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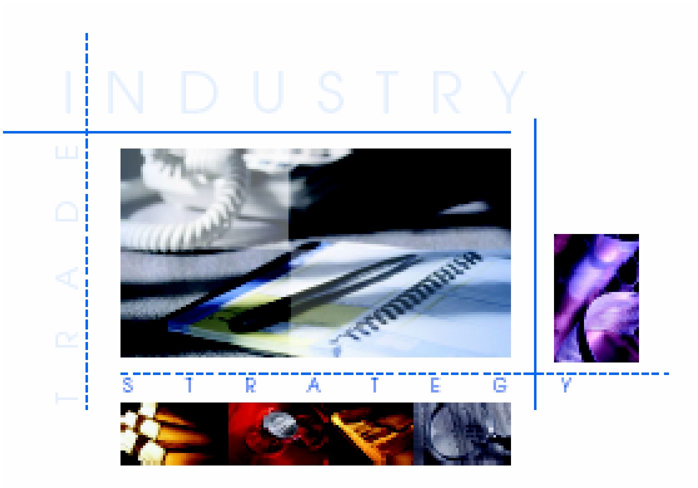
A Dynamic Computable General Equilibrium (CGE) Model for South Africa: Extending the Static IFPRI Model

James Thurlow



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A Dynamic Computable General Equilibrium (CGE) Model for South Africa: Extending the Static IFPRI Model

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1. Introduction

Computable general equilibrium (CGE) models are widely used for policy-analysis in many countries. In the past a number of CGE models have been developed for South Africa, and used to assess a broad range of policy issues.[1] However, the perceived complexity of this analytical approach, and the concentration of capacity within a small number of academic or related institutions, have generally led policy-makers, analysts and other researchers to avoid directly using CGE models in their analysis or decision-making. Since CGE modelling provides both an economy-wide assessment of policies and a framework in which the workings of policies can be more easily understood, it is the objective of this paper to present a core South African model that reduces the initial cost of undertaking CGE analysis. The core model can then be adapted according to the interests of individual researchers or policy-makers. Furthermore, since the strength of the model is dependent on its ability to reflect the specific structure and workings of the South African economy, it is hoped that the core model will be developed further as more supporting evidence and research becomes available.

The model presented in this paper has at its core the static model used by the International Food Policy Research Institute (IFPRI) as described in Lofgren *et al*. (2002). The model is recursive dynamic and is therefore an extension of the IFPRI model and the earlier static South African model presented in Thurlow and van Seventer (2002).

The construction of the South African model takes place in two stages. At the first stage the structure and interactions of the economy within and across time periods is specified in a set of mathematical equations. Section 2 describes the specification and limitations of the South African model without the aid of mathematics. Since the underlying static South African model is essentially that of the IFPRI standard model, Appendix A first presents the differences in the mathematical equations between these two models, before describing the mathematics of the model's dynamic specification.

The second stage of constructing the model involves the compilation of a database that describes the South African economy and is used to assign values to the parameters of the mathematical equations. This process is called the 'calibration' of the model. The most important database for CGE model calibration is a social accounting matrix (SAM). Two SAMs are compiled for South Africa for the years 1993 and 2000, thus allowing the model to assess the impact of both past and

[1] See Thurlow and van Seventer (2002) for a brief review of past economy-wide modeling in South Africa.

future policies. Section 3 describes the South African economy as it is represented in the SAMs and other relevant data sources. Appendix B describes the SAM construction process, and Appendix C presents a series of disaggregated SAM tables that inform the discussion in Section 3.

Finally, Section 4 concludes the paper by describing existing applications of the models and identifying areas where further research is needed to address the limitations of the model.

2. Model Description

The dynamic South African model described below has developed from the neoclassical-structuralist modelling tradition originally presented in Dervis *et al* (1982), and has at its core the static CGE model described in Lofgren *et al* (2002) and Thurlow and van Seventer (2002). The model is formulated as a set of simultaneous linear and non-linear equations, which define the behaviour of economic agents, as well as the economic environment in which these agents operate. This environment is described by market equilibrium conditions, macroeconomic balances, and dynamic updating equations.

The model belongs to the recursive dynamic strand of the dynamic CGE literature, which implies that the behaviour of its agents is based on adaptive expectations, rather than on the forward-looking expectations that underlie alternative inter-temporal optimisation models. Since a recursive model is solved one period at a time, it is possible to separate the *within-period* component from the *between-period* component, where the latter governs the dynamics of the model. Although a detailed mathematical description can be found in Appendix A and in Lofgren *et al* (2002), this section presents a more discursive overview of the model's structure.[2]

2.1 Within-period Specification

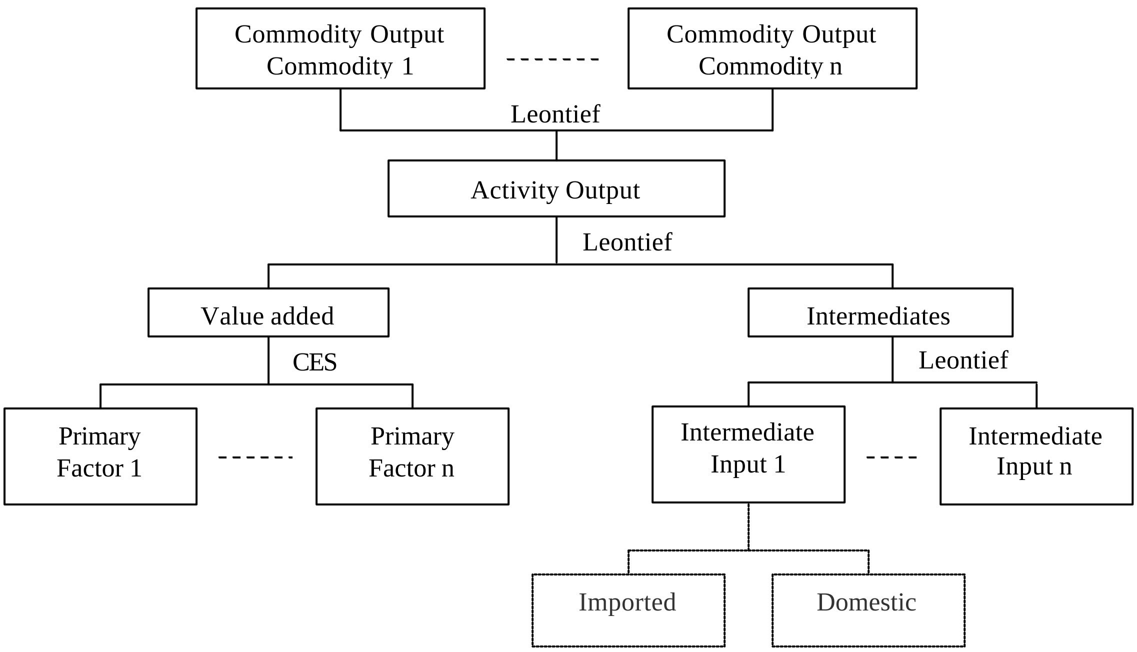
The within-period component describes a one-period static CGE model. The following description of this model is divided into the derivation of production and prices, and the generation of institutional incomes and demand. Equilibrium is maintained through a series of system constraints which are discussed last.

[2] The model and underlying data is available from Trade and Industrial Policy Strategies (www.tips.org.za) or from the author (j.thurlow@cgiar.org).

Production and Prices

The model identifies 43 productive sectors or activities that combine primary factors with intermediate commodities to determine a level of output. The four factors of production identified in the model include capital, unskilled and semi-skilled, skilled, and highly-skilled labour.[3] The technology underlying production is depicted for a single producer in Figure 2.1. Producers in the model make decisions in order to maximize profits subject to constant returns to scale, with the choice between factors being governed by a constant elasticity of substitution (CES) function. This specification allows producers to respond to changes in relative factor returns by smoothly substituting between available factors so as to derive a final value-added composite. Profit-maximization implies that the factors receive income where marginal revenue equals marginal cost based on endogenous relative prices. Once determined, these factors are combined with fixed-share intermediates using a Leontief specification. The use of fixed-shares reflects the belief that the required combination of intermediates per unit of output, and the ratio of intermediates to value-added, is determined by technology rather than by the decision-making of producers. The final price of an activity's output is derived from the price of value-added and intermediates, together with any producer taxes or subsidies that may be imposed by the government per unit of output.

Figure 2.1: Production Technology[1]



1 'CES' is a constant elasticity of substitution aggregation function. 'Leontief' is fixed shares.

[3] A detailed account of the different factor categories is provided in Section 3.

In addition to its multi-sector specification, the model also distinguishes between activities and the commodities that these activities produce. This distinction allows individual activities to produce more than a single commodity and conversely, for a single commodity to be produced by more than one activity.[4] Fixed-shares govern the disaggregation of activity output into commodities since it is assumed that technology largely determines the production of secondary products. These commodities are supplied to the market.

Figure 2.2 traces the flow of a single commodity from being supplied to the market to its final demand. The previous figure showed how a single producer could supply more than one of the 43 commodities identified by the model. In the figure below, the supply of a particular commodity from each producer is combined to derive aggregate commodity output. This aggregation is governed by a CES function which allows demanders to substitute between the different producers supplying a particular commodity, in order to maximise consumption subject to relative supply prices.

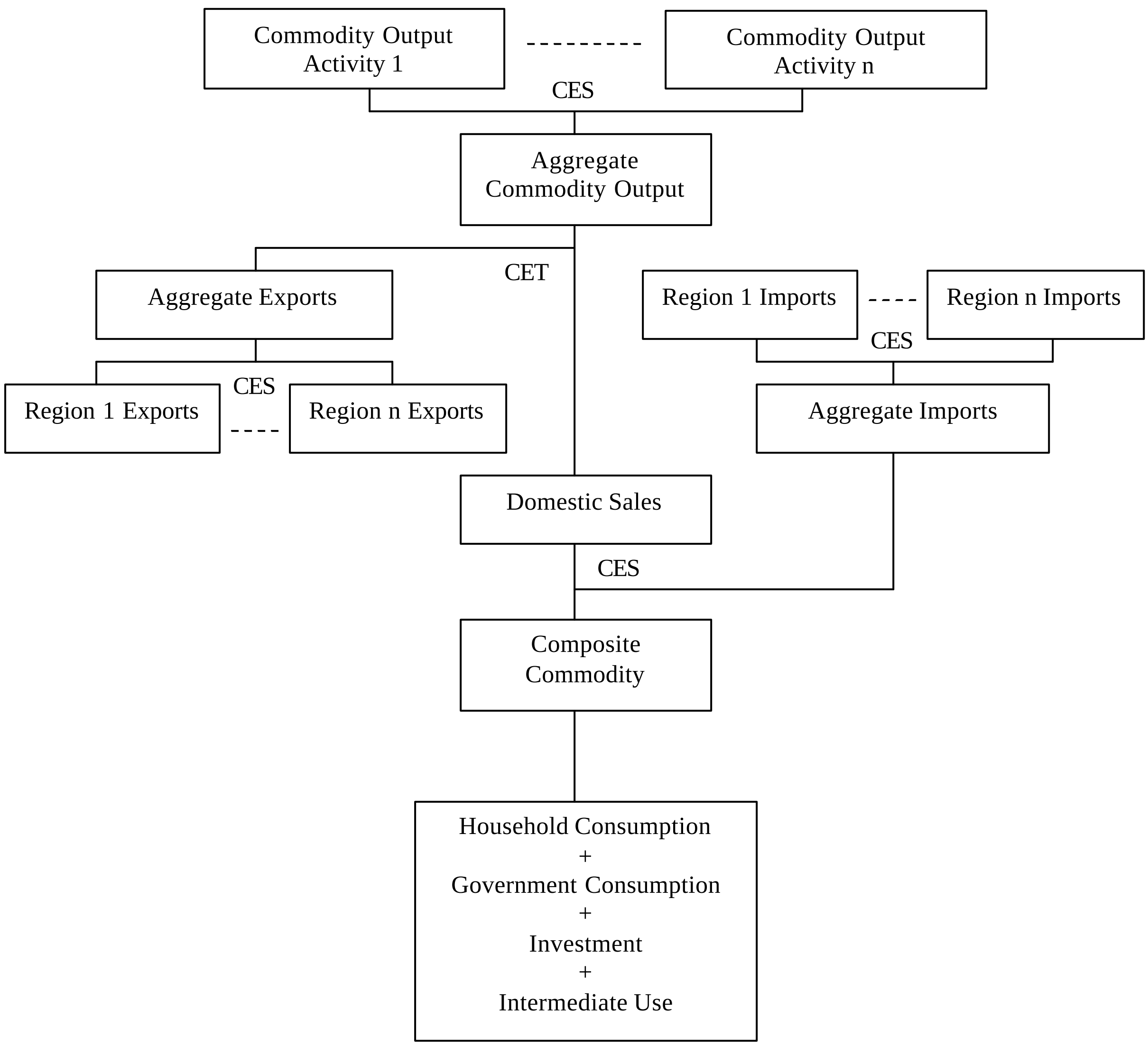
Substitution possibilities exist between production for the domestic and the foreign markets. This decision of producers is governed by a constant elasticity of transformation (CET) function, which distinguishes between exported and domestic goods, and by doing so, captures any time or quality differences between the two products. Profit maximization drives producers to sell in those markets where they can achieve the highest returns. These returns are based on domestic and export prices (where the latter is determined by the world price times the exchange rate adjusted for any taxes or subsidies). Under the small-country assumption, South Africa is assumed to face a perfectly elastic world demand at a fixed world price. The final ratio of exports to domestic goods is determined by the endogenous interaction of relative prices for these two commodity types. Commodities that are exported are further disaggregated according to their region of destination under a CES specification. Allowing substitution between regions is preferable to the use of fixed shares, since changes in relative prices across regions should lead to a shift in the geographic composition of exports.

