator. That is:

Equation 7
$$\frac{\Delta HH}{\Delta H9}$$

where,

ΔHH represents the percentage increase in price suffered by the relevant Household, e.g. the lowest income Household (d0), and

$\Delta H9$ represents the percentage increase in price suffered by Household d9 (the highest income household)

These price impact percentage figures represent the results obtained from the relevant model being employed at the time.

Clearly, the highest income Household (d9) will always produce a ratio of exactly 1 with itself. The value of this method lies in the magnitude of the other ratios. A ratio greater than 1 for low income Households implies that they suffer a greater *relative* price burden than the highest income Household (d9) does. This can be translated as an increase in fuel taxes being relatively more expensive for lower income Households than for the highest income Household, and vice versa for a ratio less than 1.

As fuel taxes are considered to be a means of taxing the wealthy, Household d9 was chosen as the benchmark Household as in such an instance it would be expected that this Household would suffer the greatest price impact burden relative to the other Households. In other words, it would be expected in such an instance that all other Households will have a ratio of less than 1 relative to d9, which is benchmarked as 1.

As was done by Casler & Rafiqui (1993), the regressivity analysis has been applied to both the direct and overall (direct & indirect) price impact results to ascertain whether the distributional profile of the burden differs between them.

Definition of Regressivity

In this study, there are two aspects to consider when assessing whether the results obtained indicate regressivity or not:

Firstly, as the highest income Household is the benchmark Household, a ratio > 1 can thus be interpreted as the lower income Households allocating a higher proportion of their total expenditure to fuel taxes than the highest income Household does. Such a result will therefore imply that a unit tax will be regressive, i.e. affect that Household negatively in terms of the relative burden that it will bear compared to the highest income Household.

Secondly, it is the magnitude of the ratio that allows one to establish the distributional profile of the burden across the Households, i.e. which Household suffers the greatest and least *relative* burden. As all the Household price impact results are benchmarked against a common Household (d9), the distributional profile can be constructed from the magnitude of each Household's deviation from this benchmark effect (set at 1). Thus the magnitude of this deviation would indicate not only the *extent* to which a particular Household suffers relative to the highest income Household, but also relative to the other Households being measured against the same benchmark.

1. Illustrative Example of Direct versus Indirect Effects

Before launching into the detailed analysis, it is important to fully understand why each calculation is performed within this study, and exactly what the calculation is attempting to measure. For this reason, the following illustrative example is presented. Whenever a methodology is introduced, a reference can be made to this example to contextualise exactly which effect it is attempting to capture:

Whilst direct effects refer to the purchase of fuel directly e.g. petrol for your car, indirect effects refer to the consumption of goods that are fuel-related, i.e. require fuel somewhere along the line as part of their input. The following example is used to clarify these effects and highlight the manner in which each of the said effects are assessed in this study with regard to Households.

The production of any commodity, e.g. flour, would always at some stage require the use of transportation services, e.g. in the distribution of the product itself. Thus, an increase in fuel taxes - which will increase the cost of fuel - will affect the cost at which these transport services are provided, which in turn will affect the final cost of the flour itself.

The increased cost of flour will then have a downstream impact on the cost of producing bread. This in turn will negatively affect the consumer thereof (usually Households if final consumer or else e.g. bakers if intermediate consumer) through the higher price at which the bread will now be sold to cover the cost increase incurred by the bread producer.

The direct effects as calculated in section 2 below, can be seen in relation to the flour producer as the increased cost incurred in transporting **flour** for distribution to the bread producer.

The **bread** producer however now suffers two effects:

- a. Increased transport costs (Direct effects). This again is the transportation of bread to the consumer and the
- b. Increased cost of flour (Indirect effects) as the flour producer raises the price of flour to try to recover the increased costs associated with his direct effects.

The direct and indirect impacts suffered by Households are similar to that presented for the bread producer. Households are therefore faced with two effects as a result of the increase in fuel taxes:

- a. Increased transport costs (Direct effects). This is essentially the increased cost the individual faces when filling the same amount of petrol/diesel at the service station and the
- b. Increased cost of bread (Indirect effects) as the bread producer raises the price of bread to try to recover the increased costs of inputs.

The Household direct effects results calculated in section 2 do not include the impact on Households that arises from Industry transferring their direct effects impact onto Households via increased product prices. This latter effect arises because Households purchase products from Industry and are consequently forced to bear at least some of the burden of the price increase suffered by Industry as in the example above.

With respect to Households, the Direct Consumption Effects model in section 2 is aimed therefore at assessing the price impact arising specifically from point b above. That is, the first round of indirect effects are assessed under this model.

This latter method still fails however to capture the full price impact on the production costs of **bread**. Only the increased **direct** cost of all of its purchased inputs, i.e. the transport costs for flour and other intermediate goods used to produce the bread are accounted for, whilst their associated downstream indirect effects arising out of inter-industry transactions are not.

In this regard, section 3 attempts to address this problem. The Input-Output model is employed to attempt to solve this latter inter-industry problem, whilst the price impacts of higher wage demands by employees to compensate for the increase in their cost of living is analysed through the use of SAM-based models.

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2. Direct Effects

2.1 Introduction

As mentioned, the SAM database contains a specific row entitled 'Fuel Levies'. This row represents the amount that each of the endogenous accounts contribute towards the total levies that government receives from taxing all types of fuel.

The fuel levy row in the SAM database is assumed to include petrol and diesel and for the purposes of this study, this levy row represents the tax component of fuel prices. This row is considered exogenous in the model and contributions to it by the endogenous accounts are all increased by 10% to simulate a 10% increase in fuel taxes.

The assessment of the direct impact of increasing fuel taxes on Households is approached in a slightly more detailed manner than was the case in the Industry chapter. There are two aspects to the approach adopted in this section:

1. Direct Effects

As was the case in the Industry chapter, the price impact that the rise in fuel taxes will have on each Household's purchase of fuel for their own private use is referred to as the Direct effect³⁵. These effects are captured as follows in an adaptation of **Equation 1**:

$$\text{Equation 8} \quad \% \Delta HHE_j = \left[\frac{0.1 * FH_j}{HHE_j} \right]$$

where

- j = Household categories split into income deciles (d0 to d9)
- FH_j = Total fuel levy paid by the Household (HH_j) to Government per the SAM database line
- HHE_j = Total expenditure by the Household HH_j (before the 10% fuel tax increase) on all Household purchases

³⁵ Refer to the illustrative example discussed earlier to contextualise understanding of the direct effect

$\% \Delta HHE_j$ = Percentage increase required in Household HH_j as a result of the 10% rise in fuel taxes

2. Consumption Effects

Initially, this new model was adopted to enable a fair comparison of results with Casler & Rafiqui's (1993) U.S. findings. It was then however also utilised to provide further insight into the distributional profile of what can be considered either as the second round of direct effects or the first round of indirect effects.

This model will be dealt with in more detail later.

Overall, these two methods provide useful information with regard to the distributional profile of the different components of the price impact burden borne by the various income Households. For this reason, each of the two aspects are initially presented and analysed on their own, before the results of each are compared in an attempt to provide an overall context to the information that each one yields.

The Direct Consumption effects results are also compared against Casler & Rafiqui's (1993) U.S. findings in order to ascertain whether there are any similarities between the South African and U.S. price impact distributional profiles.

2.2 Direct Effects Results

Table 4.1
Direct Effects Results

<u>Households</u> <u>Income Categories</u>	<u>Price Impact Results</u>	<u>Regressivity Results</u>
D0	0.189%	1.49
D1	0.183%	1.44
D2	0.171%	1.35
D3	0.161%	1.27
D4	0.149%	1.17
D5	0.142%	1.12
D6	0.135%	1.07
D7	0.132%	1.04
D8	0.130%	1.02
D9	0.127%	1.00

The direct effects of the increase in fuel taxes clearly impacts upon the lower income Households the most. This could be explained by the fact that direct fuel costs (the basic amount every Household requires purely for daily survival) forms a large part of their expenditure pattern, a fact which is supported by Solow (1985). Examples of such expenditure include the need for basic fuels for heating, cooking, and also transport in the form of bus/taxi fares etc. As such, when the fuel price rises due to the increase in taxes, this translates directly into an increase in their cost of living.

The fact that the higher income Households (d4 onwards) suffer a relatively smaller burden suggests that this type of distributional profile is a result of the demand for fuel being income and/or price inelastic.

This income-inelastic demand is initially supported by Loubser (1990) who found that fuel - specifically paraffin - has an income-elasticity of less than 1 for lower income Households. That is, the greater the income level, the less is spent on fuel as a percentage

of total income, or, as income rises (e.g. by 10 %) demand for fuel would rise by less (e.g. 5 %).

More concrete support is obtained from Case (1998) who found that, amongst others, Africans spend on average 5.3 % of their budget on fuel as against 0.2 % for Whites. Building on this, and taking into account the historical situation in South Africa, Case (1998: 5) found further that whilst *“the budget shares of food, fuel and transport are very different between Whites and Africans on average, these differences appear to be explained almost entirely by differences in log (income per household member) between Whites and Africans... Food and fuel are the two commodity groups with the lowest estimated income elasticities for Africans... These then are goods for which reductions in prices may have the highest social payoff: these goods have high budget shares on average, and the highest budget shares for the poorest South Africans.”*

Thus, as is depicted here, and supported by Case (1998), low income Households should be expected to incur a greater proportional direct expenditure burden with regard to fuel than their higher income counterparts.

With regard to relative burdens, **Table 4.1** shows that all the ratios exceed 1. This clearly indicates that, on the basis of direct effects alone, a rise in the fuel tax charge is regressive. The magnitude of the ratio decreases significantly from 1.49 to 1.27 as one moves toward the middle income Households, with the ratio then falling dramatically thereafter. This merely illustrates that, under this scenario, it is the lower income Households that will be the most prejudiced when fuel taxes are increased.

There is also support for this finding from Herendeen (1974) and Hannon (1975) who encountered similar findings in the U.S. More recently, Solow (1985: 1018) points out: *“Early analyses of energy policy in general and energy taxes in particular focused on the effects on energy consumers in the form of higher prices. This has typically been considered regressive, as the poor spend a greater fraction of their income on direct purchases of energy than do the wealthy.”*

Overall, the absolute results presented in **Table 4.1** above suggest that the price impact effect suffered by all Households is very low. However, these are only the direct effects, and as was found during the Industry analysis, basing decisions solely on direct effects may lead to erroneous conclusions about the full impact that the various Households ultimately bear, especially as the indirect effects are expected to be much larger.

Price Elasticity

Before proceeding, it is important at this point to reiterate the assumption of fixed-quantity that is inherent in the model being used. That is, the effects arising from product substitution are not being accounted for. The issue of price elasticity of demand is therefore highly relevant in determining whether the price impact results produced are a reasonably fair reflection or are in fact significantly overstated.

The price impact effect will be overstated for all Households as it is assumed that none of them can adjust their consumption in response to the price increase given the structure of the model. The degree of overestimation will depend however on two issues:

- a. Price elasticity of demand and cross price elasticity of demand are assumed to be zero. Thus no substitution effects can occur and the overall impact on Household expenditure is overstated. This holds true for all income Households and for small price increases, this is not considered an extreme assumption.
- b. The issue of relative price impacts. This is influenced by differences in price elasticity across Households. The fact that wealthier Households can substitute away from fuel and poorer Households cannot, would result in an underestimation of the impact on poorer Households relative to wealthier Households. The regressivity results may therefore be more extreme than is shown in **Table 4.1**.

With regard to the latter point, slightly differing degrees of price-elasticity can be expected to exist across various income Household categories as, unlike the lower income Households, the higher income Households demand more fuel than needed purely for basic everyday survival. As a result, higher income Households are expected to have a more elastic demand curve for fuel. As an example, higher income Households are

capable of reducing their direct fuel consumption to a degree by e.g. trading-in their vehicles for more fuel efficient ones (long-term) or carpooling (in the short-term).

However, support for the assumption of overall price inelasticity comes once again from Case (1998: 8) who states: *“For Africans, food, fuel, alcohol/tobacco and (marginally) other goods are estimated as necessities. Of these, food, fuel, alcohol/tobacco are also estimated as price inelastic. For Whites, food, fuel, alcohol/tobacco, clothing, and (marginally) personal items and other goods are estimated as necessities. Of these, only food, fuel, clothing, alcohol/tobacco are also estimated as price inelastic.”*

In further support of the price-inelasticity of demand assumption, the 2000 Fleming Martin Research Report highlights the fact that domestic petrol sales declined by 3.2% year-on-year for the first six months of 2000 – the time when petrol prices were skyrocketing in the South Africa because of a rise in world oil prices. Recall that price-elasticity is a relationship between price and quantity. Thus, if the price during this period rose by more than 3.2% (which it did, rising by approximately 30%), then price elasticity over this period would be $(3.2/30) = 0.11$. Thus it would appear a fair assumption that the overall general demand for fuel is in fact quite price-inelastic across all income Households³⁶.

This type of inelastic fuel demand profile has also been noted to exist in other countries as per the opening quote from the OECD (1993) presented as the introduction to this chapter. Because there is generally no available direct substitute for fuel, it is also one of the reasons ascribed as to why Governments worldwide continue to earn revenues so easily from fuel taxes.

Consequently, as the demand for fuel appears to be generally price-inelastic across all income Households, there appears to be sufficient justification - particularly in the case of small price increases - for the inherent assumption of fixed consumption patterns that underlie the Input-Output and SAM-based models used in this study. That is, if

³⁶ Refer to Appendix I where price inelasticity is shown to exist for petrol and diesel

substitution effects were accounted for, the price impact results and distributional profile would not be expected to alter significantly, as consumers are unable to respond to the price-rising effect sufficiently in the short-term such that the results can be expected to change dramatically.

2.3 Direct Consumption Effects

Moving along, if one considers that opportunities sometimes exist for Industry to pass on their direct costs of the fuel tax increase to the consumer (Households), then analysing only the direct effects suffered by Households is obviously insufficient.

Thus far in this study, and more specifically, in the previous section, 'direct' has been defined as being the extra amount that each Household has to spend in order to purchase the same *amount of fuel* as before the rise in fuel taxes. This method of evaluating the direct effects does not however incorporate the fuel impact indirectly felt via the consumption of Industry products.

This section therefore tries to rectify that shortcoming by attempting to assess this Direct Consumption effect. This analysis should at this stage be seen as an assessment of the second round of 'direct' effects suffered by Households, i.e. how the direct effects suffered by *Industry* impact on each Household's total expenditure.

Fuel taxes will have a direct impact on the price of Industry output, the size of which is dependent on the amount of fuel used in the production process. This then impacts on Households who now pay these higher prices to each Industry whenever they consume that Industry's goods.

Admittedly, this full pass-through of direct effects suffered by Industry onto Households is not a realistic assumption as producers would have to absorb some of the price increase themselves and only pass onto consumers that which they feel the market will be able to absorb without having too negative an impact on their product sales. The consequences of this assumption though is that the Direct Consumption effects suffered by Households are

overstated, and this should be borne in mind when analysing the results obtained not only here, but also when dealing with the indirect effects in the next section.

Based on all this, this series of effects can be calculated as follows:

Equation 9

$$\% \Delta HHE = \left[\frac{0.1 * \left(\frac{F}{E} \right)' * (H_i)}{HHE} \right]$$

Where

- $\left(\frac{F}{E} \right)'$ is an (1 x n) vector of fuel taxes paid to Government by each Industry divided by total expenditure for each Industry
- H_i is an (n x 1) vector of a particular Household's actual expenditure on each commodity i
- HHE is Household total expenditure on all items consumed by the particular Household
- $\% \Delta HHE$ represents the percentage change in Household total expenditure due to direct consumption of Industry commodities

Under this model, Households are still essentially treated as an exogenous account.

A Household's individual consumption pattern of various industries' products over another industry's products could clearly be a significant factor in the overall price impact suffered by that Household relative to other income Households.

2.4 Comparison of Direct Effects and the Direct Consumption Effects

The regressivity results of the direct effects and direct consumption effects differ only in terms of the distributional profile of their price impact burden across Households.

Table 4.2

Comparison of Direct Effects and Consumption Effects Results

<u>Household</u> <u>Income</u> <u>Categories</u>	<u>Price Impact</u> <u>Consumption</u> <u>Effect</u>	<u>Regressivity</u> <u>Consumption</u> <u>Effect</u>	<u>Price Impact</u> <u>Direct Effects</u>	<u>Regressivity</u> <u>Direct Effects</u>	<u>Total Price</u> <u>Impact Effect</u>	<u>Total</u> <u>Regressivity</u>
D0	0.028%	1.18	0.189%	1.49	0.217%	1.44
D1	0.028%	1.19	0.183%	1.44	0.211%	1.40
D2	0.029%	1.22	0.171%	1.35	0.200%	1.33
D3	0.029%	1.23	0.161%	1.27	0.191%	1.27
D4	0.029%	1.24	0.149%	1.17	0.178%	1.18
D5	0.029%	1.24	0.142%	1.12	0.172%	1.14
D6	0.029%	1.21	0.135%	1.07	0.164%	1.09
D7	0.028%	1.17	0.132%	1.04	0.160%	1.06
D8	0.025%	1.07	0.130%	1.02	0.155%	1.03
D9	0.024%	1.00	0.127%	1.00	0.151%	1.00

Per **Table 4.2** above, the absolute Direct Consumption effect results are clearly much smaller than the direct effects. Recall though that the Direct Consumption effect is only the first of many rounds of indirect effects, and excludes the direct effect impact. Consequently, the smaller results are to be expected.

Whilst the Direct Consumption price effect is very similar across all the Households, it is very small and does not highlight the expected underlying difference in consumption patterns of Industry products across income Households. Instead, evidence of this is obtained via a comparison of the Direct Consumption effects and the direct effects regressivity ratios which highlights the significant differences in terms of the relative price burdens borne by the lower income Households when consumption effects are considered.

The Direct Consumption effects regressivity results have a larger ratio the higher the income level of the Household (until one gets to Households d6-d8), whereas the direct effects results show the opposite trend, i.e. a steadily decreasing ratio. This can be interpreted as the direct effect of a higher fuel tax being biased against low income Households, whilst the consumption effect is biased against middle income Households. That is, under the Direct Consumption effects model, the type of Industry products most affected by the fuel tax increase are those that are consumed mainly by wealthier Households. Again the importance of capturing indirect effects has been highlighted, most notably by this change in the distribution profile of the price impact burden across Households.

Overall, the ratios are generally all much closer to 1 under the Direct Consumption effect results, indicating that whilst the first round of indirect effects are regressive overall due to all ratios exceeding 1, it is not as regressive as the direct effects.

The interesting point to note is that the Direct Consumption effects distributional profile indicates that, unlike the direct effects, the second round of 'direct' effects are distributed roughly in proportion to income levels. The higher income Households are obviously the exception to this as it is they who now suffer the greatest relative burden. This finding will be explored in more detail in the next section, as well as during the analysis of the overall effects.

With regard to the implication of assuming full pass-through of direct effects suffered by Industry onto Households, the Direct Consumption effects results presented here are not significant. As a result, it is considered that this assumption will not have a major impact in terms of analysing the distributional profile of the fuel tax increase, as all the Household results will be similarly overstated. Thus the distributional profile presented here is considered to be fairly reflective of the true profile.

In terms of the total Consumption and Direct effects, the direct effects clearly dominate both the price impact and regressivity ratio results. Thus, the impact on Household expenditure arising from Industry passing on their increased direct costs onto Households

is not very influential once combined with the direct effects that Households suffer. The only visible effect appears to be the fact that, when the total Consumption effects are accounted for, the overall regressivity ratios tend to move closer to 1.

Thus, accounting for what is effectively the first round of indirect effects suffered by Households provides an indication that the strong regressivity effect introduced by the Direct effects may be minimised as more associated indirect effects are captured.

2.5 Comparison of U.S. and South African Direct Consumption Effects Regressivity Results

A very real problem encountered in comparing results obtained in one country to that of another is that the same income Household may have different expenditure profiles. To ascertain whether this is the case with regard to Casler & Rafiqui's (1993) findings, the methodology employed in obtaining the South African direct consumption effects is the same as that of Casler & Rafiqui's (1993) for his analysis of rising gasoline taxes.

This serves the purpose of minimising the effect of methodological differences as a possible answer for any differences identified.