Domestically produced commodities that are not exported are supplied to the domestic market. Substitution possibilities exist between imported and domestic goods under a CES Armington specification (Armington, 1969). Such substitution can take place both in final and intermediates

[4] For example, although the agricultural sector's primary output is agricultural products, this sector might also produce some processed food products. Therefore this single sector or activity can produce more than one product or commodity. Conversely, since food is also produced by the processed food sector, the combination of agricultural and processed food production suggests that some commodities can also be produced by more than one activity.

usage. The Armington elasticities vary across sectors, with lower elasticities reflecting greater differences between domestic and imported goods.[5] Again under the small country assumption, South Africa is assumed to face infinitely elastic world supply at fixed world prices. The final ratio of imports to domestic goods is determined by the cost minimizing decision-making of domestic demanders based on the relative prices of imports and domestic goods (both of which include relevant taxes). Imports are further disaggregated according to their region of origin using a CES function. This specification allows for regionally specific tariffs, and for substitution between regions following changes in relative import prices.

Figure 2.2: Commodity Flows[1]



1 'CES' is a constant elasticity of substitution aggregation function. 'CET' is constant elasticity of transformation function.

[5] The use of an Armington specification is justified by the likely heterogeneity of commodities within broad commodity categories, and by the observed two-way trade between South Africa and its trading partners. See Section 3 and Appendix C for the values of the Armington elasticities used in the model.

Transaction costs are incurred on exports, imports and domestic sales. These costs are treated as a fixed share per unit of commodity, and generate demand for trade and transportation services. The final composite good, containing a combination of imported and domestic goods, is supplied to both final and intermediate demand. Intermediate demand, as described above, is determined by technology and by the composition of sectoral production. Final demand is dependent on institutional incomes and the composition of aggregate demand.

Institutional Incomes and Domestic Demand

The model distinguishes between various institutions within the South African economy, including enterprises, the government, and 14 types of households. The household categories are disaggregated across income deciles with the exception of the top decile, which has five income divisions. Figure 2.3 summarises the interaction between institutions in the model.

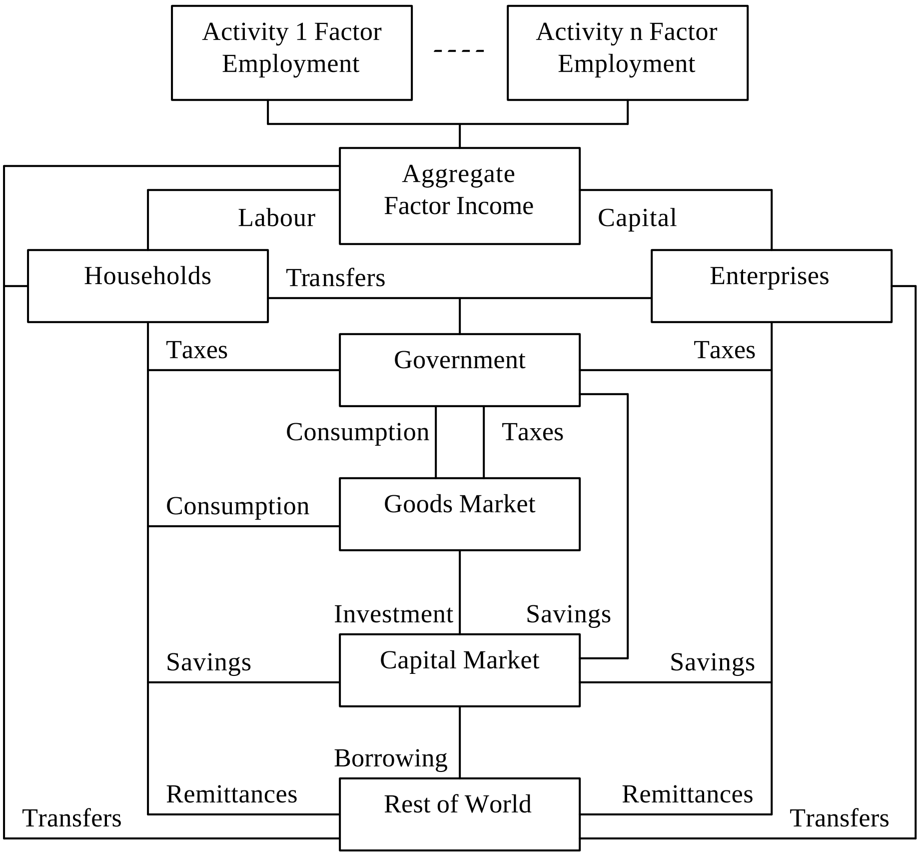
The primary source of income for households and enterprises are factor returns generated during production. The supply of capital is fixed within a given time-period and is immobile across sectors, thus implying that capital earns sector-specific returns. Unskilled and semi-skilled, and skilled labour supply is assumed to be perfectly elastic at a given real wage. Highly-skilled labour face upward-sloping labour supply curves, with wage elasticities determining adjustments to supply following changes in real wages.[6] Each activity pays an activity-specific wage that is the product of the economy-wide wage and a fixed activity-specific wage distortion term. This specification, in which factor returns are sector-specific, is preferable to the use of simple average wages, since average factor returns in South Africa are observed to vary both across occupations and sectors. Final factor incomes also include remittances received from and paid to the rest of the world.

Households and enterprises earn factor incomes in proportion to the implied share that they control of each factor stock. Enterprises or firms are the sole recipient of capital income, which they transfer to households after having paid corporate taxes (based on fixed tax rates), saved (based on fixed savings rates), and remitted profits to the rest of the world. Households within each income category are assumed to have identical preferences, and are therefore modelled as ‘representative’ consumers. In addition to factor returns, which represent the bulk of household incomes, households also receive transfers from the government, other domestic institutions, and the rest of the world. Household disposable income is net of personal income tax (based on fixed rates), savings (based

[6] The motivation for adopting these labour market closures for each of the three labour categories is presented in Section 3.

on fixed marginal propensities), and remittances to the rest of the world. Consumer preferences are represented by a linear expenditure system (LES) of demand, which is derived from the maximization of a Stone-Geary utility function subject to a household budget constraint. Given prices and incomes, these demand functions define households' real consumption of each commodity. The LES specification allows for the identification of supernumerary household income that ensures a minimum level of consumption.

Figure 2.3: Institutional Incomes and Domestic Demand



The government earns most of its income from direct and indirect taxes, and then spends it on consumption and transfers to households. Both of these payments are fixed in real terms. The difference between revenues and expenditures is the budget deficit, which is primarily financed through borrowing (or dis-saving) from the domestic capital market. Although not shown in Figure 2.3, the government also makes payments to the rest of the world. In the current model the government's role as a consumer is treated separately from the production of government services. The latter is specified as an activity producing services for which the government institution is the primary consumer.

Savings by households and enterprises are collected into a savings pool from which investment is financed. This supply of loanable funds is diminished by government borrowing (or dis-saving) and augmented by capital inflows from the rest of the world. There is no explicit modelling of the investment decision or the financial sector within a particular time-period, with savings equalling investment as per the ex post accounting identity. This implicitly assumes that the necessary adjustment in the interest rate takes place to ensure that savings equals investment in equilibrium. The disaggregation of investment into demand for final commodities is done using fixed shares, with changes in aggregate investment leading to proportional increases in the demand for individual commodities. Therefore there is no real compositional shift in investment following changes in relative commodity prices.

Production is linked to demand through the generation of factor incomes and the payment of these incomes to domestic institutions. Balance between demand and supply for both commodities and factors are necessary in order for the model to reach equilibrium. This balance is imposed on the model through a series of system constraints.

System Constraints and Macroeconomic Closures

Equilibrium in the goods market requires that demand for commodities equal supply. Aggregate demand for each commodity comprises household and government consumption spending, investment spending, and export and transaction services demand. Supply includes both domestic production and imported commodities. Equilibrium is attained through the endogenous interaction of domestic and foreign prices, and the effect that shifts in relative prices have on sectoral production and employment, and hence institutional incomes and demand.

The equilibrating of factor demand and supply is dependent on how the relationship between factor supply and wages is defined. As discussed above, capital is fully employed and sector-specific, implying that sector-specific wages adjust to ensure that demand for capital equals total supply. Unemployment amongst unskilled and semi-skilled, and skilled labour is assumed to be sufficiently large such that wages are fixed in real terms and supply passively adjusts to match demand. Highly-skilled labour is neither fully employed nor significantly unemployed to justify either a fixed supply or a fixed wage. Rather the supply of this factor is responsive to changes in real wages, which adjust to ensure that demand and supply are equal in equilibrium.

The model includes three broad macroeconomic accounts: the current account, the government balance, and the savings and investment account. In order to bring about equilibrium in the various macro accounts it is necessary to specify a set of 'macroclosure' rules, which provide a mechanism through which adjustment is assumed to take place.

For the current account it is assumed that a flexible exchange rate adjusts in order to maintain a fixed level of foreign borrowing (or negative savings). In other words, the external balance is held fixed in foreign currency. This closure is appropriate given South Africa's commitment to a flexible exchange rate system, and the belief that foreign borrowing is not inexhaustible. However given movements in South Africa's current account balance, it might be necessary to exogenously adjust foreign savings based on observed trends and let the exchange rate adjust accordingly.

In the government account the level of direct and indirect tax rates, as well as real government consumption, are held constant. As such the balance on the government budget is assumed to adjust to ensure that public expenditures equal receipts. This closure is chosen since it is assumed that changes in direct and indirect tax rates are politically motivated and thus are adopted in isolation of changes in other policies or the economic environment.

Although the government and current account closures can be selected based on current government policies, the choice of a savings-investment closure is less obvious. According to Nell (2003), the relationship between saving and investment remains one of the most debated and controversial issues in macroeconomics. On the one hand, neoclassical and recent endogenous growth theory maintains that it is prior savings that is most important when determining an economy's level of investment and output. This view suggests that savings is exogenous, and that investment adjusts passively to maintain the savings-investment balance. By contrast, a more Keynesian view reverses the causality found in neoclassical theory by arguing that investment is exogenous and that it is savings that adjusts. Finally, there might exist, as in the case of some developed countries, a two-way causality between savings and investment. In such cases both the level of savings and investment are endogenously determined and may both adjust in response to policy-changes.

The choice of which direction of causality is appropriate for South Africa might have implications for the outcomes of policies. For example, under the more neoclassical approach and in the case trade liberalization, a reduction in tariff revenue will decrease the level of government savings and thereby crowd-out private investment. Under the exogenous investment paradigm, maintaining the level of investment would require that savings would have to increase through increases in domestic savings rates. In such a case, the level of disposable income is reduced with 'crowding-out' effects on private consumption.

Recent work on this issue concluded that the long-run savings-investment relationship in South Africa has been one characterized by exogenous savings with no feedback from investment (Nell, 2003). Therefore the model adopts a savings-driven closure, in which the savings rates of domestic institutions are fixed, and investment passively adjusts to ensure that savings equals investment spending in equilibrium. However, the inclusion of dynamics into the model allows past investment to influence economic growth in the economy, and thereby the level of savings available for investment in the current period. The dynamics of the model are discussed below.

Finally, the consumer price index is chosen as the numéraire such that all prices in the model are relative to the weighted unit price of households' initial consumption bundle. The model is also homogenous of degree zero in prices, implying that a doubling of all prices does not alter the real allocation of resources.

2.2 Between-period Specification

While the static model described above is detailed in its representation of the South African economy within a particular time-period, its inability to account for second-period considerations limits its assessment of the full effect of policy and non-policy changes. For example, the model is unable to account for the second-period effect that changes in current investment have on the subsequent availability of capital. In attempting to overcome these limitations, the static model is extended to a recursive dynamic model in which selected parameters are updated based on the modelling of inter-temporal behaviour and results from previous periods. Current economic conditions, such as the availability of capital, are thus endogenously dependent on past outcomes, but remain unaffected by forward-looking expectations. The dynamic model is also exogenously updated to reflect demographic and technological changes that are based on observed or separately calculated projected trends.

The process of capital accumulation is modelled endogenously, with previous-period investment generating new capital stock for the subsequent period. Although the allocation of new capital across sectors is influenced by each sector's initial share of aggregate capital income, the final sectoral allocation of capital in the current period is dependent on the capital depreciation rate and on sectoral profit-rate differentials from the previous period. Sectors with above-average capital returns receive a larger share of investible funds than their share in capital income. The converse is true for sectors where capital returns are below-average.[7]

Population growth is exogenously imposed on the model based on separately calculated growth projections. It is assumed that a growing population generates a higher level of consumption demand and therefore raises the supernumerary income level of household consumption. There is assumed to be no change in the marginal rate of consumption for commodities, implying that new consumers have the same preferences as existing consumers.

Highly-skilled labour supply adjusts endogenously across periods in response to continuing changes in real wages. Between periods there may be an exogenous adjustment to the supply of this labour category as is typical in most recursive dynamic models. This treatment of the model's labour supply dynamics assumes that for the highly-skilled labour category there is neither a binding supply-constraint nor involuntary unemployment. Rather labour supply is seen as being driven by changes in real wages, thus suggesting the existence of an effective reservation wage.

Unskilled and semi-skilled, and skilled labour supply within a particular time period is infinitely elastic at a fixed real wage. As such it is the real wage, rather than labour supply, that adjusts between periods. In the dynamic model it is assumed that real wage changes for unskilled and skilled workers are relative to previous period changes in the real wage of highly skilled workers. This specification allows for the endogenous determination of wages for lower skilled workers, as well as the exogenous determination of skilled-unskilled wage convergence rates.[8]

Factor-specific productivity growth is imposed exogenously on the model based on observed trends for labour and capital. Growth in real government consumption and transfer spending is also exogenously determined between periods, since within-period government spending is fixed in real terms. Furthermore, projected changes in the current account balance are exogenously accounted for. Finally, mining production is assumed to be predominantly driven by a combination of changes in world demand and prices, and other factors external to the model. One such external factor might be the gradual exhaustion of non-renewable natural resources. Accordingly, the value-added growth

[7] See Dervis *et al* (1982) for a more detailed discussion of this and other approaches to modelling capital accumulation in CGE models.

[8] Exogenously imposed wage convergence (or divergence) suggests that there are there are factors outside of the model that are important in determining wages for unskilled and semi-skilled, and skilled workers. These factors might include the effective bargaining of trade unions or changes in South Africa's labour laws. As will be discussed in Section 3, observed wage convergence between highly-skilled and less-skilled workers justifies the current specification.

of these sectors and the world price of exports are updated exogenously between periods based on observed long-term trends.[9]

The South African dynamic model is solved as a series of equilibriums, each one representing a single year. By imposing the above policy-independent dynamic adjustments, the model produces a projected or counterfactual growth path. Policy changes can then be expressed in terms of changes in relevant exogenous parameters and the model is re-solved for a new series of equilibriums. Differences between the policy-influenced growth path and that of the counterfactual can then be interpreted as the economy-wide impact of the simulated policy.

2.3 Limitations of the Model

Applied general equilibrium modelling is an important tool for policy-analysis given that it is able to isolate the effects of individual policies, while explicitly specifying the causal mechanisms through which policies influence the economy. The CGE approach has advantages over data-based econometric analysis, which not only requires considerable and reliable time-series data, but also faces difficulties in isolating the effects of individual policies from other changes in policies and external factors. Furthermore, the sectoral and institutional detail of the CGE model allows for a more detailed analysis of policies than is typically possible with macro-econometric models. Finally, CGE models have an advantage over partial equilibrium analysis in that they offer an economy-wide assessment of policies, including the concurrent effects of policy-changes on production, employment, and poverty and inequality.

However, while economy-wide models have certain advantages over other methods of analysis, these models are more closely tied to theory, which often incorporates or necessitates an abstraction from the real workings of an economy. Therefore it is important to identify and account for the limitations of the model, especially in terms of its ability to reflect the country-specific characteristics of the economy being studied.

[9] Exogenously imposing a factor growth rate on a sector requires adjusting the capital accumulation process. For example, reducing mining output when capital is sectorally fixed leads to increases in mining capital's profit-rate. Since new capital allocation is driven by sectoral profit-rate differentials, a mining high profit-rate will therefore attract new investment. The mining sector therefore is excluded from the capital allocation decision after adjusting the stock of new capital to account for depreciation and fixed capital changes taking place within the mining sector.

Static and Dynamic Equilibrium

Perhaps the main criticism of the static model is that its core formulation is closely tied to the Walrasian ideal of equilibrium (Dervis *et al*, 1982). In a pure neoclassical setting, producers and consumers react passively to prices in order to determine their demand and supply schedules. Markets are therefore assumed to clear through the interaction of relative prices, such that equilibrium is achieved in both goods and factor markets. However, it might be argued that that certain institutional and structural rigidities within the South African economy result in cases of persistent disequilibrium or deviations from neoclassical theory.

The South African model does attempt to incorporate some the perceived rigidities in the economy's factor markets. For example, capital is assumed to be immobile across sectors, and unskilled and semi-skilled, and skilled labour supply is unemployed at a fixed real wage. Furthermore, factor returns are assumed to vary across sectors based on observed and persistent sectoral deviations from economy-wide averages. These rigidities allow for a 'constrained' general equilibrium that, while remaining close to the Walrasian model, accounts for some of the observed structural characteristics of the economy. However, Dervis *et al*. (1982) note that the adoption of a more Walrasian approach leads to problems in both factor *and* product markets. In the case of the latter, the South African model retains a neoclassical specification, and ignores such considerations as the existence of imperfect competition and monopoly-pricing.

The model assumes there is no interaction between monetary and real economies. The use of a numéraire and the lack of an explicitly modelled monetary sector imply that the model is essentially one of a barter economy in which money is neutral. Taylor (1983), in outlining the structuralist approach, discounts money-neutrality by arguing that nominal changes can influence the real economy, particularly within the short-run and in respect to the demand for money balances. Dervis *et al*. (1982) suggest however that, while separability is not always possible to preserve, the overall strength of the CGE approach lies in its ability to address questions of medium to long-term resource allocation.

The specification of capital accumulation and allocation within the dynamic model also represents a deviation from the perfect neoclassical inter-temporal equilibrium. Within the neoclassical framework, market and production prices of capital are identical, within-period sectoral profit-rates are equalised, and the economy moves along an inter-temporally efficient path characterised by perfect foresight (Dervis *et al*., 1982). However, in the adaptive dynamic South African model, capital is immobile across sectors and the allocation of new capital is partly determined by the distribution of previous-period capital incomes. Together these rigidities prevent both a within- and between-period equalisation of sectoral profit-rates. By not determining the inter-temporally efficient allocation of capital the model greatly simplifies the investment allocation decision, and avoids having to explicitly model expectations. This specification can be justified on the grounds that agents within the South African economy are unlikely to possess perfect foresight, and as such, the inter-temporal efficient growth path is unlikely to be achieved.

Given the institutional and structural rigidities of the South African economy, the use of a more neoclassical market-clearing mechanism suggests that caution be exercised in interpreting the model's results. Most importantly, the model is not able to provide short-term predictions, but rather highlights the direction and relative magnitude of adjustments to the economy following changes in policies, technology, and other external factors.

Production and Factor Demand

Production within the South African model is governed by neoclassical production functions, which may not reflect the specific workings of individual sectors. The model assumes constant returns to scale, and models 'representative' sectors such that all producers within each sector are assumed to share the same behaviour. Capital and labour are treated as equally substitutable for one another, thus implying, for example, that unskilled labour is as substitutable for capital as is highly-skilled labour. Finally, all producers are assumed to be on their factor demand curve. This last assumption rules out the possibility of excess capacity and the hoarding of labour during economic downturns. Although it is possible to adopt more flexible specifications of production, such as translog or nested-CES functions, these formulations require considerably more parameter estimates than are currently available for South Africa. Furthermore, the relatively high sectoral and factor aggregation of the model, and its medium to long-term focus, are likely to lessen the severity of the above limitations. For example, higher sectoral aggregation reduces the likelihood of monopoly-power within an individual sector.

Final Demand

Final household, government, and investment demand for each commodity is assumed to be a fixed share of aggregate institutional spending. Therefore expenditure shares for each commodity are fixed and do not adjust in response to changes in relative prices. While this is unlikely to reflect actual institutional behaviour, the use of fixed shares is preferable to the use of a more flexible functional form since short and medium-term substitution possibilities are likely to be limited. Furthermore, there is no existing information on South Africa that could inform the calibration of such behaviour.

This specification also does not allow household consumption patterns to adjust following changes in household incomes. The assumption that there is no income effect on final demand, or that the income elasticity of demand is unity, is unlikely to reflect reality. However, there is little reason to suspect that consumption patterns will adjust significantly as long as the time-period over which the model is used remains relatively short and income changes are small.

Foreign Trade

The model assumes that imports, exports, and domestic goods are imperfect substitutes. This assumption is more realistic than a 'perfect substitutes' specification, since the high sectoral aggregation of the model increases the likelihood of within-sector cross-hauling. However, in the case of imports, the allowance for differentiated products leads to the construction of a composite good containing both imported and domestic commodities. This marketed composite good is then supplied to all components of demand, thus assuming that all consumers of an individual commodity have the same import-intensity of consumption. For example, the import-share of the food composite is the same for low-income and high-income households. This is likely to overstate the import-intensity of low-income household food consumption, and understate high-income households' import-intensity.

By measuring trade policy using fixed tariff rates, the model does not explicitly account for the existence of quantitative restrictions or differential tariff rates that are determined by trade volumes. While the use of quantitative restrictions in South Africa had been greatly reduced prior to the beginning of the 1990s, South Africa's use of formula duties persisted into the 1990s, mainly within the agricultural and textiles sectors (Cassim *et al*, 2002). For these sectors the model assumes that tariff rates are fixed simple ad valorum rates that are unaffected by changes in import-quantities. Assuming that some tariff rates do increase as import volumes increase, the current specification is likely to understate tariff rates following increases in imports, and understate rates following declines in imports. However, Cassim *et al.* (2002) find that, even in the case of agriculture, collections rates are a good proxy for statutory rates, thereby lessening the likely severity of this limitation.