The two sets of results are presented below:

Table 4.3³⁷

Comparison of Regressivity Results For Consumption Effects

<u>Households</u> <u>Income Categories</u>	<u>Regressivity</u> <u>U.S. Consumption Effect</u>	<u>Regressivity</u> <u>S.A. Consumption Effect</u>
D0	1.15	1.18
D1		1.19
D2	1.27	1.22
D3		1.23
D4	1.30	1.24
D5		1.24
D6	1.31	1.21
D7		1.17
D8	1.00	1.07
D9		1.00

Casler & Rafiqui (1993) only has 5 Household income classifications, compared to the 10 in this study. Whilst the detail of the 10 Household categories has been retained, when comparing the above local results on the basis of only 5 income Households categories, the South African results appear surprisingly similar to Casler & Rafiqui's (1993) U.S. results.

There is only a very slight difference in the magnitude of the ratios and distribution of the burden across the various income Households. In the U.S., it was the second highest income Household (the equivalent of d6 and d7 in this study's Household classification) that bore the largest relative burden of the fuel tax. In South Africa, however, the

³⁷ The South African Household income categories can be matched directly against the U.S. categories. The South African Households D0 and D1 should be compared against U.S Household D0, i.e the table reflects a match-up of U.S and South African Household categories on the basis that 2 South African Household categories are equivalent to 1 U.S. category. The Household income classes identified in the U.S. study are therefore indeed the same as those used in this study.

comparative results indicate that it is in fact the middle income Household (d5) that appears to bear the greatest relative burden.

It should also be pointed out that, apart from Households d6-d8, the distribution of the burden is also proportional to income levels - much as Casler & Rafiqui (1993) found in his study as well. Thus despite all the ratios exceeding 1, the South African (and U.S.) results are not truly regressive in terms of this study's second requirement for regressivity.

As an aside, this anomaly arises because the highest income Household does not bear the greatest relative burden, but rather Households d7 and d8 in Casler & Rafiqui's (1993) study, and Households d4 and d5 in this study.

It should be noted that Casler & Rafiqui (1993) utilises the term 'direct effects' to describe what this study recognises as 'Direct Consumption effects'. As Casler & Rafiqui (1993) only had an Input-Output Table available in their study, they could not approximate the 'direct effects' impact on Households the Input-Output Table does not have a fuel levy line. As a result, assessing the Direct Consumption effects was the closest that they could get to assessing the 'direct effects' impact on Households.

2.6 Conclusion: Direct and Direct Consumption Effects Results

In essence, the direct effects results produced support Solow's (1985) assertions. Lower income Households suffer the most because their direct consumption of fuel makes up a greater proportion of their total expenditure than is the case for wealthier Households.

The results intimate, as supported by Solow (1985), that the poor spend relatively more on direct fuel purchases than do the wealthy - both in buying fuel directly, and also when suffering the direct effects that Industry incurs and passes onto Households in the form of higher product prices. This deduction is based upon the fact that all regressivity ratios under the Direct and Direct Consumption effects were all greater than 1 - aside from Household d9.

Solow (1985) does however go on to point out that in studies conducted by Herendeen (1974) and Hannon (1975), energy consumption across income classes was in fact found to be roughly proportional to income. They argued that even though the poor consume a larger fraction of their energy directly, as was found to be the case here, the wealthy in fact consume a larger fraction of their energy indirectly. By this, Herendeen (1974) and Hannon (1975) imply that the poor spend a larger proportion of their income on direct purchases of fuel than the wealthy do, whilst conversely, the wealthy spend a larger proportion of their income on products that require fuel as part of their inputs, as opposed to purchasing fuel directly.

Interestingly, and despite all the regressivity ratios exceeding 1, the Direct Consumption effects results provide an initial indication that this may be the case in South Africa as well. With the exception of Households d6-d8, the Direct Consumption effects were found to be distributed roughly in proportion to income levels, and when combined with the Direct effects impact, the overall regressivity ratios were seen to move closer to 1 as reflected in the last column of **Table 4.2**. Thus, the inclusion of the Direct Consumption effects helps to reduce the overall regressivity created by the Direct effects and appears at this point to lend credence to Solow's (1985) assertion in the South African context.

However, in order to obtain a more accurate picture of the welfare and distributional burden that an increase in fuel taxes will have on the various income Households, a more detailed assessment of the overall effect (i.e. both direct and indirect effects) needs to be performed. The significant influence of indirect effects in relation to direct effects has already been documented in the Chapter 3 of this study. It is therefore considered that evaluating only the direct effects without due regard for the indirect could lead to ill-informed and therefore incorrect deductions being made.

3. Direct and Indirect Effects

3.1 Introduction

As opposed to being viewed only as the second round of 'direct' effects, the Direct Consumption effects could also be simultaneously seen as the first round of 'indirect' effects suffered by Households. In light of this, the results of the Direct Consumption effects analysis provide an initial hint that the indirect effects arising from the rise in fuel taxes may affect the Household distributional profile in a different manner that differs from that of the direct effects. Following on this insight, it is therefore important to continue further and attempt to assess the impact of these indirect effects.

In order to continue further, the assumption made with regard to the assessment of the Direct Consumption effects is extended to this segment of the analysis as well. More specifically, it is assumed that the full direct cost increase suffered by Industry will be passed onto the consumer (which includes Households and other Industries) in the form of higher product prices.

Whilst there is scope to justify that the direct effect of the increase in fuel tax borne by an industry may be recouped *either* partially or in full depending upon the market demand and consumer sensitivity to price changes for that industry's product, this assumption is still not considered to be totally realistic. Consequently, it should be noted that any results produced where this assumption is applied will reflect an overestimate of what the true results would be expected to be.

Importantly, and despite this failing, the models employed nevertheless at least provide a starting point for assessing the impact of the indirect effects.

In this regard, and as was the case in the Industry chapter, three slightly different models are utilised:

1. The Input-Output model
 - for comparability with findings from Casler & Rafiqui (1993),
 - and to capture the price impacts where factors are unable to demand higher wages to compensate them for increased product prices associated with the rise in fuel tax
2. The Partial SAM-based model
 - to assess the impact on prices when nominal wages are increased to compensate employees for the increase in their cost of living as a result of only the rise in product prices associated with the initial fuel tax increase
3. The full SAM-based model
 - to assess the impact on overall prices when nominal wages rise sufficiently to maintain the original real wage of employees, as was the case prior to the fuel tax increase.

3.2 Input-Output analysis

The Input-Output model as discussed in the methodology chapter is adapted in order to estimate this impact.

The last term in **Equation 10** has however had to be included. This is because Households are exogenous accounts under this model, and it is the only way of including them as part of the Input-Output model calculation that is needed in order to assess the direct and indirect effects of the rise in fuel taxes on Industry.

In general, the methodology employed is similar to the Direct Consumption effect calculation discussed earlier, except that, as opposed to only the direct effects, it is now the direct **and** indirect effects suffered by the various industries that are now assumed to be passed on entirely to Households. This required the inclusion of the Leontief inverse into **Equation 9** presented earlier for the calculation of the Direct Consumption effect.

Equation 10

$$\% \Delta HHE = \left[\frac{0.1 * \left(\frac{F}{E} \right)' * ((I - A)^{-1})(H_i)}{HHE} \right]$$

Where

$\left(\frac{F}{E} \right)'$ is an (1 x n) vector of fuel taxes paid to Government by each Industry divided by total expenditure for each Industry

$(I - A)^{-1}$ is the Leontief inverse for the Input-Output model

H_i is an (n x 1) vector of a particular Household's actual expenditure on each commodity i

HHE is Household total expenditure on all items consumed by the particular Household

$\% \Delta HHE$ represents the percentage change in Household total expenditure due to direct consumption of Industry commodities

Essentially, as Industry total price impacts have been captured by the first three terms in the calculation above, this model assesses this impact on each income Household via the Household's increased cost of consuming the same bundle of Industry goods/services as before the fuel tax increase.

3.2.1 Comparison of Input-Output results against the Direct effects results

Table 4.4

Comparison of Input-Output results against the Direct effects price impact results

<u>Households</u> <u>Income</u> <u>Categories</u>	<u>Direct</u> <u>Consumption</u> <u>Effects</u>	<u>Remaining</u> <u>Input-</u> <u>Output</u> <u>Effects</u>	<u>Total</u> <u>Input-Output</u> <u>Results</u>	<u>Direct</u> <u>Effects</u> <u>Results</u>	<u>Total</u> <u>Effects</u>
D0	0.028%	0.042%	0.070%	0.189%	0.259%
D1	0.028%	0.042%	0.070%	0.183%	0.253%
D2	0.029%	0.039%	0.068%	0.171%	0.239%
D3	0.029%	0.037%	0.066%	0.161%	0.227%
D4	0.029%	0.035%	0.064%	0.149%	0.213%
D5	0.029%	0.033%	0.062%	0.142%	0.204%
D6	0.029%	0.031%	0.060%	0.135%	0.195%
D7	0.028%	0.029%	0.057%	0.132%	0.189%
D8	0.025%	0.027%	0.052%	0.130%	0.182%
D9	0.024%	0.024%	0.048%	0.127%	0.175%

The total Consumption effects as represented by the Input-Output results above are more than double the Direct Consumption effects results analysed earlier. Even more interesting however, is that the Input-Output results, which because of its focus on Industry accounts exclude the direct effects that Households suffer, are still much smaller than these direct effects.

Including the direct effects therefore produces an overall price impact that Households suffer according to this model. Effectively, Households are bearing the full impact of the rise in fuel taxes in this scenario. Wages paid to factors are not adjusted at all, and therefore employees suffer a real wage decline as their cost of living increases. As a result of the fuel tax increase, Households now face higher product costs and increased

direct fuel costs, but under the Input-Output model, they receive no wage increases to compensate for these effects.

Table 4.5

Comparison of Input-Output results against the Direct effects regressivity results

<u>Households</u> <u>Income</u> <u>Categories</u>	<u>Direct</u> <u>Consumption</u> <u>Effects</u>	<u>Remaining</u> <u>Input-Output</u> <u>Effects</u>	<u>Total</u> <u>Input-Output</u> <u>Results</u>	<u>Direct Effects</u> <u>Results</u>	<u>Total</u> <u>Effects</u>
D0	1.18	1.75	1.48	1.49	1.48
D1	1.19	1.75	1.46	1.44	1.45
D2	1.22	1.63	1.43	1.35	1.37
D3	1.23	1.54	1.39	1.27	1.30
D4	1.24	1.46	1.34	1.17	1.22
D5	1.24	1.38	1.31	1.12	1.17
D6	1.21	1.29	1.25	1.07	1.11
D7	1.17	1.21	1.19	1.04	1.08
D8	1.07	1.13	1.09	1.02	1.04
D9	1.00	1.00	1.00	1.00	1.00

What is interesting is that once the inter-industry effects are accounted for (column 3), a very strong regressivity emerges (Table 4.5 above). By looking only at the Direct consumption effects one could miss the large biases against labour under this scenario. Moreover, this could lead to incorrect conclusions being drawn with regard to the distribution of the price impact burden across income Households.

As pointed out from Table 4.4 above, the indirect consumption effects are more than double that of the direct consumption effects, and therefore drive the overall Input-Output regressivity ratios more so than the direct consumption effects. Accounting for the direct effects, which are still substantially larger than the total Input-Output results, the overall distributional profile becomes much worse than that created when only the direct effects and the direct consumption effects were accounted for.

Again, it is the poorer Households that are impacted upon most negatively, and because of the larger magnitude of the regressivity ratios overall, this negative impact is even greater than under the direct effects and direct consumption effects scenario. Thus, in the scenario where Households are not being compensated at all for a rise in fuel taxes, it is the poorer Households who will suffer the greatest real wage impact.

Once more the importance of accounting for indirect effects has been highlighted with a distributional profile changing quite significantly as more indirect effects are captured and analysed.

3.2.2 International comparison of Input-Output results

As the Consumption effects regressivity ratios produced by Casler & Rafiqui (1993) were found to be similar to their South African equivalent in terms of the distributional profile of the impact across income Households, the comparability test was extended to the Input-Output model results. From a Household point of view, this comparison reflects the scenario wherein Households are not being compensated for the increased direct costs and increased product prices that they suffer as a result of the fuel tax increase.

Recall though that unlike Casler & Rafiqui (1993), this study has the benefit of a SAM database from which to develop models and draw information and therefore the difference between the direct effects, the Direct Consumption effects (what Casler & Rafiqui (1993) referred to as their Direct effects) and the results produced by the Input-Output model can all be presented in a South African context.

In this simulation, the distributional profile of the Industry direct and indirect effects on income Households are being compared to ascertain whether similar results will again be produced. Should this be the case, then a reasonable deduction would be that the Industry consumption patterns and economic linkages in the U.S are almost identically reflected in South Africa. As the latter point could safely be assumed to not be the case, the results produced in this study are closely scrutinised:

Table 4.6
Regressivity Results

<u>Household</u> <u>Income</u> <u>Categories</u>	<u>U.S. Input-</u> <u>Output</u> <u>Model</u>	<u>U.S.</u> <u>Consumption</u> <u>Effect</u>	<u>Input-</u> <u>Output</u> <u>Model</u>	<u>Consumption</u> <u>Effect</u>	<u>Direct</u> <u>Effect</u>
D0	1.11	1.15	1.48	1.18	1.49
D1			1.46	1.19	1.44
D2	1.21	1.27	1.43	1.22	1.35
D3			1.39	1.23	1.27
D4	1.24	1.30	1.34	1.235	1.17
D5			1.31	1.243	1.12
D6	1.24	1.31	1.25	1.21	1.07
D7			1.19	1.17	1.04
D8	1.00	1.00	1.09	1.07	1.02
D9			1.00	1.00	1.00

Casler & Rafiqui's (1993) U.S. findings indicate that even after accounting for the indirect effects, a gasoline tax would still have a regressive impact. However, the overall regressivity effect is smaller than when only the Direct Consumption effects were considered, as evidenced by Casler & Rafiqui's (1993) ratios in the Table above all moving closer to 1 when Industry indirect effects are accounted for.

These results are also supported by similar earlier findings of Herendeen (1974) and Hannon's (1975) in the U.S.

Casler & Rafiqui (1993) therefore concluded that:

- the indirect effects that occurred were not regressive, but in fact proportional to income levels,
- but the influence of these indirect effects were not large enough to overcome the regressive effect of the consumption results, as evidenced by the fact that the ratios still exceeded 1.

From a distributional point of view, Casler & Rafiqui (1993) found that the higher income Households were the ones bearing the greater overall (direct and indirect) burden, and in particular, the second highest income Household bore the greatest burden.

However, under the Input-Output model in South Africa, the impact of the Industry indirect effects are seen to be regressive as all the ratios except for Household d9 have become larger instead of smaller. This can be attributed, per **Table 4.5**, to the influence of the indirect consumption effects which produced regressivity ratios that were as large as those produced by the direct effects.

When compared to the Direct Consumption effect ratios as Casler & Rafiqui (1993) have done in their study, there is a marked difference in the magnitude and distributional profile of the Input-Output model and Direct Consumption effect regressivity ratios. In fact, there appears to be no discernible link between the two sets of regressivity ratios as is the case in Casler & Rafiqui's (1993) U.S. study.

Against this, the direct effects regressivity ratios appear to be very similar in terms of magnitude and distributional profile to the South African Input-Output model ratios. Bearing in mind Casler & Rafiqui's (1993) conclusions and the fact that the direct effects are not included as part of the Input-Output results, these findings indicate that, under the Input-Output model, the Industry indirect effects are on the whole as regressive as the direct effects. Thus the direct effects results - under such circumstances - are a fair proxy for the overall price distribution impact that will result from an increase in fuel taxes.

In this regard, it is therefore interesting to note that whilst the Consumption effects regressivity results are very similar between Casler & Rafiqui's (1993) U.S study and the South African scenario, the Input-Output model regressivity ratios differs in terms of both magnitude and distributional profile from it's U.S. counterpart.

As mentioned earlier however, the South African Input-Output model and direct effects regressivity ratios are instead very similar.

What makes this relationship in the South African case seem somewhat strange is the fact that Direct Consumption effects are essentially the first round of indirect effects that Households suffer due to Industry passing on their direct effects. As pointed out earlier from Table 4.5 though, the Direct Consumption effects are not as regressive as the overall results produced by the same Input-Output model, mainly because the more influential indirect Consumption effects are extremely regressive.

Closer inspection does reveal though that the Direct Consumption effects seem to have a limited influence over the regressivity impact of the 3rd and 4th income quintiles, where the magnitude of the Input-Output regressivity ratios approximate the Direct Consumption effects regressivity ratios. This hints at Solow's (1985) assertion of the expenditure patterns of poor and wealthy Households with regard to fuel perhaps still being applicable to the South African context.

Ultimately however, the final results produced by the Input-Output model are found to contradict not only Casler & Rafiqi's (1993) findings above - where Casler & Rafiqi's (1993) regressivity ratio increases with income levels³⁸ this study finds the opposite trend - but also Herendeen (1974) and Hannon (1975). Thus, as expected, these results reinforce the expected difference in Industry consumption patterns between South African Households and their U.S. counterparts.

Overall though, the results still indicate that the lowest income Households in South Africa will suffer the most from a rise in fuel taxes should they not receive a nominal increase in wages to compensate for the increased product prices and/or direct fuel costs that they will be faced with as in this scenario.

³⁸ From a regressivity point of view, Casler & Rafiqi's (1993) findings indicate that the relative burden borne by the various income Households increases as income levels increase, whereas this study suggests the exact opposite trend. As the relative burden becomes progressively bigger as one goes down the income scale in this study, this clearly illustrates the fact that the results obtained in this study reflect true regressivity in comparison to Casler & Rafiqi's (1993) results.

3.3 Partial SAM-based model

Under this model, the aim is to assess the impact on prices where Households receive a nominal wage increase to compensate them for the increased product prices that they face when purchasing Industry products after the rise in fuel taxes³⁹. Despite this nominal increase however, it should be noted that Households will still experience a real wage decline as the direct costs that they incur in consuming fuel are not compensated for by the wage increase measured under this model.

As was the case with the Input-Output model earlier, the Partial SAM-based model discussed in the methodology chapter was adapted slightly to be able to assess the impact on Households arising from the increase in fuel taxes.

As mentioned earlier, the Partial SAM-based model, like the Input-Output model, also focussed on Industry accounts. Therefore, in order to overcome this problem, the last term in the equation below was added to the Partial SAM-based model presented in the methodology chapter:

³⁹ As noted by Case (1998) 'Wages in South Africa in many sectors are rigid, due not only to the presence of unions and industrial councils but also to government statutes and lack of competition in some sectors, see Butcher and Rouse (2001)'. Thus, this is a fairly reasonable assumption to make in a South African context.

Equation 11

$$\% \Delta HHE = \left[\frac{0.1 * \left(\frac{F}{E} \right)' * ((I - A)^{-1})(H_i)}{HHE} \right]$$

where

- $\left(\frac{F}{E} \right)'$ is an (1 x n) vector of fuel taxes paid to Government by each Industry divided by total expenditure for each Industry
- $(I - A)^{-1}$ is the Leontief inverse for the Partial SAM-based model
- H_i is an (n x 1) vector of a particular Household's actual expenditure on each commodity i
- HHE is Household total expenditure on all items consumed by the particular Household
- $\% \Delta HHE$ represents the percentage change in Household total expenditure due to direct consumption of Industry commodities

Aside from this extra link captured via the Leontief inverse, as Industry total price impacts have been captured by the first two terms in the calculation above, this model assesses this impact on each income Household via the Household's increased cost of consuming the same bundle of Industry goods/services as before the fuel tax increase, whilst at the same time receiving a wage increase to be enable them to purchase the same amount of goods as before the fuel tax increase.

This wage increase will also have an impact on the price of Industry products as wages are an input cost for Industry, and as wages increase, so will product prices, which will lead to further price increases and so on until a new equilibrium is arrived at.

3.3.1 Comparison of Partial SAM-based model and South African Input-Output model results

The results obtained from the Input-Output model are briefly contrasted against those obtained using the Partial SAM-based model. Recall that the difference between these 2 models is essentially the make-up of the inverse which, in the case of the Partial SAM-based model, contains the Household and Government linkages that have an impact on Industry via wage costs as opposed to the Input-Output inverse which lacks this additional link.