3. Description of the South African Social Accounting Matrices

Typically the main database used to calibrate a CGE model is a social accounting matrix (SAM), which provides a comprehensive economy-wide representation of the economy for a particular year.[10] However, while a SAM provides insight into the sectoral and institutional structure of the economy, it does not contain information on the behaviour of the country's economic agents, or the process of dynamically updating the model across time. In such cases, information is taken from additional data sources and from the literature. Given both the data-intensity of the calibration process, and the importance of this data in determining the results of the model, this section provides an overview of the South African economy as it is described by the data.[11]

3.1 Broad Comparison of South Africa and Other Countries

Two SAMs were constructed for South Africa for the years 1993 and 2000. Table 3.1 disaggregates gross domestic product (GDP) for these years. The largest components of demand are private and government consumption, which together account for over 80 percent of total GDP at market prices. A comparison between 1993 and 2000 shows that, apart from developments in international trade, there has been little change in the overall structure of GDP during the 1990s. However, exports and imports as a share of GDP have risen by six and eight percentage points respectively, possibly reflecting increased openness. By contrast, the share of fixed investment in GDP has remained unchanged.

Table 3.1: Structure of Gross Domestic Production (1993 and 2000)

	Value (Billions of Current Rands)		Share of GDP (Market Prices)	
	1993	2000	1993	2000
Private consumption	265.4	556.7	59.8	59.8
Fixed investment	62.6	131.8	14.1	14.1
Inventory changes	-3.1	8.7	-0.7	0.9
Government consumption	103.3	209.9	23.3	22.5
Exports	86.7	249.1	19.5	26.7
Imports	-71.0	-224.6	-16.0	-24.1
GDP (market prices)	443.9	931.6	100.0	100.0
Net indirect taxes	40.8	100.0	9.2	10.7
GDP (factor cost)	403.1	831.6	90.8	89.3

Source: 1993 and 2000 South African SAMs

[10] For a discussion of SAMs and their use in economy-wide policy analysis see Dervis *et* al (1982), Pyatt and Round (1985) and Reinert and Roland-Holst (1997).

[11] Appendices B and C provide a more detailed account of the general structure of a SAM, as well as the data sources and procedures used to construct the South African SAMs used in this thesis. Although this thesis constructs and uses SAMs for 1993 and 2000, Thurlow and van Seventer (2002) offer a detailed description of the 1998 South African SAM.

Although some indication of the structure of production in South Africa is provided in the table, more disaggregated data is required if the CGE model is to accurately capture the country-specific interactions of the economy. The following subsections largely follow the model specification in Section 2 by first outlining the structure of production and trade, before discussing the workings of the country's factor markets. Subsequent sections review the institutional organisation of the economy, the composition of the savings-investment relationship, and the country's current account balance. At each stage particular attention is paid to the interaction between model specification, closure, and calibration.

Table 3.2: Comparison of South Africa and Other World Regions (1993)

	South Africa	**Latin America and Caribbean**	**Sub-Saharan Africa**1	**East Asia and Pacific**	**South Asia**	**World**
GDP per capita (1995 $US)	3468.4	3492.8	543.1	871.7	351.4	5026.6
Share of GDP (Market Prices)						
Private consumption	59.8	65.9	67.3	51.7	70.7	60.2
Investment	13.4	20.6	16.3	37.8	21.1	22.3
Government	23.3	14.4	18.1	11.5	11.1	17.1
Exports	19.5	13.2	26.1	26.4	11.7	19.8
Imports	-16.0	-14.1	-27.8	-27.4	-14.6	-19.4
GDP (market prices)	100.0	100.0	100.0	100.0	100.0	100.0
Share of GDP (Factor Cost)						
Agriculture	4.2	7.6	17.5	15.8	29.7	5.6
Industry	33.2	35.8	32.9	43.2	25.8	34.3
Services	62.6	56.6	49.6	41.0	44.5	60.1
Total Production	100.0	100.0	100.0	100.0	100.0	100.0
Manufacturing	19.5	22.1	15.6	29.8	16.0	-

Source: 1993 South African SAM; World Development Indicators (World Bank, 2002).
1. Sub-Saharan Africa includes South Africa.

3.2 Sectoral Production and Trade

As mentioned in Section 2, the South African model identifies 43 productive sectors or activities which combine factors and intermediates to arrive at a total level of output. Table 3.3 shows the structure of production across aggregate sectors for the years 1993 and 2000.[12]

[12] This section aggregates sectors and institutions to allow for a more accessible overview of the economy. Fully disaggregated tables are included in Appendix C and are referred to as required.

Although the share of primary production in South Africa is relatively low when compared to other developing countries, the first two columns of the table indicate that the agricultural and mining sectors together account for one-tenth of total GDP at factor cost, with gold generating over half of total mining value-added.[13] Mining-related activities also play an important role as reflected the share of the metals and machinery sector, of which almost two-thirds is attributable to metals and metal-beneficiation. Other large manufacturing sectors include chemicals, and processed foods.

Despite the importance of the primary and secondary sectors, services are responsible for generating the largest share of GDP. In aggregate, these sectors account for almost two-thirds of national production. Within services the government sector is the largest contributor generating around one-fifth of GDP. Trade and financial services are the largest non-government sectors, together accounting for over a quarter of total production. A comparison between 1993 and 2000 shows that there has been a shift out of manufacturing and into services over the last decade.

Table 3.3: Production Structure (1993 and 2000)

	Share of GDP at Factor Cost		Share of Capital in Sectoral Value-Added		Share of Value-Added in Sectoral Output	
	1993	2000	1993	2000	1993	2000
Agriculture	4.2	3.1	70.5	66.1	58.0	49.0
Mining	7.0	6.3	46.8	52.2	58.4	53.3
Food products	3.3	2.9	51.3	55.2	27.5	29.2
Textile products	1.4	0.9	26.7	22.1	33.6	34.3
Wood / paper	1.9	1.8	40.7	39.2	33.5	35.1
Chemicals	3.8	3.8	52.4	52.0	32.7	31.0
Non-metal minerals	0.9	0.7	38.0	60.1	40.5	39.6
Metal and machinery	4.7	4.4	35.3	48.1	31.7	32.5
Scientific equipment	0.3	0.3	36.7	27.6	29.7	32.5
Transport equipment	1.6	1.4	39.8	41.7	26.8	20.2
Other manufacturing	1.6	0.5	65.6	35.7	50.7	28.1
Electricity / water	3.3	2.6	71.6	65.5	65.1	57.4
Construction	3.4	3.1	21.4	40.1	29.9	31.1
Trade / catering	13.4	12.1	46.4	49.4	57.2	56.3
Transport / comm.	8.3	9.6	47.2	57.3	59.2	55.6
Financial services	15.1	18.4	65.5	65.1	64.9	64.1
Other services	6.0	7.0	23.6	24.3	61.5	63.3
Government services	19.8	21.1	30.7	33.7	71.5	78.3
Manufacturing	19.5	16.7	44.2	46.0	33.1	31.0
Non-govern. services	42.8	47.1	50.1	52.9	60.9	59.9
All sectors	100.0	100.0	45.9	48.9	50.6	50.7

Source: 1993 and 2000 South African SAMs

The second two columns in the table show the percentage contribution of capital to total value-added within each sector. Agriculture in South Africa, unlike in most other developing countries, is highly capital-intensive, with capital accounting for around two-thirds of value-added. Other highly capital-intensive sectors include the energy, and financial services sectors. Conversely, the most

[13] See Table C.1 in Appendix C.

labour-intensive sectors are textiles, construction, and government services. Although non-government services tend to be more capital-intensive than manufacturing, the chemicals sector includes petroleum processing, which is the most capital-intensive disaggregated sector. Between 1993 and 2000 there has been an overall increase in the capital-intensity of production, with capital's share in total value-added increasing from 45.9 to 48.9 percent. A decomposition of this change finds that almost two-thirds of the rise in capital-intensity has been driven by the government, financial, and communication services sectors. The remaining change is evenly distributed across mining and manufacturing.

Since output comprises both factor and intermediate inputs, the final two columns of the table show the contribution of value-added to the total value of production. In the context of economy-wide modelling, those sectors with the lowest value-added shares are the sectors with the largest backward linkages to the rest of the economy. The table suggests that sectors with high capital-intensities are also likely to have high factor-intensities. Such sectors include agriculture, energy, and the services sectors. By contrast, sectors with a larger share of intermediates in total output tend to be more labour-intensive. This is the generally the case for the manufacturing sectors, and for textiles and vehicles in particular. Therefore the structure of manufacturing justifies the inclusion of backward linkages into the specification of the South African model. Finally, there has been a shift in the factor-intensity of production between 1993 and 2000. Although the aggregate share of value-added has remained unchanged at around half of total output, this is largely a result of increased factor-intensity within the large government sector.

Table 3.4 shows the composition and structure of South Africa's trade with the rest of the world. Although mining contributes only seven percent to GDP, it is the single most important source of foreign earnings for South Africa. The first two columns of the table show that in 1993 mining accounted for 41 percent of export earnings, with gold dominating this sector.[14] However, between 1993 and 2000 there was a substantial decline in gold production, whose share of exports fell from 26.5 to 10.1 percent. This collapse in gold exports has been partially cushioned by the rapid rise in other mining exports.[15]

Aggregate manufactured exports are equally important for South Africa, generating 42.4 percent of total export earnings. However, most manufactured exports originate from within the metals and machinery sector, and are therefore mining-related. For example, in 1993 iron, steel, and other

[14] See Table C.2 in Appendix C.
[15] Other mining is largely comprised of non-coal and non-gold mining and services incidental to mining.

metals accounted for over 80 percent of this sector's total exports. Increases in this sector's export share between 1993 and 2000 were however driven by an expansion in machinery exports. Other important manufactured exports include processed-food, chemicals, and transport equipment, with the latter comprising mostly vehicles.

Table 3.4: International Trade (1993 and 2000)

	Export Share		Export-Output Share		Import Share		Import-Demand Share	
	1993	2000	1993	2000	1993	2000	1993	2000
Agriculture	3.7	2.7	10.3	11.7	3.1	1.6	7.9	7.7
Mining	41.0	33.4	79.1	87.8	1.9	10.2	10.4	91.6
Food products	7.1	5.2	9.7	11.3	6.5	4.6	8.8	12.0
Textile products	2.7	2.1	11.2	20.0	4.6	3.5	17.7	27.7
Wood / paper	3.0	3.6	13.0	20.3	5.0	2.7	15.8	16.2
Chemicals	6.5	10.0	18.5	35.4	15.5	12.6	23.1	30.4
Non-metal minerals	0.6	0.6	7.1	9.2	1.3	1.3	13.1	19.4
Metal and machinery	14.4	17.4	34.5	39.4	23.6	20.0	36.5	53.0
Scientific equipment	0.5	1.1	7.1	34.1	6.5	8.2	50.0	77.2
Transport equipment	3.6	6.1	10.3	28.2	13.6	15.4	30.6	49.7
Other manufacturing	4.0	2.6	24.7	31.7	3.4	1.8	23.2	33.7
Electricity / water	0.4	0.5	2.0	3.7	0.1	0.1	0.6	1.0
Construction	0.0	0.1	0.1	0.2	0.2	0.3	0.4	0.9
Trade / catering	2.4	2.8	21.5	31.2	2.9	2.1	21.8	24.1
Transport / comm.	5.3	6.4	8.1	12.8	7.0	10.4	8.6	18.2
Financial services	3.6	4.0	3.9	5.0	3.1	3.6	2.3	3.3
Other services	1.1	1.4	2.6	3.0	1.7	1.6	2.5	4.0
Government services	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Manufacturing	42.4	48.7	15.5	24.5	80.0	70.1	23.1	35.0
Non-govern. services	12.4	14.6	5.8	7.8	14.7	17.7	4.9	8.2
All sectors	100.0	100.0	10.0	13.7	100.0	100.0	9.8	15.2

Source: 1993 and 2000 South African SAMs.