Table 4.7
Comparison of Partial SAM-based model and South African Input-Output model Results

<u>Households</u> <u>Income</u> <u>Categories</u>	<u>Input-Output</u> <u>Price Impact</u>	<u>Input-Output</u> <u>Regressivity</u>	<u>Partial SAM</u> <u>Price Impact</u>	<u>Partial SAM</u> <u>Regressivity</u>
D0	0.070%	1.48	0.156%	1.38
D1	0.070%	1.46	0.154%	1.36
D2	0.068%	1.43	0.150%	1.33
D3	0.066%	1.39	0.146%	1.29
D4	0.064%	1.34	0.140%	1.24
D5	0.062%	1.31	0.138%	1.22
D6	0.060%	1.25	0.132%	1.17
D7	0.057%	1.19	0.127%	1.12
D8	0.052%	1.09	0.119%	1.05
D9	0.048%	1.00	0.113%	1.00

The Partial SAM-based model inverse clearly induces a significantly larger price impact - in fact more than double that of the Input-Output model. As was also discovered in the Industry chapter, the Partial SAM-based model results again highlights the magnitude of the influence that the wage increase - given to factors to compensate for the increased product prices - has in terms of the overall price impact suffered by each Household.

It should be noted that this model was essentially developed more for the Industry analysis conducted in the previous chapter than as a means of assessing the indirect effects impact on Households. However, this model was considered valuable enough to be adapted and utilised in this section in order to ascertain the magnitude of the indirect effects that arise when wage effects are accounted for.

In essence, it is the different type of interpretation and analysis of the results above that will reflect the importance of having presented this model. At this point, the results indicate that the true magnitude of indirect effects impacting upon Households, as well as the distribution of these impacts across income Households, are vastly different when wage adjustments are introduced.

Note that the Partial SAM-based model results include the Input-Output model results, with the difference in results being attributable solely to the additional wage implications that it captures.

Further, recall that the Household direct effects are still not included in the results produced by the Partial SAM-based model. As such, it is interesting to note that the results produced by this model are almost as large in terms of magnitude as that of the Household direct effects presented earlier. The results of this model therefore provide further evidence to the potential price impact that different indirect effects can have on Households.

Overall the regressivity results presented in **Table 4.7** are very similar to that of the Input-Output model, with the ratios being smaller for all income Households under the Partial SAM-based model.

The Partial SAM-based model price impact results need to be interpreted with extreme care; whilst the regressivity ratios are essentially have no interpretive value.

With regard to the price impacts results, the difference between the Input-Output results and the Partial SAM-based model results are meaningless in the context of Household price impacts and price burdens.

Under the Direct effects, Direct Consumption effects and Input-Output models, the price impacts per income Household were used as a means of establishing a price burden distribution profile from which to ascertain which income Household was bearing the greatest relative burden. The justification behind this was that Households were not being compensated via nominal wage increases for the higher product prices they faced as a result of the rise in fuel taxes. Thus, the full price impact a Household suffered under these models was the impact that the Household was forced to absorb without any compensation, and therefore was a fair proxy to use to generate the price impact distributional profile.

However, under the Partial SAM-based model, nominal wage increases do occur in order to compensate Households for increased product prices. As a result, the price impact suffered by each income Household can no longer be viewed in this light.

In addition, as Households are being compensated via wage increases, so the price impact that they face will be expected to be bigger. This is because the wage increase that Households now receive will result in an additional increase in product costs, and therefore raise the price of the product in the market until this new wage and product price equilibrium is reached, and employees receive an increase in wages that maintains their product purchasing power at the level that it was before the fuel tax increase.

In summary, Households are no longer being disadvantaged by having to bear the full price impact that they suffer, whilst part of the larger price impact that each Household now 'suffers' is as a result of the additional compensation that they eventually receive. Thus, as the Household direct effects are not captured by either model, the difference between the Partial SAM-based and Input-Output price impact results is a nominal – not

a real - price impact increase as each income Household is compensated for this price increase.

Consequently, the price impact 'suffered' by each income Household has no real meaning, and can no longer be used as a means of generating the distributional profile of the price impact burden across income Households.

The only cost increase for which Households are not being compensated for under this model is the direct effects that they suffer. Thus, based on this, a realistic proxy for the distributional profile of price impacts across income Households under the Partial SAM-based model would be the direct effects regressivity ratios.

3.4 Full SAM-based model analysis

Under this model, Households are fully compensated for their total increase in their cost of living, and therefore suffer no real wage loss at all. Wages have been increased to compensate employees for their increased direct costs of fuel consumption, and for the increased product prices that they face in the market. Thus, this scenario indicates the level to which prices will increase if full wage increases were to occur when fuel taxes are raised.

These results also reflect that poorer Households will have to push for much higher compensation in the labour market than high income Households in order to retain their original purchasing power. The question that arises therefore is whether these poorer Households are in the same position to push for compensation as the high income Households. This seems highly unlikely as poorer Households are more likely the owners of unskilled labour which is in abundant supply and given the normal functioning labour market, then they would not be in as favourable a position to bargain for compensation.

This is essentially due to:

- a. poorer Households have to bargain for higher compensation and,
- b. their bargaining power is less than high income Households who are the owners of scarce skilled labour. This allows higher income Households the ability to index their wages to a higher degree under the normal rules of supply and demand.

Aside from this, the results and regressivity ratios have no interpretive value for the same reason as was the case under the Partial SAM-based model. As full wage increases occur to maintain the cost-of-living at the same standard as before the fuel tax increase, the price impact that results merely indicates the potential level to which prices must move to balance with the requisite wage increases demanded.

Per Chapter 2, the equation used for this model is expressed by **Equation 5**:

$$\Delta P = \Delta v' [I-A]^{-1}$$

where the 'A' matrix and the $\Delta v'$ vector above contain both Government and Household accounts.

3.4.1 Full SAM-based model results

Table 4.8
Full SAM-based Model Results

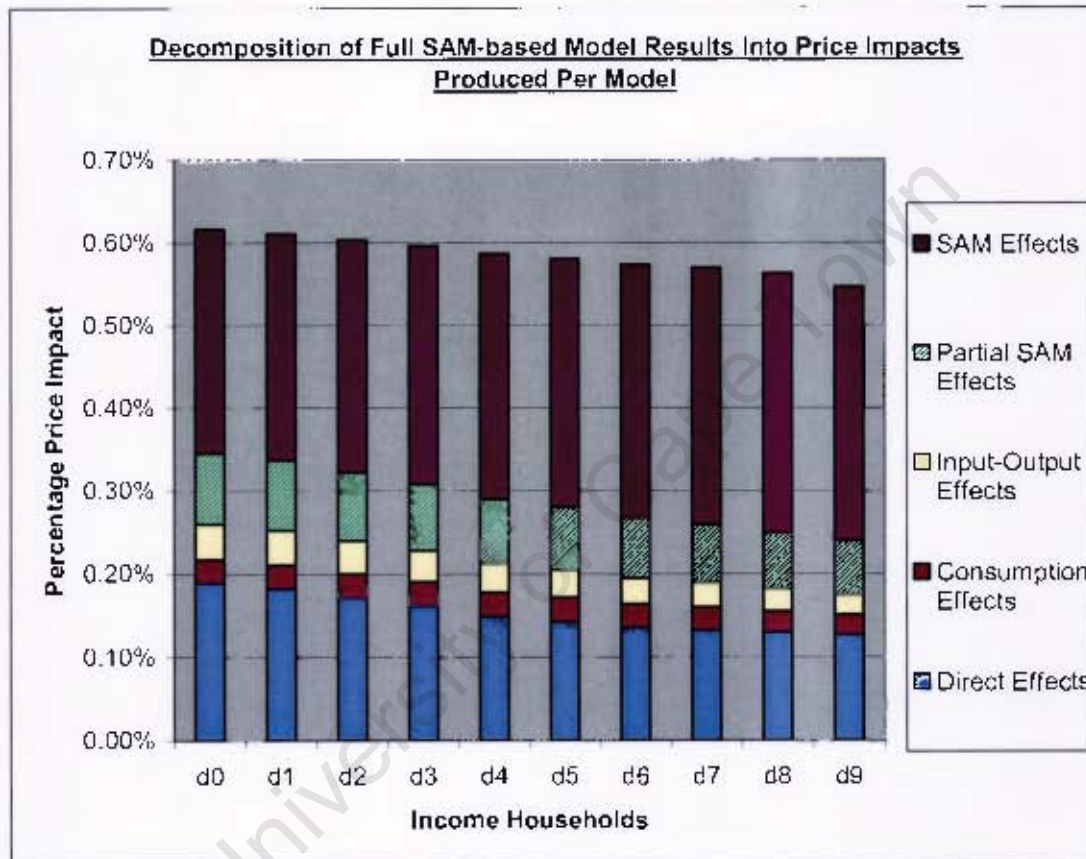
<u>Household Income</u> <u>Categories</u>	<u>Price Impact Results</u>	<u>Regressivity Results</u>
D0	0.616%	1.13
D1	0.611%	1.12
D2	0.604%	1.10
D3	0.596%	1.09
D4	0.587%	1.07
D5	0.580%	1.06
D6	0.573%	1.05
D7	0.570%	1.04
D8	0.562%	1.03
D9	0.546%	1.00

The magnitude of the absolute results presented in **Table 4.8** above highlights the price impact that can be generated when capturing as many of the direct and indirect effects impacting on Households as possible. The results are, as expected, the largest produced thus far of any of the models. Aside from including the direct effects, and additional indirect effects arising from Household and Government interaction between and amongst themselves and with Industry, the price impact is driven by the fact that wages have increased sufficiently to fully compensate each Household for all the increased costs that they suffered as a result of the fuel tax increase. This includes the direct effects that Households suffered, as well as the associated downstream Industry and wage impacts, which is something that was not captured under the Partial SAM-based model.

The regressivity results are not analysed as Household real income is effectively unchanged under this scenario.

The following graph provides an indication of the incremental contribution by each model to the overall price impact suffered by each income Household under the full SAM-based model.

Graph 4.1⁴⁰



The extent of the direct effects influence is clearly visible. It is second only to the indirect price impacts arising under the full SAM-based model which are also generated as a result of Households being able to transfer this direct effects of the fuel tax increase onto Industry via increase wage demands.

⁴⁰ The direct effects suffered by households have been included as direct effects on the graph. The SAM effects reflected on the graph only reflect the impact relating to the wage push back onto prices. The graph represents the total impact as produced by the SAM, but is merely split into the effects contributed by the direct, direct consumption, Input-Output, Partial SAM and remaining SAM effects.

The Partial SAM-based model indirect effects are the next largest, again because of the wage increase granted to Households to compensate for the increased cost of product prices as a result of the increase in fuel taxes.

Clearly therefore, the direct effects and associated downstream effects, as well as the ability of Households to pass on their cost increases to Industry via wage increases are the main drivers behind the price impact that a Household suffers should fuel taxes be increased.

However, it must be remembered that the Partial and full SAM-based model price impact contributions above have no welfare implications. They are merely nominal price increases that occur as a result of the wage increases given to Households to compensate them for any real price increases that they face.

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4. Sources of Price Increases

4.1 Significant individual Industry contributors under each model⁴¹

In this section, a brief analysis is presented of the individual industry contributions to the price impact suffered by each income Household under each model.

Under the Direct Consumption effects model, the price impacts suffered by all Households is driven mainly by agriculture and transport. Each of these individual industries contributes about 0.01% to the overall price impact burden for all Households.

The highest income Household however is not affected as much by the agriculture price impact, which helps to explain why the distribution profile generated under this model indicates that the highest income Households suffers the least relative impact of all Households.

Moreover, it is interesting to note that transport has the largest impact on Households d4, d5 and d6, thus explaining why these Households bore the greatest relative price burden under the Direct Consumption effects model.

The Input-Output model Household results are driven predominantly by food, whose impact is more than double that of transport and agriculture. However, this food impact halves as from Household d5 onwards, thus illustrating why the regressivity results produced under this model are so extreme when Industry indirect effects are passed onto Households. The long accepted linkage between food and fuel prices is therefore evident under this model and is seen as one of the main reasons why lower income Households suffer relatively larger price impact burdens than the wealthier Households.

⁴¹ These results are not formally presented in a Table or Graph format in this study as the results are highly disaggregated and quite substantial in terms of volume. Summarising the information is akin to aggregating it and therefore the presentation of the data would lose its purpose. Hence only a brief general analysis has been conducted without the actual formal presentation of the data.

Interestingly, the Transport price impact suffered by Household d5 is double that suffered by any other Household.

As was the case under the Direct Consumption effects model, the agricultural sector plays a smaller role in the price impact suffered by income Households d8 and d9. Thus, it would appear that price impacts suffered by the agricultural sector have the most damaging effect on lower income Households. If one considers that the food industry is closely linked to the agricultural industry upon which it relies for most of its inputs, then clearly this sector can generate quite a severe price impact burden for lower income Households to bear.

Also noticeable is the increased role that wholesale & retail trade plays under this model. Its price impact influence is as influential as transport and agriculture, but provides a constant price impact increase across all income Households.

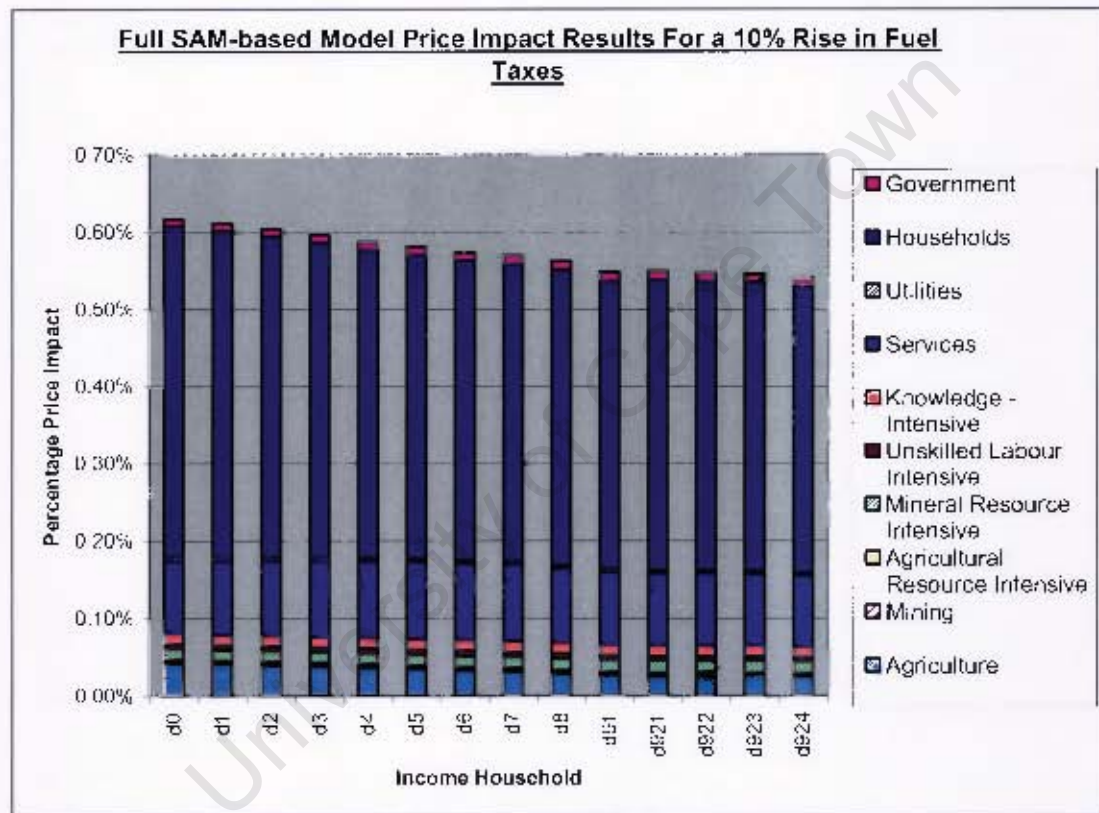
Interestingly, business services, coke and refined petroleum products only have a significant price impact on income Household d9 only. This latter industry influence is interesting as it suggests that Solow's (1985) assertion with regard to the expenditure patterns of the poor and wealthy on direct and indirect purchases does have some grounding. This result indicates that wealthier Households spend more on indirect purchases of fuel than the poorer Households who do not suffer any significant price impact as a result of the price increases being generated and passed on to Households from the coke and refined petroleum products industry.

Finally, when interpreting the SAM results, recall that the full SAM inverse results contains the impact of the Household loop, which is present even in the Industry elements. The Household row in the SAM inverse reflects the overall impact arising from a R1 increase in Household expenditure as it filters through the economy in the form of higher wages. Because each element in the inverse includes this Industry and Household loop the elements in the full SAM inverse are larger than e.g. the Input-Output inverse.

An interpretation of the results produced under the SAM-based models has to be done with extreme care.

4.2 Sectoral analysis of price impacts suffered by each income Household under the full SAM-based model

Graph 4.2



The sectoral distribution of the price impact burden can be seen more clearly from the **Graph 4.2** above. As was found in the Industry chapter for the full SAM-based model decomposition, the major contributor towards the price impact suffered by Households in general arises from the intra-Household effect.

More specifically, this large effect contains both the direct expenditure on fuel impact - which was seen earlier to be relatively large- as well as the indirect effects on industry prices as this increase in expenditure is passed onto producers in the form of higher

wages. This latter effect would be expected to occur in order for Households to be able to maintain their real level of consumption. In simple terms, this result appears to indicate that if Households can transfer their increased direct cost of consumption onto producers, then this, along with the significant direct effects that they suffer, will effectively have the greatest impact on their cost of consumption.

The detailed reasons behind all this were provided in the Industry chapter dealing with the full SAM-based model, and therefore in order to avoid repetition, the reader is referred to the relevant section in the Industry chapter.

Also, consistent with the findings of the Industry chapter, the services sector is the second most influential driver behind the overall price impact suffered by any given Household. This reinforces the fact that the services sector contains extensive linkages within the economy, and therefore plays a significant role in the price impact suffered by not only Industry sectors, but also Households. Recall that it was the services sector's relation to labour usage (Industry) and labour supply (Household) that was one of the reasons submitted as to its ability to play this pivotal role in both groups when the full circular flow of income is captured.

Another reason behind the services sector being such a consistently significant force behind the price impact suffered by a Household or Industry sector is that the transport industry is contained within this sector, and it is this Industry which is most affected by the rise in fuel taxes. Moreover, due to the nature of the transport business, it is a necessary component of all economic activity in the economy and therefore will have an impact on the costing of the products and services offered by other sectors and Households.

4.3 Government

Government accounts for a very small component of the price impact suffered by all income Households. Whilst this means that Government activities have some influence over the final price impact suffered by Households, the fact that the influence is pretty constant across income Household categories, as well as the fact that it is ultimately Households and certain industry sectors that have the majority of influence, means that Government on its own can do very little to alter the distributional impact of higher fuel taxes. In essence therefore, Government would need to prescribe additional policies that would influence Industry and Household expenditure patterns if the aim was to ensure a more equitable distribution of the price impact burden across income Households.

It should be noted that this is also the reason behind why Government has been endogenised, but not discussed as much as Industry or Households in this study.

Chapter 5

Scenario Analysis

Introduction

The results produced and analysed thus far in this study have all revolved around the price impacts arising from a 10% rise in fuel taxes. In this section however, the aim is to build upon the findings presented thus far, and to model two scenarios that are considered to have significant potential as possible policy decisions by Government.

The scenarios being modelled are:

1. The impact of exempting the Agricultural sector from the direct effects of the increase in fuel tax
2. The impact of exempting Households and Government from the direct fuel tax increase

Scenario 1

The initial reason behind simulating this scenario is the fact that the Agricultural sector was consistently identified as one of the most affected sectors under all the models employed in this study. Moreover, there have also been calls in the recent past by the agricultural sector to be exempted from fuel taxes because of the potential downstream impact that it has on basic food prices.

This downstream impact was evident in Chapter 3, wherein the influence of the agricultural sector over the agricultural resource intensive sector was found to be relatively significant under all the models, except of course the Direct Effects model. Significantly, the agricultural resource intensive sector contains the food industry, which began to suffer relatively larger price impacts as soon as the indirect effects arising from these linkages with other Industries were accounted for. This therefore provides further support for the link between Agricultural prices and food prices.

From a production point of view, the Agricultural sector itself had no other Industries that could exert a significant influence over its price impact. For this reason, as well as the relative influence that Agriculture was able to exert over other sectors, it was concluded that the Agricultural sector had large downstream linkages and minimal upstream linkages. Simply put, whatever price impacts occurred in the Agricultural sector would have an influence over the price increases experienced by other Industries, whilst whatever price impacts occurred in other Industries would only have a negligible effect on the price of the Agricultural sector output.

With regard to the Agricultural sector lobbying Government for fuel tax relief, in July 2001 Government re-introduced taxation concessions to diesel users in important primary industries such as agriculture and forestry, mining, coastal shipping (including the NSRI), offshore fishing and mineral exploitation, which also brought down costs of running railway diesel locomotives.

According to the SAPIA Annual Report (2001)⁴²:

“This important tax reform redressed two inequities:

- 1. It ended a process during the past 10 years of withdrawal of all diesel taxation concessions to primary industry, which for example resulted in diesel taxation payable by the agriculture, forestry and fishing sectors rising from a net 28, 2 c/l (46, 8 less 18. 6 c/l concession), to 101, 5 c/l prior to this reform.*
- 2. It stopped an unfair practice in which diesel-users at work underground or on the surface of mines, at sea, in forests and ploughed fields – anywhere but on the road – were being obliged to pay a levy to the Road Accident Fund (16. 5 c/l at July 2001)⁴³.”*

In addition, SAPIA noted that the other main benefit aside from point 2 was the alignment of diesel taxation methods in South Africa with general international practice,

⁴² Website reference number 4

⁴³ Refer to Appendix I for a Tabular Analysis of these components

“thereby helping local producers and exporters of primary products to become more competitive.”

Scenario 2

This scenario was initially selected due to welfare concerns about possible ways in which to reduce the price burden that Households would most likely to have to bear. A secondary objective was a means of minimising the overall price increases resulting from the initial increase in fuel taxes.

Recall that there are at least two price impact effects that Households face:

1. The increased direct cost of consuming fuel, and also
2. The fuel tax raises industry prices, which consequently raises the cost-of-living for Households.

As the direct effects were found to be a significant contributor to the price impacts faced by Households, and as it was the poorer Households who were most negatively affected in this regard, this scenario effectively models Households and Government being exempted from the price effects generated by point 1. This therefore helps to attain a balance between welfare concerns and minimising the large price impacts overall.

This latter aspect would be of particular interest to the Reserve Bank and Government as it could have a significant impact on assisting them to achieve their inflation targets.

Models employed

From an Industry perspective, all three indirect effects models results are presented where applicable in order to fully understand the price impact implications under differing circumstances.

However, it is only the Input-Output model that has been selected to simulate the Household impacts arising under both scenarios. This model is considered to represent the more realistic, albeit worst case, scenario wherein no wage adjustments occur to compensate Households for both their increased direct costs of consuming fuel, and for the increased product prices that arises when fuel taxes are increased and inter-industry indirect effects are accounted for.

The Partial and full SAM-based models, in allowing for wage increases to occur to differing degrees, contains too much 'noise' to be useful from a welfare analysis point of view. The 'noise' referred to is the fact that in receiving higher wages to compensate for some or all of their increased cost-of-living, Households in effect push nominal price impacts to even higher levels until Industry prices ensure that the increase in wage input costs is recoverable through the higher product prices. However, unlike in the Input-Output model where these price impacts are borne completely by Households, some of this increased price impact is due to Households receiving compensation in the form of higher wages. As a result of this compensation, the full price impact under the SAM-based models can no longer be used as a measure of the price impact burden to be borne by Households.

For each of the above scenarios, the Industry and Household effects are modelled and analysed in this chapter. This is done in order to provide as complete a picture of the overall scenario impact as possible. More specifically, whilst a policy may make sense from an Industry point of view, it is important to ensure that Industry does not benefit to the detriment of Households, especially the poorer Households.

1. Scenario 1

The impact of exempting the Agricultural sector from the direct effects of the increase in fuel tax

1.1 Industry Perspective

Townsend & McDonald's (1998) SAM study of the effects of changes in agricultural policies on income distribution in South Africa, found that differing policy simulations, including a 6% reduction in agricultural prices, would benefit poorer Households more so than wealthier Households. Whilst this study is concentrating on the effects of a rise in fuel taxes, this scenario could in effect be seen to be 'reducing' the price of agricultural products by NOT increasing the price via exempting Agricultural sector from the direct price increase.

Bearing this in mind, however, as well as the increased downstream influence exerted by the agricultural sector under the Partial and full SAM-based models, Vogel's (1994) specific reference to the potential misstatement of the agricultural sectors contribution to the economy when using only the Input-Output model, and finally the fact that the agricultural sector was consistently the most affected Industry sector under all the models used in this study, a brief Industry effects analysis of this scenario under differing circumstances is clearly necessary.

Whilst the Agricultural sector is exempted from the direct effects of consuming fuel, the impacts it suffers due to the indirect effects of the fuel tax rise are still accounted for. This is achieved as the interaction linkages between Agriculture and the other elements of the economy are still captured under the relevant model.

The impact on overall PPI is best reflected by the following table that compares the scenario where the agricultural sector is and is not exempt from the fuel tax increase:

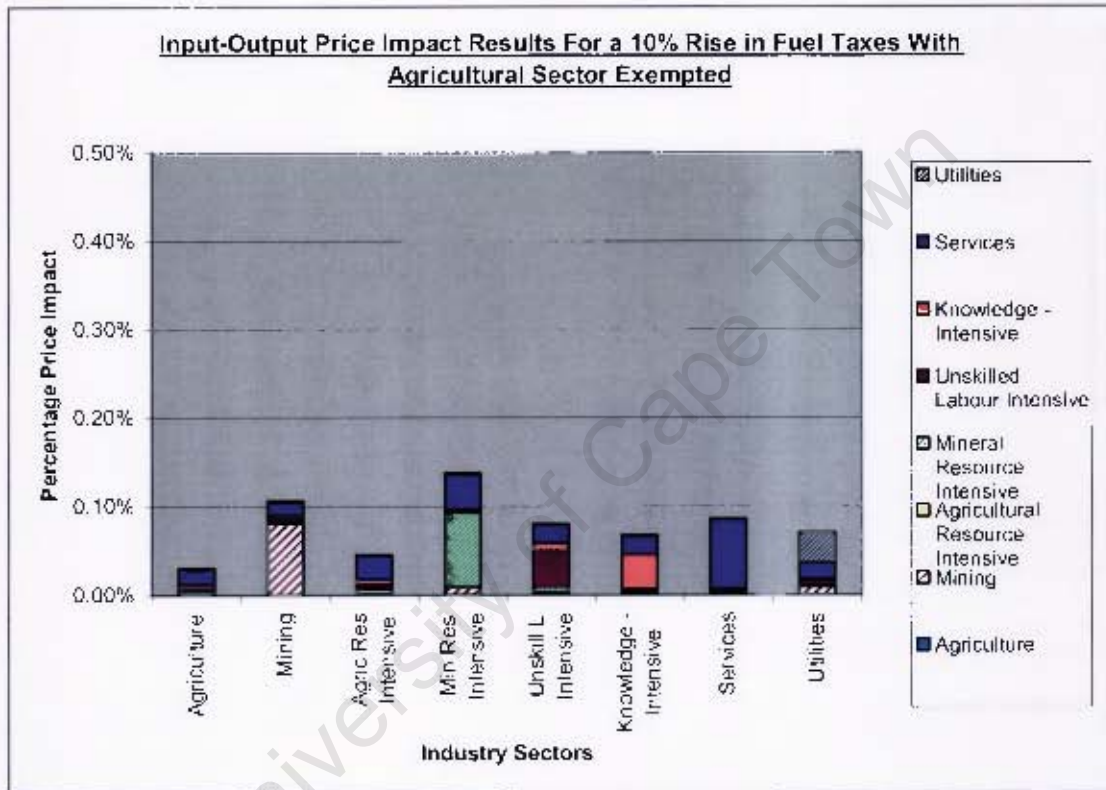
Table 5.1
Comparison of PPI Impacts when the agricultural sector is and
is not exempt from the fuel tax increase

	Not exempt	Exempt
Direct	0.05%	0.04%
Input-Output model	0.09%	0.08%
Partial SAM-model	0.20%	0.17%
Full SAM-model	0.46%	0.43%

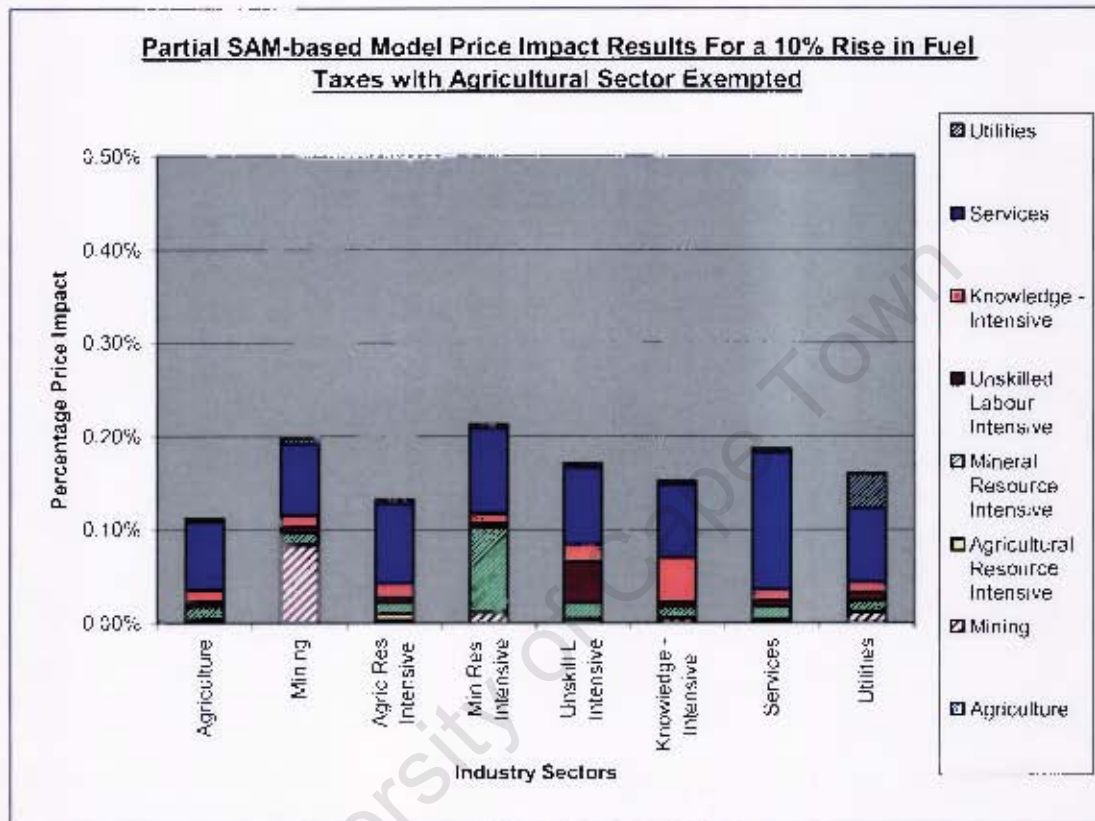
The results clearly indicate that there is some merit in considering this scenario. The extent of the downstream linkages of the agricultural sector are highlighted as the beneficial impact on overall PPI becomes more obvious under the Partial and full SAM-based models. Recall that it is under these two models that the role that wage costs play in magnifying the impact of this change in the economy is captured.

In order to understand what has occurred at an individual sectoral level and to ascertain which sectors now drive the overall price impact under each model, the following series of graphs are presented:

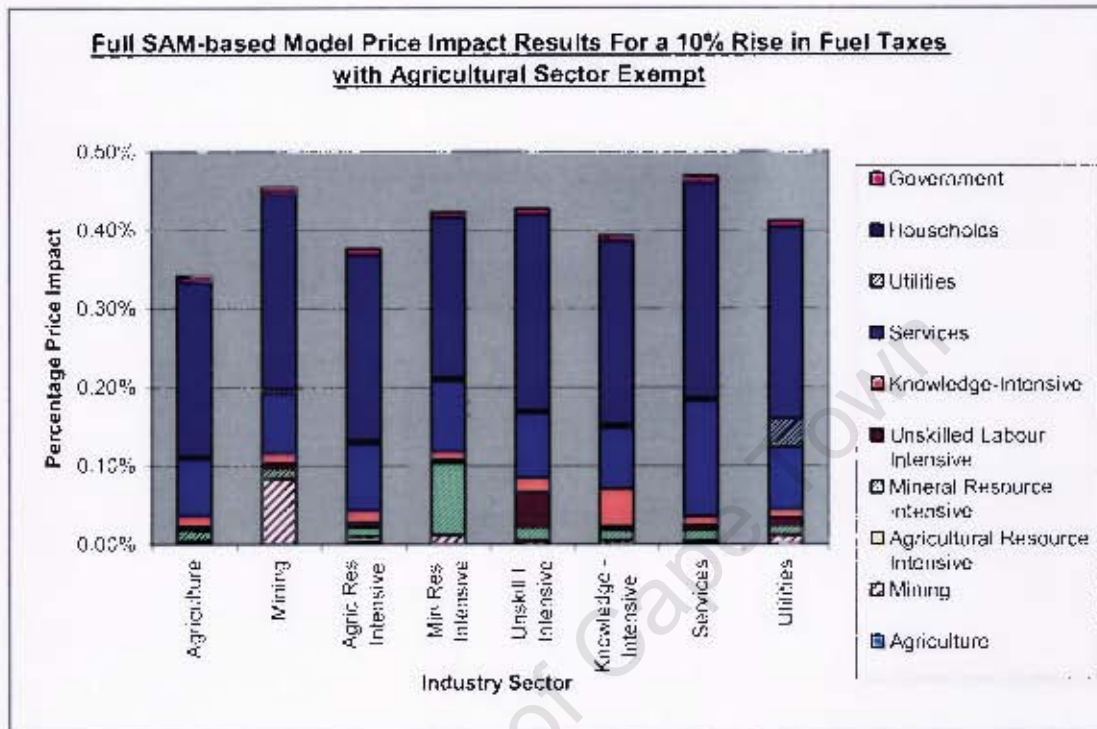
Graph 5.1



Graph 5.2



Graph 5.3



Insofar as the sectoral impacts are concerned, from **Graphs 5.1 - 5.3** presented above, the agricultural sector, as would be expected, is now the least affected sector under all the models, followed closely by the agricultural resource intensive sector. The former point reinforces the fact that the agricultural sector has small backward linkages, given the fact that removing the direct effects moves the agricultural sector from the most to the least affected sector. The second finding should also not be surprising given the fact that earlier analysis has highlighted the influential role that the agricultural sector plays in the price impact suffered by the agricultural resource intensive sector, which importantly contains the food industry.

The Table below summarises the reduction in price impact suffered by each of the aforementioned sectors under each model.

Table 5.2

Reduction in Price Impact Suffered by Each of the Following Sectors
Under the Relevant Model

	Agriculture	Agricultural Resource Intensive
Input-Output	0.16%	0.02%
Partial SAM-model	0.18%	0.05%
Full SAM-model	0.18%	0.05%

The price impact suffered by these two sectors are now influenced predominantly by the services sector – under the Input-Output and Partial SAM-based model – as well as Households – under the full SAM-based model.

The influence of the services sector can firstly be attributed to the transport industry which is contained within this sector. As expected, this industry was consistently the most affected industry under all models, i.e. the fuel tax increase had the largest price impact on this individual industry.

Secondly, the services sector has also been shown to utilise a significant amount of labour in terms of the relative wage costs of other sectors. Consequently, under the Partial and full SAM-based models, when wage increases occur to compensate Households for increased prices, the price impact suffered by the services sector will be significant magnified. This therefore helps to explain the relatively larger price impact being suffered by the services sector under the Partial and full SAM-based models, as well as the mining sector as discussed in chapter 3.

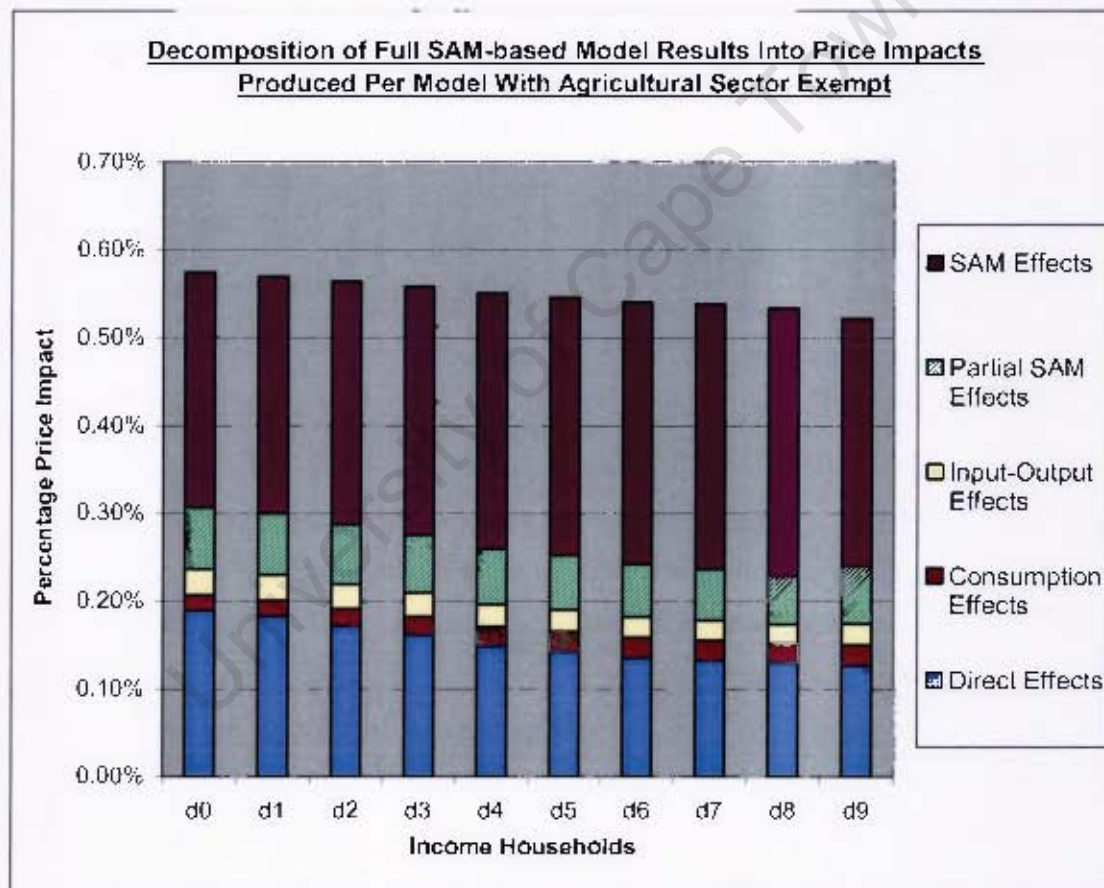
From an Industry perspective, these results clearly advocate the value of exempting the agricultural sector from an increase in fuel taxes should Government wish to minimise the overall price impact associated with the rise in fuel taxes. That is, under this scenario, Government would be able to increase fuel taxes, without simultaneously compromising too much with regard to attaining their inflationary target range. Thus it appears that the

decision to grant fuel tax concessions to the Agricultural sector in 2001 will have the desired objectives as stated by SAPIA.

1.2 Household Perspective

With respect to the Household price impacts, **Graph 5.4** is presented in order to illustrate the component parts of the overall price impact suffered by Households once Households have been compensated fully for all their increased cost-of-living:

Graph 5.4



Aside from indicating the level to which overall prices will settle at once Households have been fully compensated for their increased cost-of-living, the results produced by the full SAM-based model have no interpretive value as dealt with in Chapter 4.

The incremental price impacts highlighted as being produced by the Partial and full SAM-based models are merely nominal increases and hence have no interpretive value from a Household welfare perspective. The reason for this is that Households are fully compensated for this nominal price increase via higher wages.

The main reason behind presenting the above graph in terms of the overall price impact produced by the full SAM-based model is to illustrate the contribution made by the previous models in estimating this overall price impact.

In this regard, it is interesting to note the importance of the direct effects contribution. The contribution to all income Household price impacts is substantial, albeit that it diminishes the higher the income Household. Thus, from the Household point of view of exempting the agricultural sector from the effects of a direct fuel tax increase, there does not seem to be any substantial benefit, aside from a slightly lower overall price impact on Households.

However, per **Table 5.3**⁴⁴, the regressivity ratios generated by the Direct Consumption effects and Input-Output model highlight a slightly different picture.