The rapid increase in mining imports can be seen more clearly in the final two columns of the table, which show the share of imports in total final demand. The import-intensity of mining rose from 2.7 percent in 1993 to 56 percent in 2000, with almost all of this increase being driven by growth in the other mining sector. This coincides with a general increase in import-intensity across all sectors. Manufacturing's share rose considerably from 23.1 percent to 35 percent, while non-government services' increased from 4.9 to 8.2 percent. Overall manufacturing remained one of the more import-intensive sectors in the economy, with the chemicals and equipment sectors experiencing high market penetration.

The second two columns of the table show the share of domestic output that is exported. Mining is the most export-intensive sector, with over 80 percent of domestic production sold abroad. Manufacturing, with a share of 15.5 percent, is more export-intensive than services, whose share is only 5.8 percent. However, between 1993 and 2000 there was an increase in the export-intensity of

South African production, with both manufacturing and services' share of exports in output rising rapidly during this period.[16]

Like exports, imports are concentrated within a few sectors. The largest import sectors include the chemicals, machinery, and equipment sectors, with the latter comprising mainly vehicles. In aggregate, manufacturing in 1993 accounted for over 80 percent of total imports, although this share fell sharply over the last decade to 70 percent, due mainly to increases in mining imports. Beneath this overall decline in imported manufactures there was a considerable increase in imported vehicles.

Table 3.5 shows the tariff duties collected on manufactured imports across disaggregated commodities. The low average tariff of 5.1 percent hides a wide variation in tariff rates commodities. High tariffs are mainly clustered within the textiles, chemical-derivative, non-metallic mineral, and machinery and equipment sectors. Exceptions include furniture, metal, and paper products. Between 1993 and 2000 there was some reduction in tariffs, with aggregate tariff rates falling by almost one-third. However, there still remains considerable protection on many of South Africa's major imports. Most important amongst these are textiles, machinery, and vehicles.

Table 3.5: Import Tariff Duties (1993 and 2000)

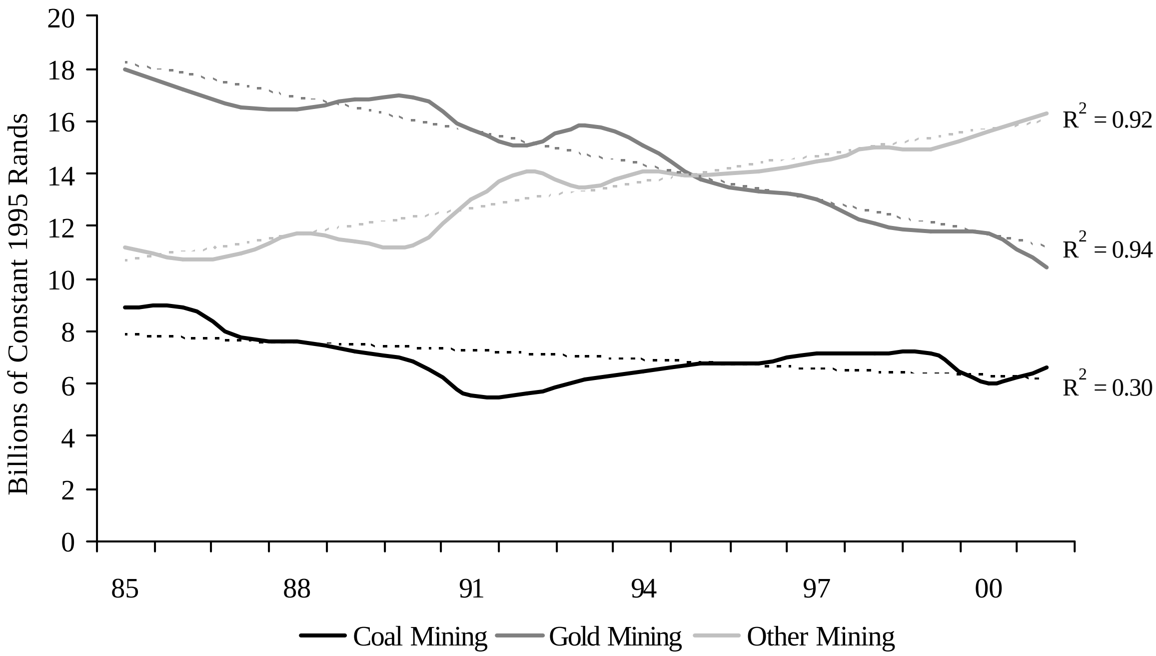
Commodity	**Tariff Rate**		**Percent**	**Commodity**	**Tariff Rate**		**Percent**
	1993	**2000**	**Change**		**1993**	**2000**	**Change**
Agriculture	0.5	0.7	38.4	Glass products	17.1	18.6	9.1
Food processing	7.7	7.4	-3.1	Non-metal minerals	17.1	10.9	-36.6
Beverage / tobacco	1.4	1.6	17.0	Iron and steel	6.7	5.8	-14.1
Textiles	10.2	10.7	4.8	Non-ferrous metals	2.8	1.1	-62.2
Clothing	4.4	4.0	-9.7	Metal products	14.5	11.0	-23.8
Leather products	12.6	9.3	-26.1	Machinery	1.8	1.6	-8.3
Footwear	29.0	22.8	-21.6	Electrical machinery	12.6	11.0	-13.0
Wood products	5.6	5.6	0.2	Comm. equipment	11.0	4.7	-57.3
Paper products	14.1	15.3	8.7	Scientific equipment	0.6	0.5	-13.8
Printing / publishing	0.9	1.6	74.1	Vehicles	8.2	5.3	-35.1
Petroleum products	0.1	0.1	23.6	Transport equipment	0.5	0.3	-41.9
Chemicals	3.7	3.5	-3.9	Furniture	28.6	17.3	-39.5
Other chemicals	4.8	3.6	-24.3	Other manufacturing	5.4	8.7	61.4
Rubber products	33.6	24.2	-28.1				
Plastic products	19.8	15.0	-24.2	All sectors	5.1	3.6	-28.5

Source: 1993 and 2000 South African SAMs.

[16] The aggregate export-intensity in 1993 is low due to the inclusion of government service exports (which are a negligible share of total exports). Since the share of exported government services is very low compared to government service production (which is a substantial portion of total production), this considerably reduces the weighted aggregate measure. Excluding government services raises the aggregate export-intensity to 13.4 percent in 1993, and 17.1 percent in 2000.

In summary, trade is concentrated within a narrow range of sectors. The mining and metal-related sectors generate the largest share of exports, while imports comprise mostly machinery, vehicles, and chemicals. Despite its declining importance, gold and other mining have dominated the structure of trade over the last decade. Given the importance of mining as an export sector it is necessary to account for these recent developments in the model. This is achieved by exogenously determining the growth path of these sectors based on observed trends. Figure 3.1 shows long-term trends in value-added for each of the three disaggregated mining sectors identified in the South African model. Changes in mining value-added appear to have been unaffected by short-term fluctuations in South Africa's economic performance, thus suggesting that the performance of these sectors is largely determined by structural or policy-independent factors. Therefore exogenously determining a real growth rate for these sectors seems appropriate. Furthermore, the figure suggests that imposing a constant growth rate adequately captures long-term trends in these sectors.

Figure 3.1: Long-term Trends in Mining Value-Added (1985 to 2001)



Source: South African Standard Industrial Database (TIPS, 2003).

South African trade is further disaggregated across the trading regions or countries shown in Table 3.5. The regional disaggregation of trade occurs only for agricultural, non-gold mining, and manufactured commodities.[17]

[17] Gold exports are excluded from the regional analysis because the South African Customs and Excise department withholds information on the destination of these exports.

Table 3.5: Trading Regions within the Model

Trading Region	Member Countries
Southern African Development Community (SADC) excl. South Africa	Angola, Botswana, Democratic Republic of the Congo, Lesotho, Mauritius, Malawi, Mozambique, Namibia, Seychelles, Swaziland, Tanzania, Zambia, and Zimbabwe
Rest of Africa	African countries not in SADC
United States of America (US)	
Mercosur	Argentina, Brazil, Paraguay, and Uruguay
European Union (EU)	Austria, Belgium, Germany, Denmark, Spain, Finland, France, United Kingdom, Greece, Ireland, Italy, Luxembourg, Netherlands, Norway, and Portugal
India	
China	
Japan	
Rest of East Asia	Hong Kong, North Korea, South Korea, Mongolia, Macao, and Taiwan
Rest of World	All countries not listed above

Source: ComTrade.

Table 3.6 shows the distribution of imports across trading regions in 2000.[18] The most important countries or regions supplying the South African market are the European Union (EU), the United States (US), and Japan. Together these countries account for 60 percent of total non-gold imported goods. The EU and the US export a wide range of manufactured goods to South Africa, while the smaller trading regions tend to focus on particular commodities. For instance, while China's share of total imports is relatively low, it is the largest exporter of textiles to South Africa. Similarly, SADC is the largest exporter of food.[19]

In terms of the exporting countries, machinery and metals is a large share of all regions' exports to South Africa, with the only exception being the US whose exports are heavily concentrated in mining. Transport equipment, mainly representing vehicles, is a large component of imports from Mercosur, the EU, and India.[20] However, most of South Africa's imported transport equipment originates from within the US, EU, and Japan, with only US trade being concentrated in non-vehicle exports. Finally, textile imports contribute greatly to South Africa's total imports from China and Japan.

The most important imported goods for South Africa are machinery and vehicles, which are largely imported from the developed countries. By contrast, agricultural, food, and textile imports originate largely from within developing countries. Therefore in terms of trade policy, a relaxation of trade

[18] The distribution of trade across regions is based on a three-year moving average between 1999 and 2001 use information taken from ComTrade.
[19] The high mining share for the rest of the world (88.2 percent) reflects large flows of imported 'other mining' from Saudi Arabia, Iran, and Nigeria.
[20] See Table C.3 in Appendix C.

restrictions within the 'sensitive' vehicles and textiles sectors is likely to result in increased competition from both developed and developing countries respectively.

Table 3.6: Regional Imports (2000)

	Region's Share of Imported Commodity								
	SADC	US	Mer-cosur	EU	India	China	Japan	Rest of World	Total
Agriculture	24.4	11.7	11.0	10.3	2.8	2.7	0.2	36.9	100.0
Non-gold mining	0.9	0.5	0.1	10.0	0.1	0.3	0.0	88.2	100.0
Food products	2.6	7.0	16.7	34.5	2.9	1.8	0.1	34.4	100.0
Textile products	5.5	4.3	1.2	17.3	6.3	25.7	0.4	39.2	100.0
Wood / paper	2.0	19.8	1.8	53.9	0.4	1.2	1.2	19.7	100.0
Chemicals	0.7	16.2	1.5	50.1	1.3	3.6	4.7	22.0	100.0
Non-metal minerals	1.5	12.4	2.9	53.1	1.3	7.2	7.3	14.2	100.0
Metal and machinery	1.8	12.4	1.3	45.1	0.8	4.6	7.1	26.9	100.0
Scientific equipment	0.5	15.7	0.2	49.5	0.2	3.8	5.4	24.8	100.0
Transport equipment	1.0	17.4	2.4	46.7	0.3	0.4	23.4	8.5	100.0
Other manufacturing	5.3	11.1	0.4	36.2	2.0	16.6	4.1	24.3	100.0
All imported goods	2.0	12.3	2.4	40.0	1.0	3.9	7.7	30.8	100.0

	Commodity's Share of Total Imported Goods from Region								
	SADC	US	Mer-cosur	EU	India	China	Japan	Rest of World	Total
Agriculture	24.3	7.7	1.9	9.1	0.5	5.4	1.3	3.1	2.0
Non-gold mining	5.8	73.0	0.5	2.4	3.1	0.7	0.9	46.6	12.5
Food products	7.6	4.8	3.2	38.0	4.8	15.6	2.5	8.5	5.6
Textile products	12.1	1.5	1.5	2.2	1.9	26.4	28.1	8.8	4.3
Wood / paper	3.4	2.7	5.3	2.6	4.5	1.2	1.0	2.4	3.3
Chemicals	5.5	4.1	20.4	10.0	19.5	19.3	14.2	11.3	15.6
Non-metal minerals	1.2	0.4	1.6	1.9	2.0	2.0	2.8	0.8	1.5
Metal and machinery	22.4	3.0	24.5	13.9	27.5	18.9	28.6	21.9	24.4
Scientific equipment	2.4	0.9	12.7	0.7	12.4	1.7	9.6	10.8	10.0
Transport equipment	9.6	0.8	26.6	18.8	21.9	4.6	1.7	5.9	18.8
Other manufacturing	5.8	1.1	1.9	0.4	2.0	4.2	9.1	2.1	2.2
All imported goods	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: 1993 and 2000 South African SAMs.