⁴⁴ Refer to Table 4.5 for comparative regressivity ratios before this scenario was simulated

Table 5.3
Input-Output and Direct Effects Regressivity Results

<u>Households</u> <u>Income</u> <u>Categories</u>	<u>Direct</u> <u>Consumption</u> <u>Effects</u>	<u>Remaining</u> <u>Input-Output</u> <u>Effects</u>	<u>Total</u> <u>Input-Output</u> <u>Results</u>	<u>Direct</u> <u>Effects</u> <u>Results</u>	<u>Total</u> <u>Effects</u>
D0	0.75	1.22	0.99	1.49	1.35
D1	0.78	1.20	0.99	1.44	1.31
D2	0.85	1.15	1.00	1.35	1.25
D3	0.89	1.10	1.00	1.27	1.19
D4	0.93	1.05	0.99	1.17	1.12
D5	0.97	1.02	1.00	1.12	1.08
D6	0.98	0.98	0.98	1.07	1.04
D7	0.98	0.95	0.96	1.04	1.02
D8	0.92	0.90	0.91	1.02	0.99
D9	1.00	1.00	1.00	1.00	1.00

The Direct Consumption effects ratios are the closest that this study has come to producing a series of progressive ratios. The relative price impact burden increases the higher the income level of the Household, and all ratios are less than 1 except of course the highest income Household. This means that the highest income Household bears the greatest relative burden.

The remaining indirect Input-Output effects are still however regressive, although the ratios are much closer to 1 than was the case before this simulation was conducted. In fact Households d6-d8 now bear a smaller price impact burden than the highest income Household, hence their ratios being less than 1. The lower income Households still face relatively larger indirect price burdens than the higher income Households.

The Input-Output Total effects are fairly evenly distributed though, with only a very slight benefit for second highest income Household. Overall therefore, the Input-Output effects are substantially less regressive than was the case before simulating this scenario.

The Direct effects ratios are unaffected by this simulation, as they have no linkages with the agricultural sector or any other sector price impacts by definition.

Consequently, the overall (including direct) effects are therefore much less regressive than before simulation, but as the direct effects influence is still substantial, the overall ratios still indicate regressivity. However, there is definitely a welfare benefit, albeit relatively small, to be gained from implementing this policy scenario.

1.3 Source of Price Increases

As the overall indirect effects generated are not as large as some of the other results produced by the SAM-based models, a sectoral aggregation and analysis of results has not been performed. Instead, the significant individual industries have been highlighted under the Direct Consumption effects and Input-Output models.

Direct Consumption effects

As is to be expected, Transport is the only individual industry that suffers a significant price impact (approximately 0.01%). Other than that, the other industries effects are too small to warrant an analysis.

Input-Output model

The Agriculture sector impact is almost 0% as is to be expected. In chapter 3, recall that this sector contributed approximately 0.01% suffered by all Households, with the higher income Households suffering about half of this. Thus, this is a significant impact to model.

In addition, the downstream impact of modelling this simulation is the most interesting. The price impact contribution from the food industry also halved – from 0.02% across most Households, declining significantly again from Household d5 onwards, to just under 0.01%.

This provides yet further evidence of the link between the two sectors as well as the downstream impact that agriculture has on food industry. In addition, this also highlights why this sector was selected for exemption over the seemingly more important food industry. The agricultural sector will have far more beneficial price effects over other industries, including most importantly the food industry, as illustrated not only here, but by the linkages highlighted in chapter 3. For this reason, it was the prime candidate for exemption from the fuel tax increase.

Aside from that, transport, and wholesale & retail trade industries price impacts remain unchanged at 0.01% across all income Households. This merely indicates that these industries are more affected by other linkages than by the price impact effects that occur in the agricultural sector.

Overall though, the price impact borne by each Household will be slightly lower than was the case before the exemption was simulated. Therefore, as this would in effect also reduce the absolute burden borne by the lower income Households as well, and as the regressivity ratios also indicate that this will have a positive effect on the distribution of the price impact burden across income Households, such a policy appears beneficial from a welfare point of view as well.

2. Scenario 2

The impact of exempting Households and Government from direct fuel tax increase

2.1 Industry Perspective

From an Industry perspective, this scenario has already been modelled, with the reader being referred to the combination of the analysis of results produced by the Input-Output and Partial SAM-based models in Chapter 3.

When revisiting these results, consider that the Input-Output model does not allow for any wage adjustments to occur, and therefore Households bear the full price impact of their direct fuel consumption and increased product prices. These increased product prices therefore do not contain effects arising from increased wage input costs as Households attempt to pass their increased cost of living onto Industry.

Under the Partial SAM-based model however, Households are compensated for the increased product prices that they face via nominal wage increases. This has the effect of increasing product prices further, but Households are compensated for all these product increases.

Where Households experience the decline in real wage however, is that under the Partial SAM-based model, they are not compensated for the increase in direct costs that they face in consuming fuel. Thus, this cost is not passed onto Industry via wage increases, and industry product prices are therefore not affected by this impact. A by-product of this is that from an Industry point of view, Households and Government have implicitly been deemed to be exempt from the fuel tax increase.

Bearing all this in mind, as well as the detailed analysis and presentation of results under both models from an Industry perspective, this scenario has already been adequately dealt with, albeit indirectly, in Chapter 3.

2.2 Household Perspective

One of the major issues identified in Chapter 4, and highlighted in scenario 1 above, is the extent of influence of the direct effects on the price impacts suffered by all income Households. Aligned to this is the fact that these direct effects are also highly regressive. Thus the direct effects price impacts are a serious cause for concern, particularly from a distributional burden point of view.

This scenario, unlike the Industry perspective, has not really been dealt with already.

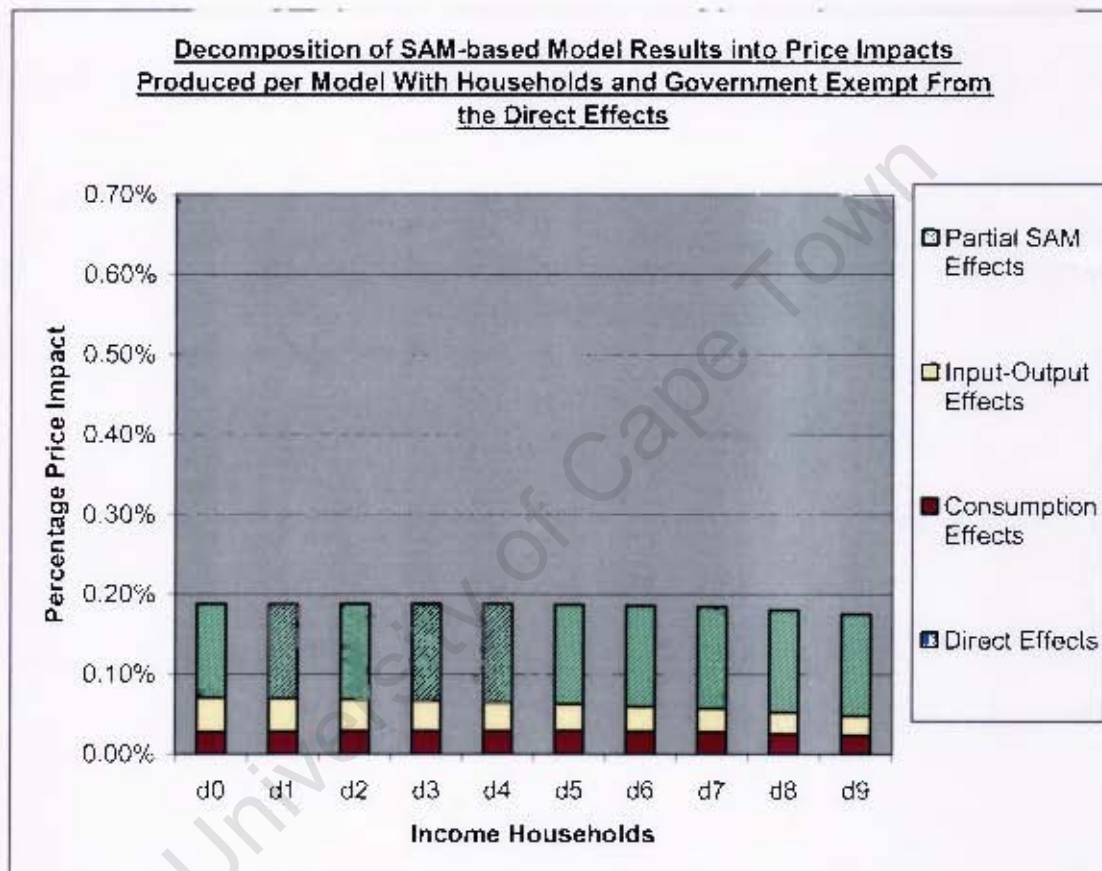
The Partial and full SAM-based models, as noted earlier, allow wages to adjust for the increased cost-of-living that Households face when fuel taxes are increased. Under this scenario however, these two models will produce the same result as the direct effects that Households and Government experience are now deemed to be nil. As a result, the full SAM-based model no longer needs to generate price increases to compensate for this effect and its associated downstream price impacts.

The only effect for which wages now rise is therefore the increased product prices that are generated by Industry. As this is what the Partial SAM-based model captures anyway, the two SAM-based models will produce the same result. Thus, Graph 5.5 below does not represent the full SAM-based model's results as they are the same as the full SAM-based model under this simulation.

Once again, the Partial SAM-based model results are presented in order to assess the level to which prices must rise before wage costs and product prices stabilise to maintain the cost-of-living standard as before the fuel tax increase. Aside from that, the Input-Output model results are essentially the focus of this section, along with the overall impact of deeming Household and Government direct effects to be nil.

Per Graph 5.5 this level appears to be roughly 0.18% - 0.19%.

Graph 5.5



Thus the exemption of Households and Government from the direct effects of the fuel tax increase results in a significantly smaller overall price impact effect than was encountered anywhere else in this study. From a welfare point of view, this simulation indicates that this exemption is a worthwhile policy consideration.

However, if wage increases arising from the higher product prices were not allowed to occur, then the true price impact burden borne by each income Household would be approximately 0.07% - 0.08%. Recall that the Partial SAM-based model's contribution to

the price impacts illustrated above are nominal increases. Households are fully compensated for these price impacts through the receipt of higher wages. Thus, the Partial SAM-based models contribution above should also be ignored in order to identify the true price impact burden that Households would have to bear under this simulation scenario.

Thus far in this study, fuel taxes have been consistently found to be regressive as they impact on the relative cost of living for poorer Households the most. Much of this has been shown to be driven by the significant influence of the direct effects that Households suffer. This latter aspect has therefore now been removed under this scenario, with the revised regressivity results being presented in **Table 5.4**.

Table 5.4
Input-Output and Direct Effects Regressivity Results

<u>Households</u> <u>Income</u> <u>Categories</u>	<u>Direct Consumption</u> <u>Effects</u>	<u>Remaining</u> <u>Input-Output Effects</u>	<u>Total</u> <u>Input-Output Results</u>
D0	1.18	1.75	1.48
D1	1.19	1.75	1.46
D2	1.22	1.63	1.43
D3	1.23	1.54	1.39
D4	1.24	1.46	1.34
D5	1.24	1.38	1.31
D6	1.21	1.29	1.25
D7	1.17	1.21	1.19
D8	1.07	1.13	1.09
D9	1.00	1.00	1.00

These results are exactly the same as those presented and analysed in **Table 4.5** in Chapter 4. The only difference is that the Direct effects regressivity influence has been removed. As a result, the overall regressivity is slightly worse than indicated per **Table 4.5**.

However, as the overall price impact burden that each Household bears is significantly smaller than when the direct effects were considered, this slightly more regressive distributional profile has a much smaller impact on each income Household. That is, the more regressive distributional price impact profile is more than adequately compensated for through the smaller overall price impact that each income Household now faces.

Clearly therefore, this would be a reasonable strategy for Government to consider implementing in some way. For example, providing relief to poorer Households through subsidising paraffin in an attempt to lower the negative effects of fuel taxes/prices on these poorer Households.

On the other hand, Government would also have to weigh up the welfare benefit obtained from this strategy against the loss of revenue that they will experience, and therefore exempting all Households and Government departments from all forms of fuel taxation will not be a realistic option.

In summary, Case (1998) suggested that the welfare payoff associated with trade liberalisation would be highest were it to result in lower prices of food stuffs and fuels purchased by the poorest African Households. The findings of these simulations provide another means of ensuring that these types of income Households are not disadvantaged when fuel taxes, and hence fuel prices are increased.

Whilst this study models the opposite scenario⁴⁵, that is the impact of raising fuel taxes, the findings of this study complement that found by Case with regard to fuel prices. This is particularly true of the group that she indicated would stand to benefit the most from a reduction in the price thereof.

⁴⁵ It should be considered that in the context of raising fuel taxes, this study is also implicitly raising the price of fuel as well. Further, because of the stringent assumptions made in this study, modelling a reduction of fuel taxes, and implicitly, fuel prices will have the same equal and opposite effect to that found by raising fuel taxes.

Chapter 6

Conclusion

As mentioned at the beginning of this study, there is no obvious measure available that fully captures all the price impacts that arise within the economy when fuel taxes are increased.

However, by employing different models in an attempt to capture these price impacts, this study was able to effectively isolate the price impacts arising from specific economic linkages. Moreover, the importance of capturing these economic linkages was underlined by the fact that the price impacts produced under each of the models differed quite significantly. Thus, it is submitted that the price impact results produced became more accurate and complete the more economic linkages were captured.

A proper understanding of the results produced by the Input-Output and SAM-based models is also crucial in terms of being able to interpret the differences in these results.

Methodology

The Direct effects scenario simply illustrates the direct cost that an entity will bear after the fuel tax increase in order to be able to purchase the same amount of fuel as before the increase.

The Input-Output model however, reflects the scenario wherein Industry product prices rise because of two effects. The first is the direct effects that the Industry suffers as captured by the Direct effects model. The second effect captured is the impact arising from Industries passing on this increased cost onto other Industries in the form of higher prices. As the various industries purchase and sell goods/services to each other, the second effect can be seen to be generated in a rather complex manner. The Input-Output model's value therefore lies in this latter capability.

However, the price impact results that are generated need to be interpreted carefully as the Input-Output model is focused exclusively on Industry transactions and inter-relationships. Essentially the results indicate the level to which Industry prices would increase to, if no wage adjustments were to occur to compensate employees for the effect of the fuel tax rise.

From an Industry point of view, this means that wage input costs do not change and therefore will not impact on the price of output by Industry. From a Household income perspective, employees are suffering a wage decline equivalent to the increase in Industry product prices and the increase in direct costs of their (Household) fuel consumption expenditure. Thus the price impact that each income Household suffers is the full price increase burden that the Household will have to bear.

Building on this scenario, the Partial SAM-based model therefore allows for a wage increase equivalent to the rise in industry product prices. This has the effect of increasing product prices even more as wages are an input costs for industry, thereby setting off a vicious circle of price increases until a new equilibrium level is reached.

From an Industry perspective, this reflects the level to which industry prices must move to recover the increased wage input costs. From a Household point of view, the price impact burden facing each income Household can no longer be taken as the full burden that Households must bear. Part of the larger price impact burden generated under this model is because Households have received nominal wage increases to compensate them for the higher industry product prices. However, Households still suffer a real wage decline under this model, as the direct effects that they suffer are still not compensated for. Households therefore suffer a real price impact burden equivalent to this latter effect only.

Consequently, the full SAM-based model allows for additional wage increases that compensate for these direct effects as well. The results produced under this model are therefore considered the most complete. The levels to which price increases must occur

under this model reflects the scenario wherein prices and wages are in the same equilibrium situation as before the fuel tax increase. Thus, as Households receive full wage increases for all the price increases that they suffer as a result of the fuel tax rise, they therefore suffer no real wage increase/decline. This nominal wage increase impact on industry prices is also reflected by the level to which industry prices must increase in order to recover their higher input costs.

Thus, under the full SAM-based scenario, nominal price increases must occur, to the extent reflected by the results of this model. That is, if price increases occur to this extent, then neither Industry nor Households will bear any real price increase burdens after the fuel tax increase. This therefore should be seen as the real value behind utilising a SAM-based model in this study, alongside the other models of course.

Industry

From an Industry perspective, the attempt at assessing the impact of rising fuel taxes on PPI proved extremely insightful. By capturing the additional indirect effects in each model as noted above, the overall PPI impact was seen to continually double from 0.05% under the Direct effects model to eventually 0.46% under the full SAM-based model. These additional price impacts arose from first capturing inter-industry linkages, and then wage increase implications, with wage increases compensating for some or all of the price increases faced by Households.

The substantial difference between the overall PPI impacts under the different models clearly highlights the importance of first capturing and then understanding the indirect price effects from an Industry perspective.

From a sectoral analysis point of view, the agricultural sector was consistently the most affected in terms of price increases under all the models. However, once the indirect effects were accounted for, the remaining sectors changed ranking as regards the relative price impacts that each suffered. In this regard, the main culprit was seen to be the

changes in the relative price impact suffered by the underlying industries that were aggregated into these sectors.

The transport industry was, as to be expected by its extensive reliance on fuel as a vital input, the most affected industry under all the models. Agriculture, and even mining to a degree were amongst the top most affected sectors. However, as differing economic linkages were captured, so the changes in ranking of the underlying industries also shifted around.

Noticeably though, the food industry was the most prominent industry in this regard. When only the direct effects were considered, the food industry suffered a very small relative price impact. However, when the indirect effects were accounted for, this sector became and stayed one of the more affected sectors in terms of the relative price impact it suffered. This can be attributed to the link between the price impacts suffered by the agricultural sector, and its ability to pass on these price impacts to other sectors, most noticeably the agricultural resource intensive sector. Interestingly, the agricultural sector was found to have significant downstream influences over this sector in particular, with the food industry being one of the industries contained within this latter sector. Highlighted by this finding therefore, is the link between the price impact of the fuel tax increase on agriculture, and the resulting indirect impact on food prices.

The services sector was also seen to be a major sectoral contributor to the price impact suffered by each sector. This can be attributed initially to the inclusion of the transport industry within this sector. Under the Partial and full SAM-based models, when wage impacts began to drive the price impacts experienced within the economy, the services sector influence over other sector price impacts was magnified. Consequently, this highlighted the heavy reliance on labour by the services sector, as well as the extensive upstream and downstream linkages that this sector had with all the other sectors of the economy.

Households

The comparison of Direct consumption effects and Input-Output model results with Casler (1993) highlighted that the U.S. findings that the overall fuel tax increase burden will be distributed roughly in proportion to income levels is not true for South Africa. The one consistent result produced with regard to Households no matter which model is utilised, is that the poorest Households will suffer the greatest relative burden when fuel taxes are increased.

This implies therefore that raising fuel taxes will have undesirable consequences for the welfare of the poor. As illustrated in Chapter 3, this method of generating revenue is important to Government however, given its significant contribution to the fiscal coffers. More realistically, the use of this revenue by Government should therefore be the focal point, especially as this form of revenue-generation has been shown to be more harmful to those whom Government are trying to assist. This study very simply highlights the fact that Government needs to be aware of the welfare cost of raising revenue in this manner.

Moreover, this result also highlights the fallacy with regard to wealthier Households being assumed to bear the greater relative burden of fuel tax increases. Thus, having established that fuel taxes are more harmful to the poorer Households than to the wealthier ones as originally envisaged, Government should consider the options it has available with regard to reducing this inequality.

One of the main drivers behind the regressive nature of the price impact distribution profile was the Direct effects suffered by each income Household. The direct effects were also found to be a significant contributor to the price impact suffered by each income Household. Consequently the regressive distribution of this price impact influences the overall price impact distribution after indirect effects are accounted for.

The Direct Consumption effects and even the Input-Output model price impacts effects are substantially smaller than the Direct effects. Thus, in the case where Households fail

to receive any wage increases for the increased cost-of-living arising from the initial fuel tax increase, the price impact and distribution across income Households is driven by the Direct effects.

Moreover, under the Partial and full SAM-based models, the ability of Households to pass on their increased cost-of-living expenditure onto Industry in the form of higher wages was found to result in significantly larger indirect effects being produced by these models. Recall however that the difference between the price increases under these models and the Input-Output model and Direct effects results represent nominal price impacts for which Households are compensated through higher wage income.

Thus, if Households were unable to pass on their increased cost-of-living expenditure, then the overall price impact would be substantially smaller, albeit regressive because of the influence of the direct effects as mentioned.

Scenario Analysis

With regard to the scenario analysis performed, it is clear that exempting the agricultural sector from the direct effects of the fuel tax has beneficial Industry, and probably international competitiveness, implications for the sector. The overall PPI impacts do come down slightly as a result. Thus the implementation of this policy via a rebate system in July 2001 appears to be justified in this regard.

More importantly, from a welfare point of view, this type of policy would have a very slight benefit for Households in general as it will reduce the overall price impacts that they experience, albeit by a very small amount. The indirect effects generated by the Input-Output model, i.e. the price burden of increased product prices faced by Households is distributed fairly evenly across all income Households.

This is quite a change from the highly regressive results that are produced by the same model when the agricultural sector is not exempted from the fuel tax increase. Essentially the highly influential and regressive direct effects still over-ride this Input-Output model result, hence the overall regressive distributional profile being retained. However, the Input-Output model results are encouraging from a welfare perspective.

Thus, from an overall perspective, this seems a fair policy to implement, especially as it will also have a beneficial impact on Government being able to perhaps attain their inflation target range overall.

Finally, the exemption of Households and Government from the direct effects of the fuel tax increase was modelled. The distribution of the fuel tax burden across income Households has thus far been found to be biased against poorer Households, with the main driver behind this being the individual Households direct effects. As a result, it was always a logical scenario to simulate given the potential welfare and overall price impact benefits.

The Input-Output model results are still however regressive in this scenario, and therefore the price impact distribution across income Households will still be regressive. However, given the fact that the absolute price impacts are substantially smaller, there is still obviously an overall benefit for all Households.

From an Industry and Household perspective, if Households are unable to pass on their increased cost-of-living to Industry through wage increases, then the price impact will be as reflected by this model's results for Industry. If it were assumed that Households could receive wage increases and thereby still pass on the increased cost that they face in the form of higher Industry product prices back onto Industry, then the Partial SAM-based model results provides this answer.

The real price impact would probably lie somewhere between the results produced by both these models depending on whether and the extent to which wage increases occur.

Another aspect to consider is that whilst the scenario exempts all Households and Government from all forms of fuel tax increases, and shows that this has a substantial benefit for Industry and Household price impacts, such a scenario is not indicative of reality. Government cannot realistically exempt all Households and Government from the direct effects of the fuel tax increase, as aside from the potential loss in revenue, administering such a policy will prove to be almost impossible and ultimately extremely costly.

However, the value of considering such a policy is quite significant. Thus, a more realistic alternative would be to e.g. subsidise the price of illuminating paraffin so as to make it more affordable to the poor Households that rely so heavily on it, but for whom it may prove too expensive to purchase. Selective exemptions aimed at uplifting the standard of living of the poor Households may see the more realistic version of this scenario being adopted by Government. The benefits to be gained from such a policy should not however be lost altogether.

A caveat at this point is that the model used to assess the overall effects and perform this simulation has inherent limitations as has been discussed throughout this study. More specifically, the assumption of fixed consumption coefficients and lack of substitution of inputs may play a more significant role, and thus the net effect may conceivably be even larger for both Industry and Households than is presented here.

This is a very real possibility, and the reader is therefore advised to bear this in mind when assessing all the results presented.

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- 35 WIESE, A. M. ROSE, A. and SCHLUTER, G. 1995. "Motor-Fuel Taxes and Household Welfare: An Applied General Equilibrium Analysis", *Land Economics*, 71(2): 229-43

II. WEBSITES

The latest information was obtained from all these sites on the last access date of 13 September 2002.

- 1 www.dme.gov.za
Energy: Liquid Fuels: Fact sheet of petrol price composition
Breakdown of petrol and diesel prices
History of prices and price elements
Petrol price per zone
Consumption figures of paraffin, petrol and diesel

- 2 www.sapia.com

- 3 Article on SAPIA website:
Publications: 2001 Annual Report: Fuel Taxation History:
www.mbendi.co.za/sapia/pubs/2001_Arep/arep01a12.htm

- 4 Article on SAPIA website:
Publications: 2001 Annual Report: Fuel Tax Reform:
www.mbendi.co.za/sapia/pubs/2001_Arep/arep01s7.htm

- 5 Article on SAPIA website:
Product sales figures: Current sales figures and historical data:
www.mbendi.co.za/sapia/rsacons.htm#QUARTERLY

- 6 Article on SAPIA website:
Product sales figures: Fuel price changes:
www.mbendi.co.za/indy/oilg/ogds/af/sa/p0020.htm#10

- 7 Lawrence Edwards Lecture notes in Power Point on SAM-based models:
www.commerce.uct.ac.za/economics/programs/postgrad/specialisation/msstrpol/crsematerial/Impactcrse02/ewpia.htm
- 8 National Budget Review (2002), Annexure B – Statistical Tables, Table 3 Main Budget pages 192 – 194): www.finance.gov.za
- 9 CPI Figures used to convert **Graph 3.1** from nominal to real values were obtained from the following website and associated link
<http://www.statssa.gov.za/Uploads/Exceldownload.asp>
DOWNLOAD CONSUMER PRICE INDEX.ZIP
 LAST UPDATE: 8/26/2003 2:19:14 PM

Statistics used:

VPI40615	CONSUMER PRICE INDEX GROUP AND PRODUCT INDICES	METROPOLITAN AREAS	INDICES
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These were the only statistics available for the entire period from March 1987 to February 2002, The base year is 2000, so all figures are presented in terms of the 2000 year values

Appendices

University of Cape Town

Appendix I

The following is an extract from the Department of Minerals and Energy website (www.dme.gov.za). It details and describes the various components that make up the price of petrol in South Africa:

1. Components of the Petrol Price

“International Dimension

FOB value (product postings)

An average of the "free-on-board" (FOB) petrol prices "posted" (listed) by four international export refineries is used to calculate the FOB portion of the landed cost. These refineries are BP, Mobil and Shell in Singapore and Caltex in Bahrain. The value of these "products Postings" reflects the purchase price for petroleum products should South Africa be required to import significant volumes of these products. The four refineries would be able to supply sufficient volumes of petrol of the right quality and at the most economical freight rates. This figure is based on international prices and it can therefore not be manipulated.

Prior to the nationalisation of petroleum resources and refineries in the Persian Gulf by the Arabian oil producing countries during the early seventies, postings (term prices) in the Middle East were used to determine prices for refined products in South Africa. With conventional market forces neutralised in the Gulf, it was deemed essential to switch to another international refining centre obtaining its crude oil from the same area as South Africa, and which was situated at approximately the same distance from South Africa as the Gulf refineries. Singapore, with its major export refineries, was regarded the best choice. Bahrain was included as a balance to avoid using prices from only one refinery centre.

Freight

Standard international tariffs from the "Worldscale" publication for voyages from Bahrain and Singapore to SA ports are used as a base. Each month, factors reflecting the latest market trends for different types of vessels are incorporated into a market rate, which is then applied to the standard tariff or "Worldscale", to determine the freight cost.

Insurance

Lloyds of London determine insurance tariffs for different voyages according to prevailing risks to and from different areas in the world (for cargo insurance purposes) for different product types. This risk determination is normally a function of two risk elements, namely the inherent risk in shipping a specific type of product (such as volatility) and special risks associated with load or discharge ports due to political or other circumstances prevailing at these ports at the time. For instance, during the invasion of Kuwait by Iraq and the ensuing Gulf war, certain areas in the Arabian/Persian Gulf were classified as high risk war areas and attracted exorbitant insurance premiums.

The 0,1009% of cost and freight applied in the RSA situation represents a low risk tariff for petroleum product shipments.

Ocean Leakage

In international crude oil and petroleum products trading, shipping and insurance, a loss of 0,5% for crude oil and 0,3% for products has been accepted as a normal leakage/clingage and evaporation loss. Simply put, this means that the "normal" loss is not insurable and has to be accepted by the buyer. The buyer therefore has a financial loss of 0,5% on crude oil or 0,3% on petroleum products imported because payment is made on Bill of Lading Volumes (B/L), yet actual landed volumes are "normally" 0,5% or 0,3% less the B/L volumes.

The sum of the above elements represents the CIF (Cost, Insurance and Freight) cost for products "landed" in South Africa.

By adding landing and wharfage charges (actually charged at 1,8% of FOB value but for purposes of price-determination 1,78% of FOB product value of the shipment) the 'In Bond Landed Cost' (IBLC) is arrived at.

Domestic Elements

The In Bond Landed Cost, in US c/gallon, as determined above, is converted to cents/litre by applying the applicable Rand/Dollar exchange rate (four bank daily mean quoted at 11:00 averaged over the calendar month applicable) and a constant litre/gallon factor (3,8038 for petrol).

This IBLC represents the transfer price from the refinery to the marketing division and the difference between IBLC prices for the different products times the percentage yield of the products, for a specific crude oil less crude oil import costs, essentially represents the gross refining margin for the refinery. To arrive at the final pump price in the different pricing zones (magisterial district zones) certain domestic costs, imposts, levies and margins are added to the international price (IBLC).

The import parity (IBLC) principle is an elegant, arms-length method of basic price determination to ensure that local refineries compete with their international counterparts; ensuring cost efficiency and astute crude acquisition strategies to ensure survival in a volatile and competitive international environment, thus eliminating domestic inflationary pressures.

Inland transport costs (Zone differential)

Transport costs to the different pricing zones are determined by using the most economical cost of transporting the product from the coast (DBN/PE/EL/MB/CT) to the inland depot serving the area or zone. The country is divided into A, B and C zones according to the dominant mode of transport e.g. pipeline (C - zones). The transport cost to the Gauteng area, for example, is based on pipeline tariffs.

Delivery cost

This element compensates marketers for actual depot related costs and distribution costs from the depot to the end user. The element is calculated on actual historic costs (1 year previously) averaged over the country and industry.

Wholesale (marketing) margin

The margin is a fixed maximum monetary margin. The formula used to determine the wholesale margin is based on the results of a cost and financial investigation by a firm of chartered accountants (Deloitte & Touche) into the profitability of the wholesale marketers. The level of the margin is calculated on an industry basis and is aimed at granting these marketers a benchmark return of 15% on depreciated book values of assets, with allowance for additional depreciation, but before tax and payment of interest.

The profitability of the wholesale marketers is calculated on the previous year's results and does not take into account the inflationary increases in the current year. This, combined with margin increases not being implemented at the beginning of the financial year, has resulted in the returns not once achieving the benchmark of 15%.

Retail margin

The retail profit margin is fixed by the Department of Mineral and Energy Affairs and is determined on the basis of the actual costs incurred by the service station operator in distributing petrol. In this cost structure account is taken of all proportionate driveway related costs such as rental, interest, labour, overheads and entrepreneurial compensation. Petrol service stations selling higher volumes may in some cases achieve a certain advantage as they function at the same retail margin. In many cases, however, higher fixed cost may offset such an advantage.

The model does not provide for an actual net profit component but the manner in which the margin is determined creates an incentive to dealers to strive towards greater efficiency. In doing so, they can beat the average and realise a net profit proportionate to their efficiency.

Service Station Rationalisation Plan

In order to improve the viability of service stations, the Department of Mineral and Energy Affairs administers the Service Station Rationalisation Plan (RATPLAN). This is aimed at rationalising the number of service stations so as to enable them to reap the benefits of increased throughputs and the unit cost advantages flowing therefrom. This also reduces the level of retail margins required.

Equalisation Fund Levy

The Equalisation Fund levy was a fixed monetary levy, determined by the Minister of Mineral and Energy Affairs in concurrence with the Minister of Finance.

During 1979 the Republic of South Africa found itself in a situation where it could not obtain crude oil without paying a price differential. It became necessary to establish the Equalisation Fund to manage the collection of levies and financing of the price differential. A levy based on retail sales of petroleum products was imposed from January 1979. The companies marketing these products (so called Schedule C Companies) collect the levies on behalf of the Equalisation Fund.

The statutory fund is regulated by ministerial directives issued by the minister in concurrence with the Minister of Finance as laid down by the Central Energy Fund Act, No 38 of 1977 as amended. CEF (Proprietary) Limited manages the Equalisation Fund. The Chairman of CEF (Proprietary) Limited, is the accounting officer of the Fund.

In terms of Ministerial Directives the Fund was principally utilised to

1. smooth out fluctuations in the price of liquid fuel (slate payments)
2. afford Sasol tariff protection, for synlevy payments to the oil industry for upliftment of Sasol synfuel production
3. until recently to finance the crude oil "premium".
4. fund fire-fighting and security projects at identified fuel installations. These projects are funded out of accumulated levies.

This levy was reduced to zero in February 2000. Due to high oil price levels, tariff protection was deemed no longer necessary. In fact, the remaining monies within the Fund will be used to subsidise the domestic pump price to the value of 8 cents/litre until the Fund runs dry.

The "Slate" Mechanism

The IBLC is a function of daily changing postings and R/\$ exchange rate movements. The monthly average of the net effect of these changes determines the actual IBLC for the applicable month. Other domestic price elements may also change from time to time.

The sum total of these changes inevitably influence the pump price.

Petrol prices are adjusted on the first Wednesday of every month. Prices rise and fall in line with movements in the exchange rate and international product prices. The basic price is calculated on the basis of 80% of posted product prices at three refineries in Singapore and one in Bahrain, and 20% of spot prices. The Singapore basket of posted prices has been adjusted to exclude refineries operated by multinational companies with investments in South Africa. The Central Energy Fund administers the system and independent auditors check it.

Fuel Tax

A tax levied by Government.

Customs & Excise

A duty collected in terms of the Customs Union.

Road Accidents Fund

The Road Accidents Fund receives a percentage which is used to compensate third party victims in motor accidents."

2. Existing Fuel Price Structure¹

The following Table taken from the SAPIA website represents the price components of the fuel price as at 4 September 2002. The fuel levy is still clearly a substantial component of the overall price.

	Petrol 93 unleaded c/l	Petrol 93 leaded c/l	Petrol 97 unleaded c/l	Diesel* 0.3% S c/l	Diesel* 0.05% S c/l	Illuminating Paraffin c/l
Wholesale Margin	24.308	24.308	24.308	24.3	24.3	24.512
Service Cost	5.1	5.1	5.1	5.1	5.1	13.1
Recoveries						
Storage, handling & delivery costs	5.1	5.1	5.1	5.1	5.1	5.1
Distribution costs	0	0	0	0	0	8
Dealers Margin	31.2	31.2	31.2	0	0	0
Zone Differential in Gauteng	11.5	11.5	11.5	11.5	11.5	19
IP Tracer Levy	0	0	0	0.15	0.15	0
Fuel Levy	94.8	98	91.8	81	81	0
Customs and Excise Duty	4	4	4	4	4	0
RAF Levy	18.5	18.5	18.5	18.5	18.5	0
Subtotal	190.408	193.608	187.408	145.55	145.55	56.612
Contribution to the basic fuel price (IBLC)	218.592	215.392	227.592	213.65	219.55	207.488
Retail Price	409	409	415			
Wholesale Price				359.2	365.1	264.1

(* The Wholesale price of diesel is regulated, but not the retail price

This gives the price paid by the ordinary motorist at the service station pump.

¹ Source: SAPIA website reference number 6

3. Product Sales Volume and Price Elasticity²

Below are the sales volumes and prices for the different types of liquid fuels consumed within South Africa. This information was obtained directly from the SAPIA website. Note that despite the declining sales volumes, the price as reflected in the Tables below increase at a larger rate than this decline. As a result, this confirms the overall price inelasticity of fuel.

	2001	2000	1999	1998	1997	1996	1995
Product sales volumes of all liquid fuels in S.A. in millions of Litres per annum	20934	20868	21217	21096	20780	20269	19148
Petrol							
Sales volumes in millions of Litres per annum	10340	10396	10861	10883	10785	10566	10153
% change p.a.	-1%	-4%	0%	1%	2%	4%	-
Average petrol price (in cents per litre)	368	332	256	226	215	199	182
% change p.a.	11%	29%	13%	5%	8%	9%	-
Price Elasticity as calculated	-0.05	-0.15	-0.02	0.18	0.27	0.43	-
Diesel							
Sales volumes in millions of Litres per annum	6488	6254	5993	5959	5869	5759	5432
% change p.a.	4%	4%	1%	2%	2%	6%	-
Average diesel price (in cents per litre)	319	286	210	185	195	193	165
% change p.a.	12%	36%	13%	-5%	1%	17%	-
Price Elasticity as calculated	0.32	0.12	0.04	-0.29	1.59	0.35	-

² Source: SAPIA website reference number 5 for sales volumes figures and 6 for fuel prices

4. Price Structure History³

LEADED PETROL					
Year	Customs& Excise Duty	Fuel Levy	Road Accident Fund Levy	Equalisation Fund Levy	Total Imposts
1987	4,0	19,9	Nil	7,0	30,9
1988	4,0	22,9	3,6	7,0	37,5
1989	4,0	31,9	3,6	7,0	46,5
1990	4,0	31,9	4,2	7,0	47,1
1991	4,0	46,9	4,2	7,0	62,1
1992	4,0	54,9	6,2	7,0	72,1
1993	4,0	60,9	9,2	7,0	81,1
1994	4,0	60,9	9,2	9,4	83,5
1995	4,0	62,9	9,2	9,4	85,5
1996	4,0	71,6	10,5	5,4	91,5
1997	4,0	76,6	12,5	0,4	93,5
1998	4,0	86,6	14,5	8,0	113,1
1999	4,0	90,6	14,5	8,0	117,1
2000	4,0	95,6	14,5	Nil	114,1
2001 (July)	4,0	98,0	16,5	Nil	118,5
Gauteng wholesale price c/l -July 2001					367,1
Taxes and levies as a % of this wholesale price					32,2%

DIESEL					
Year	Customs& Excise Duty	Fuel Levy	Road Accident Fund Levy	Equalisation Fund Levy	Total Imposts
1987	4,0	24,7	Nil	5,7	34,4
1988	4,0	19,9	2,1	7,0	33,0
1989	4,0	31,4	2,1	7,0	44,5
1990	4,0	31,4	2,1	7,0	44,5
1991	4,0	33,4	2,4	7,0	46,8
1992	4,0	47,4	4,0	7,0	62,4
1993	4,0	47,4	4,0	7,0	62,4
1994	4,0	53,4	6,0	8,0	71,4
1995	4,0	53,4	6,0	8,0	71,4
1996	4,0	61,6	5,8	5,0	76,4
1997	4,0	63,6	6,8	3,0	77,4
1998	4,0	76,1	10,3	8,0	98,4
1999	4,0	76,1	10,3	8,0	98,4
2000	4,0	79,1	10,3	Nil	93,4
2001 (July)	4,0	81,0	16,5	Nil	101,5
Gauteng wholesale price c/l -July 2001					334,75
Taxes and levies as a % of this wholesale price					30,3%

³ Source: SAPIA website reference number 3

5. Fuel Tax Concessions Table⁴

According to the SAPIA website, the amounts of the tax concessions granted in the April 2001 Budget on qualifying diesel consumption were as follows:

TAX CONCESSIONS - April 2001 (implemented in July 2001)	Tax amount in Cents/litre	% of total price paid
Agriculture, forestry and mining	33,68	33,2%
Offshore fishing, offshore mining, shipping and National Sea Rescue Institute	97,5	96,1%
Railway locomotives	16,5	16,3%

<u>DIESEL FUELS TAXATION COMPOSITION:</u>	
Customs and Excise Duty	4,0
Fuel Levy	81,0
Road Accident Fund Levy	16,5
Total	101,5

⁴ Source: SAPIA website reference number 4

Appendix II

Data Description

1. RAS Method

“The 1997 SAM database is a RAS update of the 1993 version. To this end, an outline of what the RAS method is designed to achieve is presented here. The basic method is outlined in the Department of Applied Economics, Cambridge, Programme for Growth Series, vol. 3 (1963, pp. 27-30) and O’Connor and Henry (1975), to which the reader is referred for more detail.

If we denote the base year technology matrix by $A_0 = (a_{ij})$, then each coefficient A_{ij} is subject to 2 inter-temporal effects:

- 1) the substitution effect which is measured by the extent to which the output of the i 'th sector has been replaced by, or used as a substitute for, other sectoral outputs in the immediate production, and may be largely induced by relative price changes as, for example, the substitution of gas for oil in many UK industries after 1973;*
- 2) the fabrication effect which is measured by the extent to which the ratio of intermediate to total inputs decreased/increased in the j 'th sector.*

It is assumed that each effect works uniformly. The substitution multipliers which operate along the rows are denoted by the vector r , and the fabrication multipliers operating on the columns are denoted by the vector s . Each cell in the base matrix A_0 will be subject to these effects and the new coefficient matrix A_1 can thus be written as

$$A_1 = r' A_0 s'$$

where r' and s' are matrices with the vectors r and s in the main diagonals and zeros elsewhere.

The RAS method can be modified to incorporate exogenous information into selected rows, columns or individual cells of the updated matrix.