Table 3.7 shows that South Africa's major export markets are the EU, SADC, and the US. Non-gold mining products are the single largest export commodity for South Africa, with a majority of these exports destined for the EU. By contrast exported metals and machinery are more evenly distributed across trading regions. However, unlike imports, the largest component of trade within this sector is metals rather than machinery.[21] SADC and the EU are the most important export markets for South African agricultural and food products.

[21] The Rest of World's high share of metal exports is due to limitations in trade data. As with gold, the Customs and Excise department withholds information on the origin and destination of non-ferrous metal exports, or more specifically, platinum. Therefore trade for this disaggregated sector cannot be adequately distributed across specific regions and is instead allocated to the rest of the world. However, the regional distinction is maintained since non-platinum exports make up the remaining 20 percent of exports from this sector. This lack of regional data is also the case for petroleum and related products, albeit to a lesser extent. See Table C.4 in Appendix C.

South African exports are more evenly dispersed across developed and developing countries than is the case for imports. South Africa's position as a middle income country is reflected in its high share of manufactured exports to developing countries, and high share of primary exports to developed countries.

Table 3.7: Regional Exports (2000)

	Region's Share of Exported Commodity								
	SADC	US	Mercosur	EU	India	China	Japan	Rest of World	Total
Agriculture	10.1	4.6	0.4	54.8	0.2	1.0	8.0	20.9	100.0
Non-gold mining	1.4	9.0	0.9	57.7	0.8	4.9	6.8	18.4	100.0
Food products	23.4	4.9	0.6	31.8	0.2	0.2	5.7	33.3	100.0
Textile products	14.7	23.6	0.8	35.4	0.3	2.0	5.5	17.7	100.0
Wood / paper	13.5	4.9	2.5	30.0	2.8	1.4	13.5	31.5	100.0
Chemicals	28.9	9.9	2.2	15.6	3.8	0.7	2.1	36.8	100.0
Non-metal minerals	30.4	10.3	1.5	32.0	0.3	1.7	4.6	19.2	100.0
Metal and machinery	11.9	11.5	0.9	29.5	1.1	1.8	4.6	38.7	100.0
Scientific equipment	23.5	6.6	0.8	28.9	1.3	0.5	0.1	38.3	100.0
Transport equipment	10.9	13.5	0.6	45.7	0.3	3.6	5.7	19.8	100.0
Other manufacturing	4.3	9.3	0.1	62.2	0.4	0.5	1.6	21.4	100.0
All exported goods	11.8	9.8	1.1	40.2	1.2	2.6	5.5	27.9	100.0

	Commodity's Share of Total Exported Goods from Region								
	SADC	USA	Mercosur	EU	India	China	Japan	Rest of World	Total
Agriculture	3.1	3.1	1.7	1.2	4.9	0.6	1.5	2.9	3.6
Non-gold mining	3.8	6.7	28.5	27.1	44.7	21.1	60.0	22.1	31.2
Food products	14.0	14.6	3.5	4.1	5.6	1.2	0.4	9.2	7.1
Textile products	3.6	1.7	6.9	2.2	2.5	0.7	2.2	2.0	2.9
Wood / paper	5.6	10.1	2.4	11.1	3.6	10.8	2.6	6.6	4.9
Chemicals	32.8	26.0	13.4	27.7	5.2	40.5	3.9	18.5	13.4
Non-metal minerals	1.9	1.1	0.8	1.0	0.6	0.2	0.5	0.6	0.7
Metal and machinery	23.5	20.4	27.3	19.8	17.1	20.4	16.2	33.0	23.2
Scientific equipment	2.9	6.3	1.0	1.1	1.1	1.5	0.3	3.4	1.5
Transport equipment	7.6	8.8	11.2	4.3	9.3	1.9	11.6	6.0	8.2
Other manufacturing	1.3	1.3	3.3	0.4	5.4	1.1	0.7	3.1	3.5
All exported goods	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: 1993 and 2000 South African SAMs.

Although the data presented above indicates the structure of South Africa's trade with the rest of the world, it does not describe the behaviour of either import demand or export supply. Rather information on the substitution between domestic and foreign goods is obtained from econometric estimates found in the literature. Table 3.8 shows the values used to describe trade behaviour in the model.

The Armington elasticity reflects the ease at which domestic consumers substitute between domestic and imported commodities. A larger elasticity implies a higher degree of substitution, or a greater homogeneity, between domestic and foreign goods. According to the table, greater import substitution possibilities exist for agricultural and wood products, textiles, and transport equipment.[22] Within textiles it is the leather and footwear sectors that have the highest elasticities, while paper and printing have the highest elasticities within the wood products sector.[23] As would be expected, services have lower elasticities than the goods sectors, given the greater immediacy and necessary proximity in the consumption of these products.

Table 3.8: Trade Elasticities

Commodity	**Armington Aggregation**	**Regional Aggregation**	**Commodity**	**Armington Aggregation**	**Regional Aggregation**
Agriculture	1.60	4.40	Electricity / water	0.50	-
Mining	0.78	5.60	Construction	0.50	-
Food products	1.16	4.88	Trade / catering	0.50	-
Textile products	3.36	6.76	Transport / comm.	1.52	-
Wood / paper	2.89	4.01	Financial services	0.50	-
Chemicals	1.52	3.80	Other services	0.50	-
Non-metal minerals	0.57	5.60	Government services	0.50	-
Metal and machinery	0.92	5.60			
Scientific equipment	0.83	5.60			
Transport equipment	4.26	6.56			
Other manufacturing	1.32	5.60	All sectors	1.09	5.37

Source: IDC (2000) for Armington elasticity; Jomini *et al* (1991) for regional aggregation elasticity.

The substitution between imported and exported goods from the various trading regions identified in the model is governed by regional aggregation elasticities. These global estimates describe the ease at which import demand and export supply can shift between foreign markets in response to relative price changes. The table suggests that substitution possibilities between trading regions is relatively high and uniform across aggregate commodity categories.[24] However, higher regional aggregation elasticities generally coincide with higher Armington elasticities. This is expected since both elasticities reflect the ease at which consumers are willing to substitute between goods from different sources. The same regional aggregation elasticities are used in the export aggregation function, on the assumption that while the ratio of aggregate exports to domestic sales is largely determined by domestic producers, the distribution of exports across regions is largely governed by shifts in world demand. As such, it is foreign consumers who determine whether to substitute between South African exports and their own domestically produced goods, and thereby derive the South African export aggregation elasticity.[25]

[22] These estimates are taken from the Industrial Development Corporation's general equilibrium model. The estimation procedure used to arrive at these elasticities is discussed in IDC (2000).
[23] See Table C.5 in Appendix C.
[24] Regional trade elasticities are those used by the Global Trade Analysis Project (Jomini *et al*, 1991).
[25] This assumption is implicit in the global GTAP model, where the demand for and supply of South African exports defined in the CET export function is determined by the import demand of the rest of the world, as defined by their own Armington import functions. As such, regional import substitution possibilities for one country will determine regional export substitution possibilities for other countries.

Although not shown in the table, the model also requires estimates of the extent to which domestic producers are willing or able to shift between producing for the domestic and foreign markets. Since no estimates of these substitution elasticities are currently available for South Africa, the model assumes that export supply elasticities are generally higher than the Armington elasticities. This implies that, for example, following an increase in foreign prices, producers are more able to shift production towards the foreign market then consumers can shift their consumption patterns away from imported commodities. This assumption seems appropriate given that for domestic consumption there is likely to be greater heterogeneity between goods within a particular commodity category. Conversely, exports are more likely to be concentrated within a smaller number of finely disaggregated commodities. Higher heterogeneity within aggregate commodity categories will lower substitution possibilities between foreign and domestic goods. Accordingly, the model assumes an export substitution elasticity of three for all commodities.

In summary, while service sector production is larger than both the primary and secondary sectors combined, it is mining and manufacturing that is most important for South Africa in terms of its trade with the rest of the world. The importance of gold mining as a source of foreign earnings has declined substantially over the last decade, with only some of this sector's collapse being countered by an expansion of the other mining sectors. Both manufacturing and services have become more trade-intensive, with import-penetration rising faster than export-intensity. Despite some diversification, trade has remained largely concentrated within a few sectors. Finally, trade with specific countries and world regions is also concentrated, both across regions and within commodity categories. This implies that while changes in trade policy will have differing impacts on the various sectors within the economy, these differences are likely to become more pronounced when considering regional trade agreements.

3.3 Factor Markets

The model identifies four factors of production, including (i) capital; (ii) unskilled and semi-skilled labour; (iii) skilled labour; and (iv) highly skilled labour. The classification of labour categories according to 'skill' is based on a ranking of occupations according to an assumed skill-intensity. Table 3.9 provides a list of the occupations included in each skill category.

Table 3.9: Description of Labour Categories

Labour Category	Occupational Categories
Highly skilled	Professional, semi-professional, and technical occupations
	Managerial, executive, and administrative occupations
	Certain transport occupations (e.g. pilot navigator)
Skilled	Clerical occupations
	Sales occupations
	Transport, delivery, and communications occupations
	Service occupations
	Farmer, and farm manager
	Artisan, apprentice, and related occupations
	Production foreman, and production supervisor
Unskilled and semi-skilled (low skilled)	All occupations that are neither highly skilled nor skilled occupations

Since the capital and labour-intensity of each sector has already been discussed above, this section focuses on the distribution of employment and value-added across the disaggregated labour categories. The distribution of factor value-added across and within sectors is shown in Tables 3.10 and 3.11.[26]

Table 3.10: Factor Shares across Sectors (1993 and 2000)

	Capital		Labour						All Factors	
			Low Skilled		Skilled		High Skilled			
	1993	2000	1993	2000	1993	2000	1993	2000	1993	2000
Agriculture	6.6	4.3	5.4	5.5	1.4	1.2	1.0	0.9	4.3	3.2
Mining	7.6	7.0	20.5	18.9	2.8	2.4	2.2	2.0	7.4	6.4
Food products	4.0	3.5	5.5	5.1	2.5	2.0	2.2	1.9	3.5	3.1
Textile products	0.9	0.4	5.9	5.2	0.7	0.5	0.7	0.4	1.5	0.9
Wood / paper	1.8	1.6	3.0	3.7	2.2	2.2	1.8	1.9	2.0	2.0
Chemicals	4.7	4.6	4.8	6.0	2.2	2.3	3.8	4.0	4.0	4.1
Non-metal minerals	0.7	0.9	2.1	1.4	0.5	0.3	0.6	0.4	0.9	0.7
Metal and machinery	3.7	4.4	10.5	9.5	4.5	3.6	4.0	3.1	5.0	4.6
Scientific equipment	0.2	0.1	0.7	0.9	0.2	0.1	0.3	0.3	0.3	0.3
Transport equipment	1.5	1.2	3.0	3.1	1.3	1.1	1.8	1.5	1.7	1.5
Other manufacturing	2.3	0.4	2.0	1.3	0.7	0.4	0.5	0.2	1.6	0.5
Electricity / water	5.3	3.6	1.8	2.0	1.2	1.2	2.5	2.5	3.4	2.7
Construction	1.4	2.3	10.3	8.7	2.1	1.6	2.5	1.8	3.0	2.8
Trade / catering	14.0	12.8	8.5	8.7	18.7	16.5	11.1	9.5	13.6	12.4
Transport / comm.	8.6	11.3	6.0	6.5	12.6	12.0	4.9	4.5	8.3	9.6
Financial services	20.8	24.0	0.7	1.0	14.8	18.4	10.7	13.5	14.7	18.3
Other services	2.6	3.1	4.6	6.6	6.4	7.7	8.4	10.1	4.8	5.7
Government services	13.2	14.4	4.9	6.0	25.4	26.5	41.0	41.6	19.8	21.1
Manufacturing	19.8	17.2	37.4	36.2	14.7	12.5	15.8	13.7	20.6	17.8
Non-govern. services	46.0	51.2	19.8	22.8	52.4	54.6	35.0	37.6	41.5	46.0
All sectors	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: 1993 and 2000 South African SAMs

The services sector employs approximately 60 percent of the total available capital, of which the government is the single largest employer. The agricultural and mining sectors are also capital-intensive, but differ from services in that they are low-skilled labour-intensive. Mining, together

[26] The first two columns of Table 3.10 correspond to the second two columns of Table 3.3. See Tables C.6 and C.7 in Appendix C.

with metals, machinery, and construction are the largest employers of low-skilled labour. Conversely, services is the largest employer of more skilled labour, although the share of highly-skilled labour in sectoral value-added is broadly similar in aggregate to that of manufacturing. Government services is the largest employer of high-skilled labour, and it is also one of the least capital-intensive sectors in the economy.