Lynch (1986), and confirmed by Parikh (1979), has shown that a RAS update of the absorption flow matrix can result in large percentage errors, although there are means of reducing the magnitude of the error slightly e.g. incorporating exogenously fixed rows and columns. This short-coming is discussed in the main body of this study.

Finally, the original data needs to be updated for price changes. The key assumption in Input-Output analysis is that there exists a fixed relationship between input and output in physical quantities. As physical coefficients are rarely available in detail, we assume that there is a fixed relationship between input and output at constant prices when the coefficients are expressed in values.

Large changes in prices raise problems regarding the stability of the Input-Output matrix (Bulmer-Thomas, 1982). When large price changes take place it is very unlikely that the assumption of constant physical input coefficients can be sustained. If there are time series available for the row and column totals of the input-output absorption matrix, the r and s multipliers discussed earlier can be modified to incorporate the effects of price changes as well.” (Parikh, 1990)

2. Extract of Relevant information on the construction of the 1997 SAM⁵:

“Production activities

The 1997 provisional SAM identifies 45 production activities based on the 1993 5th edition of the Standard Industrial Classification (SIC, Stats SA 1993b).

Note that the number of production activities identified in the SAM framework is about half the size compared to WEFA's previous SAM. The reason is that intermediate interactions are essentially updated from the 1988 Input-Output table (Stats SA, 1993c) and the standard updating routine (see Millar and Blair, 1985: 276-295) not only loses accuracy due to the fixed technology assumption but also, besides the sectoral census material employed, more recent updates of lower level control totals such as sectoral sales (Stats SA, P3041.2, P2041) and other variables (Stats SA, P0441) are only available for a limited number of production activities. The choice of sectors provided represents a reasonable trade-off between sectoral detail and the quality of the data sources in the eyes of the SAM compilers.

Indirect taxes and subsidies

Import duties collected by government from each of the 45 production activities (as intermediates) and from the final demand components are derived in the same way as by Stats SA (1993c). The components of indirect taxes such as excise duties, VAT, fuel levies are based on the relevant ratios employed by Stats SA to derive the 1988 and 1993 Input-Output tables.

Sales

The sectoral column totals of the SAM represent total sales for each of the 45 production activities. They have been derived from volume and price data from Stats SA (such as P2041 and P01421 for mining and P30412 for manufacturing) and past levels have been

⁵ D. Van Seventer “Notes on the Compilation of a Provisional 1997 Social Accounting Matrix for South Africa”

benchmarked on sectoral census data for selected years in order to iron out possible inconsistencies.

Income distribution

One of the most important elements of any SAM is the mapping of income by source to household income classes. The scope of the income distribution picture contained in the 1997 provision SAM has been expanded to include more household income classes than before. Note that separate population groups are no longer presented. Use was made of the 1996 Population Census 10% sample (Stats SA, 1998a) for total household income and the Income and Expenditure component of the 1995 OHS for the distribution of its sources. The following income classes are identified:

Classes of the income distribution in the 1997 provisional SAM

	Code	Income at Lower Boundary	Income at Upper Boundary	Proportion of Households at lower Boundary	Proportion of Households at upper Boundary	Number of Households
1.	d0	0	5,500	0%	10%	962,456
2.	d1	5,501	8,000	10%	20%	960,773
3.	d2	8,001	11,000	20%	30%	961,998
4.	d3	11,001	15,000	30%	40%	961,665
5.	d4	15,001	20,000	40%	50%	961,835
6.	d5	20,001	28,000	50%	60%	961,969
7.	d6	28,001	40,000	60%	70%	961,897
8.	d7	40,001	60,000	70%	80%	961,934
9.	d8	60,001	100,000	80%	90%	961,797
10.	d91	100,001	150,000	90%	90%	481,308
11.	d921	150,001	170,000	95%	96.25%	120,630
12.	d922	170,001	200,000	96.25%	97.50%	120,075
13.	d923	200,001	280,000	97.50%	98.75%	120,507
14.	d924	280,001		98.75%	100%	120,352
15.	Total					9,619,195

In rows 10-14 it can be seen that considerable details is provided at the top end of the income distribution scale. The highest income decile is broken down in two quintiles. In turn, the highest quintile is broken down into four equally large household income classes. The reason for creating more detail at the top end of the income spectrum is the considerable concentration of income earned at the top end of the income distribution. To illustrate this point, various aspects of the distribution of total household income are presented in the next table.

Aspects of income distribution from the 1997 provisional SAM

		1	2	3	4	5
	Code	Income at Lower Boundary	Income at Upper Boundary	Total Household Income per Household ('000)	Cumulative Distribution of Total Household Income	Area under the Lorenz Curve for Total Household Income
1.	d0	0	5,500	5.94	1.3%	0.0006
2.	d1	5,501	8,000	8.35	3.1%	0.0022
3.	d2	8,001	11,000	11.66	5.6%	0.0043
4.	d3	11,001	15,000	15.43	8.9%	0.0073
5.	d4	15,001	20,000	20.42	13.3%	0.0111
6.	d5	20,001	28,000	26.55	19.1%	0.0162
7.	d6	28,001	40,000	38.10	27.3%	0.0232
8.	d7	40,001	60,000	55.19	39.2%	0.0332
9.	d8	60,001	100,000	84.54	57.4%	0.0483
10.	d91	100,001	150,000	131.21	71.6%	0.0322
11.	d921	150,001	170,000	173.12	76.3%	0.0092
12.	d922	170,001	200,000	202.91	81.7%	0.0099
13.	d923	200,001	280,000	233.00	88.0%	0.0106
14.	d924	280,001		444.23	100.0%	0.0118
15.	Ave/Gini			46.36		0.5597

The third column shows average total income per household and in the last row it can be seen that the most affluent household income class earns almost 10 times the average household income for all households in South African. In the last column are the calculations leading up to the Gini coefficient. It can be seen that based on the SAM the Gini coefficient is estimated at 0.56. This is slightly lower than the Gini coefficient of 0.59 reported by Stats SA (1997) which could be partly ascribed to the fact that only 14 observations were used as opposed to all the observations based on the full detail of 30 000 ranked households covered in the 1995 income and expenditure survey. Consequently, the table above takes significant short cuts from the original cumulative income trajectory as shown in column 4⁶.

The bottom 20% of the households (ranked according to total household income) earn about 3% of total household income, about the same of total earned household income and appropriate less than 1% of unearned income but about 23% of transfers (from households, government and the rest of the world). At the other end of the spectrum, the most affluent 1.25% of the all South African households (ranked according to total household income) earn 12% of total household income and 5.7% of total wage income, while they appropriate 34% of unearned income but less than 0.5% of all transfers.

Household expenditure

Household expenditure for each income class (as identified in Table 3), on goods and services, supplied by the 45 production activities, is based on patterns derived from the 1995 OHS. The same source has also been used for a number of other expenditure components such as remuneration of domestic services (for unskilled and informal labour only), personal income tax and transfers to government, the rest of the world, and other households. The structure of the latter has been updated from Stats SA (1993a) using new lower level income and expenditure totals.

⁶ Income-expenditure surveys usually generate lower Gini coefficients than population census data because more care is given to recording the income generating capacity of low income households.

Government current expenditure

Government current expenditure is broken into a number of functions that are listed in the next table.

Breakdown of government expenditure

	Code	Description	Selected Departments Included
1.	Gen admin	General administration	Foreign affairs, home affairs, etc.
2.	Defence	Defence	Defence
3.	Law & Ord	Law & order	Justice
4.	Educ	Education	Education
5.	Health	Health	Health
6.	Social	Social	Housing and welfare
7.	Econ & oth	Economic & other	Trade and industry, finance, etc.

Goods and services are supplied by the 45 production activities, remuneration is broken down by skill level and transfers from government to households are broken down by household income class. Most of the transfers are directed towards middle and lower income classes.

Use was made of detailed unpublished data from Stats SA on government current and capital expenditure. A complete goods and services consumption breakdown for the output of 90 industries for each general government department and by province for the year 1993 was allocated to the 7 government functions defined in Table 5. A functional distribution of current and capital expenditure as well as labour remuneration by general government was obtained from Stats SA for 1982 to 1996. The data from the medium-term expenditure framework (MTEF) of the Department of Finance was utilised to generate an update for 1997. The breakdown for 1997 by function was then superimposed on the 1993 input-output expenditure structure of Stats SA (1993a) to obtain expenditure by function for the 45 sectors.” (Van Seventer, 1997)

Appendix III

Industry ranking per model in terms of largest price impact experienced to least price impact experienced

Direct Effects	Input-Output Model	Partial SAM-based Model	Full SAM-based Model					
Trnsp	0.27%	Trnsp	0.31%	Trnsp	0.42%	Trnsp	0.69%	Agriculture and Mining
Agr	0.15%	Agr	0.19%	Civil	0.30%	Fin	0.62%	Agricultural Resource
Civil	0.12%	Civil	0.19%	Agr	0.29%	Civil	0.57%	Intensive
Ochem	0.10%	Petrol	0.16%	Petrol	0.24%	Agr	0.52%	Unskilled Labour
Petrol	0.09%	Ochem	0.14%	Ochem	0.24%	Oserv	0.48%	Intensive
Mining	0.08%	Wat	0.12%	Nmmin	0.23%	Nmmin	0.48%	Knowledge Intensive
Nmmin	0.07%	Nmmin	0.12%	Fin	0.23%	Ochem	0.48%	Mineral Resource
Wat	0.06%	Mining	0.11%	Wat	0.22%	Constr	0.48%	Intensive
Bchem	0.06%	Constr	0.09%	Mining	0.22%	Mining	0.47%	Utilities
Otreq	0.04%	Food	0.09%	Constr	0.21%	Metpr	0.46%	Services
Sserv	0.03%	Bchem	0.09%	Plast	0.20%	Plast	0.46%	
Constr	0.03%	Plast	0.08%	Food	0.20%	Otreq	0.46%	
Bserv	0.03%	Wood	0.08%	Wood	0.19%	Trade	0.46%	
Plast	0.03%	Sserv	0.07%	Metpr	0.19%	Wat	0.46%	
Oserv	0.03%	Rubb	0.07%	Otreq	0.19%	Other	0.45%	
Rubb	0.03%	Sequip	0.07%	Oserv	0.19%	Sequip	0.45%	
Fin	0.03%	Otreq	0.07%	Sequip	0.18%	Wood	0.45%	
Mach	0.02%	Metpr	0.07%	Other	0.18%	Food	0.43%	
Sequip	0.02%	Electr	0.07%	Electr	0.17%	Print	0.43%	
Electr	0.02%	Other	0.06%	Trade	0.17%	Petrol	0.43%	
Trade	0.02%	Tobac	0.06%	Rubb	0.17%	Electr	0.43%	
Text	0.02%	Mach	0.06%	Sserv	0.17%	Emch	0.42%	
Wood	0.02%	Leath	0.06%	Tobac	0.17%	Furn	0.42%	
Bnfm	0.02%	Furn	0.06%	Furn	0.17%	Comm	0.42%	
Metpr	0.02%	Fin	0.06%	Mach	0.16%	Paper	0.41%	
Bi&s	0.02%	Oserv	0.06%	Paper	0.16%	Cloth	0.41%	
Other	0.01%	Bnfm	0.06%	Bchem	0.16%	Cat	0.41%	
Furn	0.01%	Text	0.06%	Text	0.16%	Rubb	0.41%	
Glass	0.01%	Trade	0.06%	Bi&s	0.16%	Tobac	0.41%	
Emch	0.01%	Paper	0.06%	Leath	0.16%	Sserv	0.41%	
Oind	0.01%	Bev	0.05%	Emch	0.16%	Mach	0.40%	
Cloth	0.01%	Bi&s	0.05%	Print	0.16%	Bi&s	0.40%	
Bev	0.01%	Bserv	0.05%	Bnfm	0.15%	Glass	0.39%	
Tvetc	0.01%	Glass	0.04%	Bev	0.15%	Text	0.39%	
Paper	0.01%	Emch	0.04%	Cloth	0.15%	Bev	0.39%	
Leath	0.00%	Motveh	0.04%	Glass	0.15%	Bnfm	0.38%	
Comm	0.00%	Cloth	0.03%	Cat	0.15%	Leath	0.38%	
Motveh	0.00%	Print	0.03%	Bserv	0.15%	Bserv	0.37%	
Footw	0.00%	Footw	0.03%	Comm	0.14%	Oind	0.36%	
Print	0.00%	Oind	0.03%	Oind	0.13%	Motveh	0.35%	
Food	0.00%	Cat	0.03%	Motveh	0.13%	Footw	0.33%	
Tobac	-0.01%	Tvetc	0.03%	Footw	0.12%	Tvetc	0.33%	
Cat	-0.02%	Comm	0.02%	Tvetc	0.12%	Bchem	0.33%	

Appendix IV

Developing and Understanding Input-Output Tables and Models

1. Input-Output Tables

The basic premise underlying Input-Output Tables is that every economy is made up simply of a number of different industries - these may be industries in the usual sense (e.g. steel) or they may be smaller categories (e.g. steel nails and spikes).

However, unlike the direct effects model which only considered each industry/economic entity in isolation of other entities, Input-Output Tables present this data in a balanced square matrix format wherein the activities of each industry are recorded as one row and one column as in **Table IV.1** below.

Table IV.1
Simple 2 sector Input-Output Table⁷

	Intermediate demand		Final Demand (F)	Gross Output (X)
	Manufacturing	Agriculture		
Manufacturing	150	500	250	900
Agriculture	200	100	700	1000
Fuel Tax income	150	75		
Other income	400	325		950
Total	900	1000	950	

The figures above represent values in R millions. It is important to note that the total expenditure is equal to the total income in the table above. Thus the Input-Output Table is always balanced, with all income and expenditure accounted for.

In economic terms, the row entries record the value of all receipts (income) by an industry for products sold to other industries, (i.e. receipts by industry j from industry i) while the columns record the corresponding expenditures (i.e. the payments by account j to account i).

⁷ Input-Output Table examples obtained from lecture notes on SAM-based models of Lawrence Edwards (Department of Economics, UCT). Refer website reference number 7.

Functionally, sellers are listed down a column on the left and the same industries, now consumers, are listed in a row across the top:

- Reading down a particular industry's (e.g. manufacturing) column would reflect not only all the inputs (and hence industries) that manufacturing requires/relies on, but also the extent to which manufacturing relies on the output of any particular industry in relation to its total expenditure (e.g. expenditure on agricultural output is R200 out of a total of R900).
- Reading across the row for manufacturing would provide an indication of the sectors that purchase the output from the manufacturing sector as well as which sectors are most reliant on the output of the manufacturing sector for input into their own processes (e.g. manufacturing earns R500 from sales of output to agriculture out a total income of R900)

These figures are the core of Input-Output analysis, and based on the above interpretation, the reason why this database is called an Input-Output Table should be crystal-clear.

All of this, along with the presentation of data in this balanced matrix format, means that any model derived from the Input-Output Table would have the potential to be able to capture the underlying relationships between the various industries in an economy.

Inter-industry data

The output of any particular industry can be decomposed very simply into 2 parts:

- that part which is used as an intermediate input in its own and other industries,
- and that part allocated to final demand which includes consumption, investment including changes in stocks, government expenditure and net exports/imports.

Intermediate

With regard to the intermediate component, in order to be able to capture the inter-industry relationships, the assumption made is that sector j 's demand for inputs from other sectors during the year will have been related to the amount of goods produced by sector j over that same period. Whilst this may prove somewhat limiting later on, this assumption is a fairly reasonable one to make when considering e.g. that the demand from the vehicle sector for the output of the steel sector is very closely related to the output of vehicles, the demand for leather by the shoe-producing sector depends on the number of leather shoes being produced, etc.

For this intermediate component of an industry's output, the observed monetary value of the flow from sector i to sector j is denoted by $P_i X_{ij}$, i.e. the traditional relationship of (price \times quantity).

Final demand

It is important to note that not all output in the economy is used by Industry, and therefore there are always sales to purchasers who do not constitute part of the producers in the economy, e.g. Households, Government and foreign trade. Unlike the intermediate component mentioned above, the demands of these groups – and hence the magnitudes of their purchases from each of the industrial sectors – are generally determined by considerations that are somewhat unrelated to the amount being produced by industry.

Examples of this would include Government demand being related to broad changes in national policy, budget levels, or defence needs; consumer demand for small vehicles being related to some extent on petrol availability or income-earning capabilities and so on. Clearly therefore, it would be appear unrealistic at this point to assume, as was done with the intermediate component, that the demand by these economic entities for inputs from other sectors during the year will be related to the amount of goods produced by these entities over that same period.

It is for this reason, as well as because the demand of these external sectors tends to be more for the private consumption of goods and not for the purposes of input into an industrial production process, that this type of demand is generally referred to as Final Demand, with these types of purchasers being regarded as exogenous accounts.

Transactions with any of the exogenous accounts are usually denoted by FD_i .

To develop a model using the Input-Output Table, we impose functional forms for the aforementioned relationships between industries, factors and consumption groups:

The economy is divided into n sectors, with X_i representing the total value of output (production) of sector i and FD_i the total value of Final Demand for sector i 's product. The distribution of sector i 's value as recorded in the Input-Output Table could then be mathematically represented as:

Equation 1

$$\begin{aligned}
 &P_1 X_{11} + P_1 X_{12} + \dots + P_1 X_{1j} + \dots + FD_1 = P_1 X_1 \\
 &P_2 X_{21} + P_2 X_{22} + \dots + P_2 X_{2j} + \dots + FD_2 = P_2 X_2 \\
 &\vdots \\
 &P_n X_{n1} + P_n X_{n2} + \dots + P_n X_{nj} + \dots + FD_n = P_n X_n \\
 &\vdots \\
 &Tax_1 + Tax_2 + \dots + Tax_n + 0 - Tax_{tot} \\
 &\frac{VA_1 + VA_2 + \dots + VA_n + 0 = VA_{tot}}{P_1 X_1 + P_2 X_2 + P_3 X_3 + \dots + P_n X_n = PX}
 \end{aligned}$$

where $i = 1, 2, 3, \dots, n$,

Tax_i and VA_i represents payments to taxes, labour, capital and other costs,

P_i represents output prices and X_i represents output quantities.

Let $P_i X_{ij} = z_{ij}$, whilst $\tilde{c} = \begin{bmatrix} Tax_1 & Tax_2 & \dots & Tax_n \\ VA_1 & VA_2 & \dots & VA_n \end{bmatrix}$ and $\tilde{c}_{tot} = \begin{bmatrix} Tax_{tot} \\ VA_{tot} \end{bmatrix}$.

In a constant/fixed price⁸ model, we set $P_i = 1$, meaning that quantity is therefore the only component that is allowed to change to respond to shocks introduced into the model.

As a result, $P_i X_i = X_i$, and $z_{ij} = X_{ij}$.

In matrix format, this would form the equation:

$$\begin{pmatrix} X_{11} + X_{12} + X_{13} + \dots + X_{1i} + \dots + X_{1n} \\ \vdots \\ X_{i1} + X_{i2} + X_{i3} + \dots + X_{ii} + \dots + X_{in} \\ \vdots \\ X_{n1} + X_{n2} + X_{n3} + \dots + X_{ni} + \dots + X_{nn} \\ \hline \partial \end{pmatrix} + \begin{pmatrix} FD_1 \\ \vdots \\ FD_i \\ \vdots \\ FD_n \\ \hline 0 \end{pmatrix} = \begin{pmatrix} X_1 \\ \vdots \\ X_i \\ \vdots \\ X_n \\ \hline \partial_{tot} \end{pmatrix}$$

Let Z be an (n x n) matrix with the elements:

$$\begin{pmatrix} X_{11} + X_{12} + X_{13} + \dots + X_{1i} + \dots + X_{1n} \\ \vdots \\ X_{i1} + X_{i2} + X_{i3} + \dots + X_{ii} + \dots + X_{in} \\ \vdots \\ X_{n1} + X_{n2} + X_{n3} + \dots + X_{ni} + \dots + X_{nn} \\ \hline \partial \end{pmatrix}$$

⁸ This is the underlying assumption used when developing the value-based model. This type of model is known as the fixed price, flexible quantity model as only quantity will adjust for any shock introduced into this model. This assumption is chosen at this point for simplicity sake.