As discussed in the previous section, there has been an increase in the overall capital-intensity of production between 1993 and 2000. However, Table 3.11 indicates that it has largely been low-skilled labour that has been displaced rather than the other labour categories. Most of this decline in low-skilled labour-usage has taken place within manufacturing. High-skilled labour has been largely unaffected by the changing structure of production over the last decade.

Table 3.11: Factor Shares within Sectors (1993 and 2000)

	Capital		**Labour**						**All Factors**	
			Low Skilled		**Skilled**		**High Skilled**			
	1993	**2000**	**1993**	**2000**	**1993**	**2000**	**1993**	**2000**	**1993**	**2000**
Agriculture	70.5	66.1	18.0	20.7	6.9	8.0	4.6	5.2	100.0	100.0
Mining	46.8	52.4	39.5	34.6	8.0	7.5	5.7	5.5	100.0	100.0
Food products	51.5	55.4	21.9	20.0	14.7	13.5	11.9	11.1	100.0	100.0
Textile products	27.3	22.1	55.2	58.8	9.2	10.1	8.3	9.0	100.0	100.0
Wood / paper	40.3	39.3	20.2	21.4	22.1	22.2	17.3	17.1	100.0	100.0
Chemicals	53.3	54.5	17.0	16.7	11.6	11.3	18.1	17.5	100.0	100.0
Non-metal minerals	38.0	60.2	34.9	22.4	12.9	8.3	14.2	9.1	100.0	100.0
Metal and machinery	34.7	47.6	30.3	24.4	19.5	15.6	15.5	12.4	100.0	100.0
Scientific equipment	36.8	27.5	33.6	38.4	12.7	14.5	17.0	19.5	100.0	100.0
Transport equipment	39.5	41.9	25.4	24.3	15.5	14.9	19.7	18.9	100.0	100.0
Other manufacturing	65.7	35.7	18.6	36.4	10.0	17.8	5.8	10.1	100.0	100.0
Electricity / water	71.6	65.5	7.2	8.7	7.3	8.8	13.9	17.0	100.0	100.0
Construction	21.4	40.1	48.2	36.8	14.8	11.3	15.5	11.8	100.0	100.0
Trade / catering	47.0	50.3	8.9	8.3	29.0	27.2	15.1	14.2	100.0	100.0
Transport / comm.	47.3	57.3	10.2	8.1	31.7	25.7	10.9	8.9	100.0	100.0
Financial services	64.6	64.7	0.6	0.6	21.2	20.9	13.5	13.8	100.0	100.0
Other services	25.4	26.2	13.8	13.5	28.4	27.5	32.5	32.7	100.0	100.0
Government services	30.7	33.7	3.5	3.4	27.2	26.1	38.5	36.9	100.0	100.0
Manufacturing	44.2	47.6	26.1	23.8	15.2	14.4	14.6	14.2	100.0	100.0
Non-govern. services	50.8	54.5	6.8	5.9	26.7	24.4	15.7	15.2	100.0	100.0
All sectors	45.9	48.9	14.2	11.9	21.2	20.6	18.7	18.6	100.0	100.0

Source: 1993 and 2000 South African SAMs

The discussion of South Africa's changing structure of production and trade identified an overall increase in trade-intensity between 1993 and 2000. Table 3.12 disaggregates import and export-intensities across factors.[27] The import-intensity of factor employment reflects the degree of import

[27] The formula for calculating the weighted import and export intensities of factors is as follows:

competition facing the output produced by each factor. For example, in 1993 13.1 percent of the demand for those commodities produced by low-skilled labour was supplied from abroad. By contrast, commodities produced by high-skilled labour had an import-intensity of only 7.3 percent. Therefore lower-skilled labour faces greater competition from imported commodities, largely due to the concentration of low-skilled employment within import-intensive manufacturing. Furthermore, between 1993 and 2000 the competition faced by low-skilled labour rose faster than it did for other factors.

The export-intensity measure shows the export share of the output produced by each factor. For example, in 1993 15 percent of the output produced by low-skilled labour was exported, which is a higher export-intensity than those of other factors. However, between 1993 and 2000, high-skilled labour's export-intensity rose more rapidly than it did for capital and lower-skilled labour.

The weighted trade-intensities suggest that import-competition has risen more rapidly for labour than for capital. Furthermore, the discussion in the previous section found that there has been a shift in production towards a greater use of capital, with low and skilled-labour employment suffering as a result. Therefore, in order to appropriately calibrate the static and dynamic specification of the model it is necessary to understand not only the static structure of employment, but also the workings of the factor markets over time. Table 3.12 presents labour market trends for the period 1988 to 1999.

Table 3.12: Trade Intensity of Employment (1993 and 2000)

	Import-Intensity		**Export-Intensity**		**Percentage Change (1993-2000)**	
	1993	**2000**	**1993**	**2000**	**Imports**	**Exports**
Capital	7.6	11.2	9.8	13.6	47.2	38.7
Labour	10.5	17.0	10.0	13.8	62.1	37.5
Low skilled	13.1	22.7	15.0	20.5	72.6	36.8
Skilled	8.5	12.8	6.3	9.2	50.6	44.5
High skilled	7.3	11.0	4.3	6.6	51.6	53.6
Total	9.8	15.2	10.0	13.7	55.5	37.6

Source: Own calculations using the 1993 and 2000 South African SAMs

$$I_f^m = \sum_a \left(\frac{FQX_{fc}}{\sum_a FQX_{fc}} \cdot I_c^m \right) \qquad I_f^e = \sum_a \left(\frac{FQQ_{fc}}{\sum_a FQQ_{fc}} \cdot I_c^e \right)$$

where I_f^m and I_f^e are the weighted import and export intensities for commodities produced by factor f; FQX_{fc} is the domestic output for commodity c attributable to factor f; FQQ_{fc} is the demand for commodity c attributable to factor f; I_c^m is the import intensity of commodity c; and I_c^e is the export-intensity of commodity c. It is assumed that trade-intensities are identical across factors (i.e. that I_a^m and I_a^e are constant across f).

During the late-1980s South Africa experienced an improvement in its economic performance after suffering a prolonged recession. Labour employment during this period grew slowly alongside GDP. The economic downturn of the early 1990s led to a decline in both economic growth and labour employment. Improvements in investor confidence and a more buoyant world economy led to a short period of high growth during the mid-1990s, with employment reaching its highest levels during these years. However, the onset of the Asian crisis towards the end of the decade led to a slowdown in the economy, and a contraction of employment from its 1996 peak.

Table 3.12: Labour Market Trends (1988 to 1999)

	1988-1990	1991-1993	1994-1996	1997-1999
Total Employment				
Employment (millions of people)	8,639	8,490	8,717	8,709
Average Annual Growth rate	0.8	-1.0	1.6	-0.7
Share of Total Employment				
Formal	91.9	89.6	88.0	85.1
Informal	8.1	10.4	12.0	14.9
Low skilled	53.2	51.6	48.9	46.1
Skilled	34.3	34.7	35.7	37.2
High skilled	12.5	13.7	15.4	16.8
Total	100.0	100.0	100.0	100.0
Broad Unemployment Rate				
Low skilled	37.7	44.7	50.0	54.0
Skilled	5.3	6.1	13.6	23.0
High skilled	0.5	0.6	0.8	0.9
All labour	25.5	30.6	35.4	39.5
Real Wage Growth				
Low skilled	2.2	4.0	3.1	4.5
Skilled	0.7	3.8	1.5	2.5
High skilled	1.0	2.4	1.0	2.1
All labour	2.5	4.4	3.0	3.8
Relative Real Wages				
Low skilled to skilled wage ratio	0.49	0.50	0.52	0.52
Low skilled to high skilled wage ratio	0.23	0.23	0.25	0.27

Source: South African Standard Industrial Database for formal employment; World Bank and Quantech for informal employment, unemployment, and remuneration.

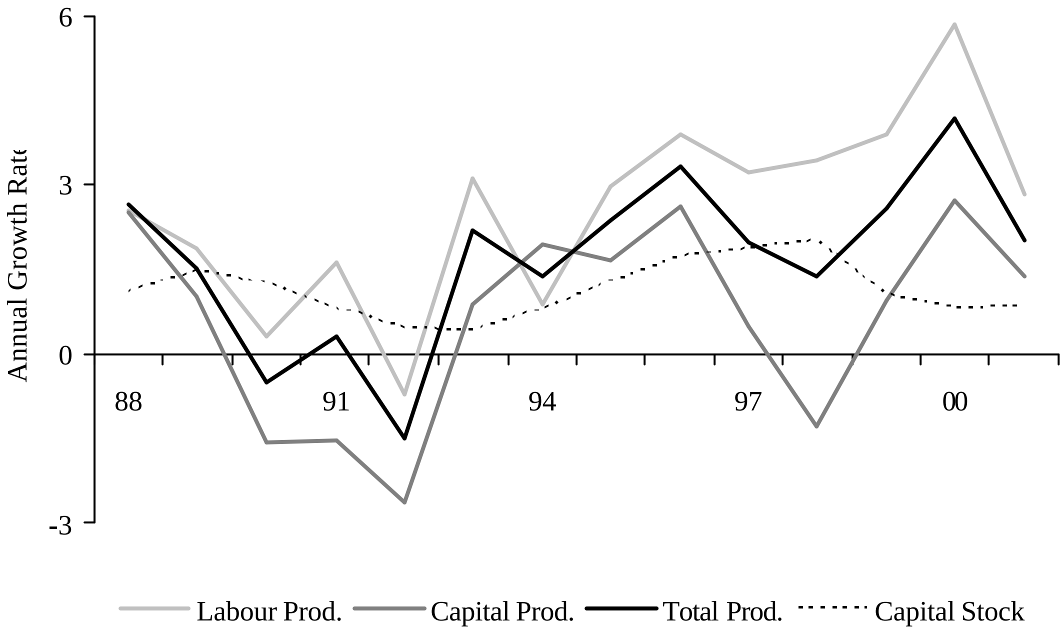
While total labour employment rose over the last decade, this growth has been both marginal and erratic. Unemployment has risen rapidly over this period as a result of both slow employment growth and increased labour force participation. Although unemployment rates increased over the decade for all of the labour categories, this increase was most pronounced for low skilled and skilled labour. Higher participation rates within these labour groups partly account some of the rising unemployment. However, there was also a shift out of the formal sector and out of low-skilled employment in particular. Low-skilled labour as a share of total employment fell from 53.2

percent to 46.1 percent over this period, while high-skilled labour's share rose rapidly. This resulted in only a small increase in unemployment amongst high skilled workers.