The fixed quantity, flexible price model which will be developed later and will be the model used in this study, assumes the $X = 1$. That is only prices will adjust for any shock introduced into this model.

and X a $(1 \times n)$ matrix with the elements:

$$\begin{pmatrix} X_1 \\ : \\ X_i \\ : \\ X_n \\ \dots \\ \partial_{tot} \end{pmatrix}$$

Then the information contained in the Input-Output Table can ultimately be simplified into the equation:

Equation 1.1 $Z + FD = X.$

Isolating row i would produce:

$$X_i = z_{i1} + z_{i2} + z_{i3} + \dots + z_{ii} + \dots + z_{in} + FD_i$$

Functionally, the right-hand side represents the sum of all sector i 's inter-industry sales (z_i) and its sales to final demand (FD_i).

For each of the n sectors, there will now be an equation just like this reflecting the sales of each sector's output to other sectors/entities.

As the rows and columns of the Input-Output Table balance as per **Table IV.1**, it is possible to either read across the rows as done here or read down a column.

Recall therefore that whilst reading across the rows represents the sales made to various sectors, reading down a particular column will provide insight into the purchases made from various sectors to obtain the necessary input for a sectors output. Consider therefore the information in the j th column of z 's on the right-hand side, that is:

$$\begin{bmatrix} z_{1j} \\ z_{2j} \\ \vdots \\ z_{ij} \\ \\ z_{nj} \\ Tax_j \\ VA_j \end{bmatrix}$$

As mentioned earlier, this column reflects the sources and magnitudes of sector i 's inputs. The z 's (representing inter-industry inputs) serve to record the purchases from what is usually termed the processing sector. Since each equation line includes the possibility of purchases by a sector of its own output as an input to production, these inter-industry inputs include intra-industry (z_{ii}) flows as well.

Further, in producing output, sector i may also have to purchase imported goods as inputs (much like it is able to sell its output as exports as in the initial row equation explanation above), whilst also having to pay for other items – e.g. labour, capital and taxes (Tax_i) – as well as other inputs, e.g. inventoried items, aside from the inputs from the processing sector. All of these inputs (value added and imports, but excluding taxes) are often lumped together as purchases from what is called the payments sector, and are represented by VA_i in the set of equations above.

1.1 Creating an Input-Output Model – Imposing Production functions

As mentioned already, one of the assumptions made in all input-output work is that inter-industry flows from i to j – recall that these are for a given period – depend entirely and exclusively on the value of total output of sector j for that same period. Clearly the more cars produced in a year, the more steel will be needed during that year by vehicle producers. However, this assumption goes one step further than this in that it assumes the

existence of fixed production coefficients⁹, i.e. constant returns to scale prevail - a doubling of output requires a doubling in the employment of the intermediate inputs.

We therefore impose fixed coefficients onto the data such that:

Equation 2
$$a_{ij} = \frac{z_{ij}}{X_j} = \frac{X_{ij}}{X_j}$$

The a_{ij} 's, or technical coefficients, measure the fixed relationships between a sector's output and its inputs.

Using the results in **Table 1.1**, once a set of observations indicates that e.g. $a_{12} = (500/1000) = 0.5$, this technical coefficient is assumed to be constant. If the question: How much would sector 2 (agriculture) buy from sector 1 (manufacturing) if agriculture were to produce a total output (X_2) of R3 000, the input-output answer would be $z_{12} = (0.5) (R3\ 000) = R1\ 500$. That is, if the output of agriculture were to triple, the input required from the manufacturing sector would also have to triple under this system.

Whilst this assumption is necessary, the consequences of utilising these technical coefficients is that economies of scale in production in a Leontief system are ignored; production is assumed to operate under what is known as Constant Returns to Scale, and there can be no substitution of the mix or type of inputs required¹⁰.

Once the notion of a set of fixed technical coefficients is accepted, the earlier equation can be re-written, replacing each z_{ij} on the right by $a_{ij}X_j$.

⁹ The consequences of this assumption are discussed later on in section 2

¹⁰ The consequences of this assumption are discussed in section 2

$$\begin{aligned}
X_i &= a_{i1}X_1 + \dots + a_{in}X_n + \dots + FD_i \\
&\vdots \\
X_n &= a_{n1}X_1 + \dots + a_{nn}X_n + \dots + FD_n \\
&\vdots
\end{aligned}$$

Equation 3

$$\begin{aligned}
Tax_{tot} &= \left(\frac{Tax_1}{X_1}\right)X_1 + \dots + \left(\frac{Tax_n}{X_n}\right)X_n + \dots + O \\
VA_{tot} &= \left(\frac{VA_1}{X_1}\right)X_1 + \dots + \left(\frac{VA_n}{X_n}\right)X_n + \dots + O
\end{aligned}$$

These equations highlight the dependence of inter-industry flows on the total outputs of each sector.

$$\text{Now, let } \beta = \begin{bmatrix} \frac{Tax_1}{X_1} & \frac{Tax_2}{X_2} & \dots & \frac{Tax_n}{X_n} \\ \frac{VA_1}{X_1} & \frac{VA_2}{X_2} & \dots & \frac{VA_n}{X_n} \end{bmatrix}$$

Then,

$$\begin{bmatrix} X \\ \dots \\ \partial_{tot} \end{bmatrix} = \begin{bmatrix} A \\ \dots \\ \beta \end{bmatrix} \begin{bmatrix} X \end{bmatrix} + \begin{bmatrix} FD \\ \dots \\ 0 \end{bmatrix}$$

$$\text{Where } X = \begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_n \end{bmatrix}$$

As the exogenous accounts are being captured by FD, and ∂_{tot} and β represent the row equivalent of this column vector, ∂_{tot} and β are ignored when developing the Value-

based¹¹ Input-Output model. Also, let I be the $(n \times n)$ identity matrix, then the complete $(n \times n)$ system above can be shown as:

$$X = AX + FD$$

$$\Rightarrow (I-A) X=FD$$

If $|I - A| \neq 0$, then $(I-A)^{-1}$ can be found

Equation 3.1 $\Rightarrow X = (I-A)^{-1}FD$

This model essentially provides the new level of gross output (X) that will arise from any shock to the economy that is introduced via a change in final demand (FD).

$(I-A)^{-1}$ is often referred to as the Leontief inverse. The 'A' matrix is known as the matrix of technical, input-output, or direct input coefficients, whilst $(I-A)^{-1}$ captures both the direct and associated indirect effects that will arise from a shock to the economy. The indirect effects captured by $(I-A)^{-1}$ will therefore only be those effects arising because of interactions between the accounts included in the $(I-A)^{-1}$ matrix.

An interpretation of these elements of the $(I-A)^{-1}$ matrix is presented later in section 1.4

1.2 Price and Value-based Output Models

The Input-Output model developed and presented thus far has been the more commonly encountered value-based output model for which there is more literature and background information available than is the case with regard to the lesser-employed price-based model. As a result, the approach adopted was to first develop and understand the value-based model, before adapting it into the price-based model to be employed in this study.

¹¹ As will be shown in section 1.2.3, the FD matrix is ignored and the $\hat{\alpha}_{tot}$ and β are used instead when developing the price-based Input-Output model.

The relationship underpinning the value-based (or fixed price) model is that prices are assumed to be fixed ($P=1$) and only quantities can change in response to changes in final demand. As Bulmer-Thomas (1982:224) notes in more economic terms: "often in Input-Output models, prices play the most marginal of parts: quantities are chosen (Leontief units) such that their price is unity and everything else is cast in real terms; all price elasticities of substitution are assumed zero and money plays no more than an accommodating role."

Clearly however, this relationship mitigates against a study attempting to assess the price impact of a 10% rise in fuel taxes on the economy. As a result, a model that instead allows prices to change in response to changes in final demand was needed. As this is essentially the inverse of the assumption used in developing the value-based Input-Output model, this model was therefore adapted.

This manipulation of the Input-Output database is supported by Bulmer-Thomas (1982) who points out further that price models - capable of being utilised in 2 different types of studies - can be also be computed from Input-Output Tables. These studies include the:

- (i) study of efficiency; and
- (ii) study of price determination.

Bulmer-Thomas (1982:224) states that: "*'Efficiency price' models have been developed primarily by East European economists in order to provide a rational basis for reforming the price systems of their countries; price determination models, on the other hand, have been developed mainly in the context of Western economies in an effort to understand better such things as the process of inter-sectoral price transmission and the wage-price spiral; both systems, with suitable modifications can be useful to LDC's (Lesser Developed Countries).*"

The specific type of model employed in this study would clearly therefore fall into category (ii), i.e. a study of price determination.

The underlying reason behind why the Input-Output Table can be used to compute price models, as well as output-driven models, is because the basic assumption of the Input-Output model concerns fixed coefficients of production and constant returns to scale. As Bulmer-Thomas (1982:224) states: “ *It follows that the long-run (supply) price of any commodity (sector) is not determined by the scale of output but by the invariant unit cost of production; thus, quantities do not appear in the price model and it is possible to compute a set of prices without simultaneously determining a set of quantities.*”

In the above paragraph, the phrase ‘long-run (supply) price’ is used advisedly because short-run (demand) considerations do not enter into the formation of prices in an input-output model; in practice, observed prices for commodities are affected by demand considerations and so supply prices computed from input-output models have to be interpreted with care.”

Simply put, this says that the price model assumes that prices are responsive to costs, but not to activity levels. Bulmer-Thomas (1982) is supported by Roland-Holst & Sancho (1995) in stating that the justifying assumption here is generalised homogeneity and fixed coefficients in activities. Roland-Holst & Sancho (1995) go on to point out that this is a situation where the classical dichotomy between prices and quantities holds true, and as will be shown, prices can be computed independently of activity levels.

It is also worthwhile noting that in South Africa, fuel tax increases are determined by Government and not by traditional demand considerations due to the fact that the Industry is so highly regulated. Further, as there is a lack of suitable/adequate substitutes for fuel in the economy, producers are forced to pay the higher price demanded for fuel in order to continue producing, and therefore the unit cost of goods that require/utilise fuel as one of their inputs will increase almost immediately when fuel taxes are increased. As a result, the fuel tax rise will ultimately have an influence on prices within the economy through the supply side more so than the demand side.

One aspect worth considering at this point is that in reality only part of the price increase arising from the fuel tax rise will be passed onto consumers, as producers will attempt to absorb some of the cost increase themselves in order to remain competitive in a market that allows for substitution of input products. In Input-Output models however, no input substitution is possible due to the use of fixed coefficients and therefore the full price increase is assumed to be transferred onto the consumer.

1.3 Developing the Price Model

The key to the price model relates to the fact that the data in the Input-Output Table, which is presented in nominal values, is made up in its most basic form of (price x quantity), and that the row and column totals balance.

Recall from **Equation 1** that under the fixed price (value-based) output model, $P_i X_{ij}$ was represented by z_{ij} .

However the key assumption made in developing this value-based output model was that $P = 1$. This assumption clearly cannot be retained when developing a price-driven model. Instead, and as pointed out by Bulmer-Thomas (1982), output (X values) somehow needs to be removed from the scenario. In the price model the interpretation of the equation 2 is that the value of output in the bottom row (say $P_1 X_1$) is made up of

$$P_1 X_{11} + P_2 X_{21} + Tax_1 + VA_1 = P_1 X_1.$$

To remove the output values from the system, the entire column j is divided by the respective output value X_j . This now effectively assumes that $X=1$ (instead of $P=1$) under this model. This also leaves the following for the first two columns (reading each column separately)

$$\begin{bmatrix} P_1 a_{11} & P_1 a_{12} \\ + & + \\ P_2 a_{21} & P_2 a_{22} \\ + & + \\ \frac{Tax_1}{X_1} & \frac{Tax_2}{X_2} \\ + & + \\ \frac{VA_1}{X_1} & \frac{VA_2}{X_2} \\ = & = \\ P_1 & P_2 \end{bmatrix}$$

where $a_{ij} = \frac{X_{ij}}{X_j}$.

Note that this is consistent with the earlier definition per **Equation 2** under the fixed price model even though P is no longer assumed to be 1.

Let

$$P = [P_1 \quad P_2 \quad \dots \quad P_n]$$

$$Tax = \left[\frac{Tax_1}{X_1} \quad \frac{Tax_2}{X_2} \quad \dots \quad \frac{Tax_n}{X_n} \right] \text{ and}$$

$$VA = \left[\frac{VA_1}{X_1} \quad \frac{VA_2}{X_2} \quad \dots \quad \frac{VA_n}{X_n} \right].$$

In matrix form this then becomes

$$PA + Tax + VA = P.$$

Where A is the normal coefficient matrix.

Now let $V = Tax + VA$

After re-arranging, we obtain

$$\begin{aligned} P - PA &= V \\ \Rightarrow P [I - A] &= V \end{aligned}$$

$$\Rightarrow P = V [I-A]^{-1}$$

The impact of an increase in fuel taxes can therefore be found via:

Equation 4¹²
$$\Delta P = \Delta v' [I-A]^{-1}$$

Where $\Delta v' = \left(\frac{\Delta tax_1}{X_1} \right)$

with the $\Delta v'$ vector at this point only capturing the change in the fuel tax experienced by Industry accounts.

¹² In the main body of the thesis, this is the equation utilised and adapted to form Equations 3,4 and 5

1.4 Interpreting the inverse (Value based output model vs. price model)

The calculated $[I-A]^{-1}$ of the information contained in Table IV.1 provides the following

$$\text{matrix: } (I - A)^{-1} = \begin{bmatrix} 1.41 & 0.78 \\ 0.35 & 1.30 \end{bmatrix}$$

The entries contained within this matrix are interpreted as follows:

Table IV.2¹³

Interpreting the Input-Output Inverse

	Manufacturing	Agriculture
Manufacturing	1.41	0.78
Agriculture	0.35	1.30

In the **value-based output model** (fixed price) the column of the inverse represents the direct and indirect effect of a R1 increase in final demand of that column's product. For example, if exports of agriculture increase by R1, then the total impact on agricultural production is R1.30 and on manufacturing is R0.78. As exports of agriculture increase by R1 so production of agriculture increases. This raises demand for agricultural inputs (seeds) and manufacturing inputs (tractor). This input demand in turn leads to further demand for inputs, and so the cycle continues.

In the **price model** the interpretation is different. A R1 price increase of agriculture causes the cost of downstream industries that use agriculture as an input to rise. These firms then pass on these price increases downstream as well. Thus with the price model one looks at the **rows** of the Leontief inverse. A R1 increase in agricultural price due to a tax rise causes the total price of agriculture to rise by R1.30 and that of manufacturing to rise by R0.35. The R1 in the R1.30 for agriculture is due to the direct tax. The R0.30 is due to the rising cost of all inputs used in the production of agriculture. The R1.30

¹³ Input-Output Inverse example obtained from lecture notes on SAM-based models of Lawrence Edwards (Department of Economics, UCT). Refer website reference number 7.

therefore captures the total direct and indirect effects on agriculture arising from an initial R1 increase in the price of agriculture.

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Appendix V

Developing and Understanding SAM and SAM-based Models

1. Expanding Input-Output Tables and Models into SAMs and SAM-based Models

Expanding the Input-Output Table to include Household accounts would – algebraically – simply require the addition of a row and a column for the new Household sector – the former showing how its output (labour services) is used as an input by the various sectors and the latter showing the structure of its purchases (consumption) distributed among the sectors.

Assuming only one factor and one household, a simple SAM model could therefore be mathematically represented as follows:

$$\begin{array}{r}
 P_1 X_{11} + \dots + P_1 X_{1n} + P_1 HHD_1 = P_1 X_1 \\
 \dots\dots\dots \\
 P_n X_{n1} + \dots + P_n X_{nn} + P_n HHD_n = P_n X_n \\
 \text{Equation 5} \quad wL_1 + \dots + wL_n + 0 = wL_{tot} \\
 Tax_1 + \dots + Tax_n + 0 = Tax_{tot} \\
 \underline{other_1 + \dots + other_n + 0 = other_{tot}} \\
 P_1 X_1 + \dots + P_n X_n + P_{exp} HHD_{tot}
 \end{array}$$

Where $i = 1, 2, 3, \dots, n$

P_{exp} is essentially a price index reflecting the cost of Household expenditure on a bundle of goods, HHD_i is Household demand for product i , w represents wages, L_{tot} is total labour, and wL_{tot} is total Household income.

Note $P_{exp} HHD_{tot} = wL_{tot}$ as is to be expected in a balanced SAM Table.

We assume $HHD_{tot} = 1$ and $L_{tot} = 1$ in order to normalize around quantities as per the requirements of the price-based model. As a result, $P_{exp} = w$.

After dividing each column by its respective X_i and the HHD column by HHD_{tot} , the resulting input coefficient matrix can be seen very simply as an $[(n+1) \times (n+1)]$ square matrix:

$$A^* = \begin{bmatrix} A & HHD \\ \sigma & 0 \end{bmatrix}.$$

Where A is the standard input coefficient matrix,

$$\sigma = \left[\frac{L_1}{X_1} \quad \dots \quad \frac{L_n}{X_n} \right] \text{ i.e. a row vector of unit labour required per output, and}$$

$$HHD' = \left[\frac{HHD_1}{HHD_{tot}} \quad \dots \quad \frac{HHD_n}{HHD_{tot}} \right]$$

HHD' is a column vector of Household consumption coefficients. Note that dividing the HHD column by HHD_{tot} effectively assumes that consumers consume in fixed proportions and do not substitute any products when a shock occurs. A similar assumption was made for the Industry accounts when developing the Input-Output model as well as this SAM-based model. This is recognised as a limitation of the model and the implications of this assumption are discussed in the main body of this study.

The equation can now be viewed as

Equation 6 $P(A^*) + V = P$

where $P = [P_1 \ P_2 \ \dots \ P_n \ w]$ and as defined in section 1.2.4, but with the Household accounts now included as well:

$V = \text{Tax} + VA$, where

Tax is a row vector as defined in section 1.2.4 of taxes per unit output (tax_i/X_i) and VA is a row vector as defined in section 1.2.4 of other costs per unit output. It is important to note however that these vectors do differ from those in section 1.2.4 in that they now capture additional accounts in the form of Households.

As the matrix 'A*' is essentially the 'A' matrix with an additional row and column entry for Households now being endogenised,

$$\Rightarrow A^* = A$$

$$\Rightarrow PA + V = P$$

Rearranging, we obtain once again

Equation 6.1¹⁴ $\Rightarrow P = V(I-A)^{-1}$

Where $(I-A)^{-1}$ is now an $[(n+1) \times (n+1)]$ square matrix which includes Household accounts. As noted above, vector V has also been extended to include Household accounts.

¹⁴ This is essentially the make-up of Equation 5 in the main body of this study

1.2 Interpreting the SAM inverse

The new inverse that would result is reflected in **Table V.1** below:

Table V.1¹⁵

Interpreting the SAM-based Model Inverse

	Manufacturing	Agriculture	Households
Manufacturing	2.93	2.51	2.65
Agriculture	1.86	3.02	2.64
Households	1.53	1.74	2.67

Under the **price model** the interpretation the R1 price increase of agriculture causes the cost of downstream industries that use agriculture as an input to rise. These industries then pass on these price increases downstream as well, with Household impacts now being included as part of this loop. Effectively, the wage increase impact on Industry prices is now captured within this system.

The wage increase impact is as a result of Households receiving wage increases to compensate them for the increase in direct costs that they suffer when consuming fuel directly, as well as the increase in Industry product prices. As wages are also an input cost for Industry, in compensating Households for higher Industry prices through higher wages, it is clear that a vicious cycle of price increases will arise. This will obviously magnify the price impacts occurring in this model until eventually the increase in wages reaches an equilibrium point. This will be the point at which Households receive wage increases that compensate them fully for all cost increases they face, whilst at the same time, Industry product prices have increased sufficiently for Industry to recover this increased wage cost that they have had to incur.

Bearing this in mind when looking at the **rows** of the Leontief inverse, a R1 increase in the agricultural price due to a tax rise causes the total price of agriculture to rise by R3.02 (previously R1.30 under the Input-Output inverse) and that of manufacturing to rise by

¹⁵ Input-Output Inverse example obtained from lecture notes on SAM-based models of Lawrence Edwards (Department of Economics, UCT). Refer website reference number 7.

R1.86 (previously R0.35). The R1 in the R1.30 for agriculture was due to the direct tax, which is still the case with these results. However, the remaining R2.02 (previously R0.30) is due to the rising cost of all inputs used in the production of agriculture. The inclusion of Household within this system therefore results in significantly larger indirect effects being generated, as was expected. As was the case with the R1.30 under the Input-Output inverse, the R3.02 now captures the total direct and indirect effects on agriculture arising from an initial R1 increase in the price of agriculture once Household wage effects have been accounted for.

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