High and rising unemployment suggests that there is an abundance of low-skilled and skilled labour in the economy. However, low and skilled labour wages have continued to grow faster than those of high-skilled labour. This has led to a convergence of average wages.

One possible explanation for the rise in low-skilled labour wages might be an improvement in labour productivity. Figure 3.2 shows annual labour and capital productivity growth over this period.[28] Lower capital productivity growth should have led to an increase in labour employment relative to capital. However, lagged capital stock growth appears to have been more influenced by changes in capital productivity than relative factor-productivity. Furthermore, relative productivity changes have not led to substantial increases in labour employment.

Figure 3.2: Annual Factor Productivity and Capital Stock Growth (1988 to 2001)



Source: South African Standard Industrial Database.

An alternative explanation suggests that exogenous changes in production technology, which require increases in capital-intensities, might have led to a shedding of labour, with rises in labour productivity exacerbating this trend and raising real wages. Furthermore, improved technology

[28] Due to inadequate data it is not possible to disaggregate labour productivity into the three skill categories.

might have higher human capital requirements, thus explaining why skilled and high-skilled labour were affected less by the capital-intensification of production over the last decade. Finally, increased bargaining and tighter labour legislation may have contributed to the rise in low-skilled labour wages, which might in turn have prompted or supported the increase in capital-intensity.

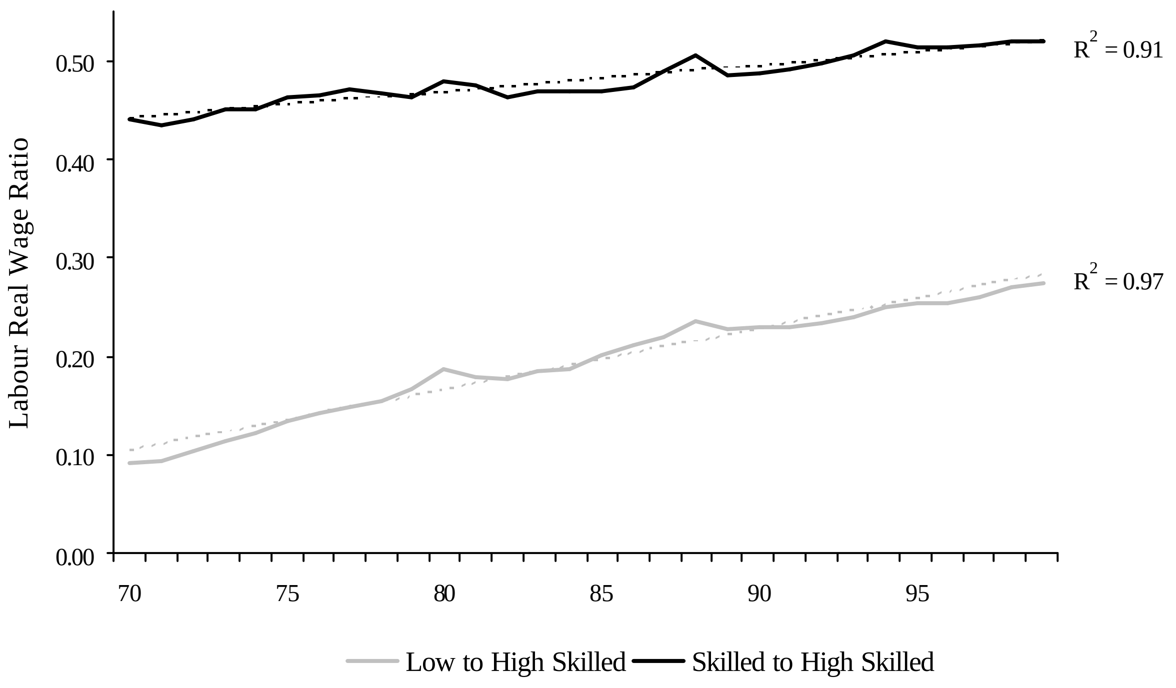
These trends and possible explanations are important in deciding which closure to adopt for each labour skill category. Low unemployment amongst highly-skilled workers suggests that this skill category faces an upwardly sloping supply curve, in which labour employment is endogenously determined by changes in the real wage. Conversely, given the high unemployment rates of both low-skilled and skilled labour, it is assumed that these skill groups have an infinitely elastic labour supply curve at a fixed real wage. However, the data indicates that the real wage has been rising rapidly over the last decade, thus necessitating the determination of the real wage outside of the model for these two labour categories.

One possibility is to exogenously specify a real wage growth rate for these labour groups. This is a very rigid specification since once the growth rate has been imposed on the model it would remain in affect regardless of any other changes that might take place in the economy. For example, since this thesis is concerned with the impact of trade liberalisation on poverty, and given that factor returns are the largest source of income for households, the exogenous fixing of wages would prevent any analysis of how trade influences poverty through changes in wages. Furthermore, fixing real wage appears to be inappropriate given that Table 3.10 showed how the real wage of lower skilled workers fluctuated over the last decade depending on the country's economic performance. Therefore what is needed is a method of exogenously determining changes in the real wage of lower skilled workers while retaining the ability of real wages to adjust endogenously to fluctuations in the economy.

The South African model attempts to overcome the problem of determining lower skilled wages by exogenously fixing *relative* real wages between the lower skilled and high-skilled labour categories. Under the current specification the real wage of high-skilled labour is free to adjust endogenously. Real wages for lower skilled workers are then exogenously adjusted between periods to maintain relative real wages. Therefore this specification allows all wage rates to adjust over time to changes taking place in the economy, with a single-period lag for lower skilled wages. Table 3.10 and Figure 3.3 also indicate that there has been a steady convergence of real wages between lower skilled and high-skilled labour over time. Therefore adjusting fixed wage ratios between periods allows for this observed wage convergence to be incorporated into the model. This specification therefore assumes that real wage changes are endogenous to the model, while wage convergence is likely to have been driven by factors outside of the model and therefore should be treated as exogenous.

While this specification of the labour market allows trade policy to influence poverty through changes in average wages, the fixing of relative wages does limit the analysis of income distribution. However, changes in income distribution are determined by changes in both relative wages and the level of employment. Since employment is free to adjust endogenously in the model, the fixing of relative wages does not imply the fixing of relative total factor incomes. Therefore the model is still able to meaningfully assess the impact of policy-changes on income inequality across the households identified in the model.

Figure 3.3: Real Wage Convergence between Labour Skill Categories (1970 to 1999)



Source: World Bank and Quantech.

3.4 Households

To allow for an analysis of the impact of policies on poverty and inequality, information is needed on both the composition and distribution of household income and spending. Although the model identifies 14 representative households according to their levels of income, this section aggregates these households into three broader categories. Low-income households contain the poorest four income deciles, middle-income households contain the next four deciles, and the high-income household category includes the richest two deciles. Furthermore, this section only describes the structure of household income and expenditure for 1993 since the underlying structure of households is very similar across those two years.[29]

Table 3.13 shows the distribution of the population across all of the household categories contained in the model, as well as the aggregate households discussed in this chapter. The table reflects differences in household sizes across the household categories. Despite containing the poorest 40 percent of households, the low-income household category comprise over half of South Africa's total population. By contrast, the high-income category contains 20 percent of households, but only 13 percent of the population. As described in Section 2, population growth is assumed to affect the level of household consumption demand, by raising the level of minimum consumption.[30]

Table 3.13: Population Distribution (1993)

Household Income Category	**Income Bracket**1	**Population (Millions of People)**2	**Share of Total Population**
Decile 1	0-10	4.9	13.0
Decile 2	10-20	5.5	14.5
Decile 3	20-30	4.7	12.5
Decile 4	30-40	4.5	12.0
Decile 5	40-50	3.8	10.0
Decile 6	50-60	3.6	9.5
Decile 7	60-70	3.2	8.5
Decile 8	70-80	2.6	7.0
Decile 9	80-90	2.6	7.0
Decile 10 (1)	90-95	1.1	3.0
Decile 10 (2)	95-96.25	0.3	0.8
Decile 10 (3)	96.25-97.5	0.3	0.8
Decile 10 (4)	97.5-98.25	0.3	0.8
Decile 10 (5)	98.25-100	0.3	0.8
Low income	0-40	19.6	52.0
Middle income	40-80	13.2	35.0
High income	80-100	4.9	13.0
Total	0-100	37.6	100.0

Source: ASSA model for total population; Liebrrant et al (2000) for population distribution.
1 Position of household within the distribution of households ranked according to income.
2 The highest income decile is disaggregated assuming equal household sizes.

The ability of the model to capture the effects of policies on poverty and inequality is dependent on the underlying data describing the different structures of households within the economy. Table 3.14 shows the composition of household income and expenditure.

[29] Similarity between years results from the same survey being used to disaggregate household income and expenditure in both of the SAMs. See Appendix B and Thurlow and van Seventer (2002) for further details.
[30] Information on the LES demand elasticities were taken from South African estimates found in Case (2002).

The most important sources of income for low-income households are the returns to low-skilled labour and transfers from the government. The latter largely refers to the government pension and child-grant schemes, and is paid almost entirely to low and middle-income households. By contrast high-income households earn a majority of their income from high-skilled labour and indirect returns to capital. The latter are paid by enterprises to households, usually in the form of corporate dividends. High-income households earn over three-quarters of indirect capital returns and high-skilled labour income. In total, high-income households earn 62.3 percent of total household income, while comprising only 13 percent of the population. Conversely, low-income households contain over half the population of South Africa, but earn less than ten percent of total income.

Over 80 percent household income is spent on consumption. This share of consumption spending is highest for low-income households, where it accounts for almost all of total disposable income. High-income households face the highest personal tax rates, and generate three-quarters of total personal tax revenue. These households also have the highest savings rates and generate over 80 percent of total household savings in the economy.

Table 3.14: Household Income and Expenditure Patterns (1993)

Income Source	**Share of Household Income**				**Share of Income Source**			
	Low	**Middle**	**High**	**Total**	**Low**	**Middle**	**High**	**Total**
Low-skilled labour	37.4	29.0	10.6	18.3	17.5	46.3	36.2	100.0
Skilled labour	21.5	32.7	24.9	26.9	6.8	35.5	57.7	100.0
Highly-skilled labour	3.0	13.9	31.3	23.8	1.1	17.0	81.9	100.0
Indirect capital	9.5	18.5	32.3	26.3	3.1	20.5	76.4	100.0
Government transfers	28.5	5.8	0.9	4.7	52.1	36.0	11.9	100.0
Foreign receipts	0.1	0.0	0.0	0.0	28.5	49.2	22.3	100.0
Total income	100.0	100.0	100.0	100.0	8.5	29.1	62.3	100.0

Expenditure Item	**Share of Household Expenditure**				**Share of Expenditure Item**			
	Low	**Middle**	**High**	**Total**	**Low**	**Middle**	**High**	**Total**
Consumption	96.8	88.2	81.2	84.6	9.8	30.4	59.8	100.0
Personal tax	2.4	9.6	14.4	12.0	1.7	23.4	74.9	100.0
Government transfers	0.3	0.1	0.1	0.1	24.2	28.2	47.5	100.0
Savings	0.6	2.1	4.3	3.3	1.5	18.1	80.4	100.0
Foreign payments	0.0	0.0	0.0	0.0	0.4	7.7	91.9	100.0
Total expenditure	100.0	100.0	100.0	100.0	8.5	29.1	62.3	100.0

Source: 1993 South African SAM.

Since consumption expenditure is a large component of both household disposable income and final demand, Table 3.15 provides further information on households' spending patterns by disaggregating private consumption demand across commodities. While food is the largest expenditure item in household consumption, it is considerably more important for low-income households. By contrast, vehicles and petroleum products are a large share of high-income household expenditure, as reflected in the shares of the transport equipment, and chemicals commodities. High-income households are also the largest consumers of services.

Table 3.15: Household Consumption Patterns (1993)

Commodity	Share of Household Consumption				Share of Commodity Consumption			
	Low	**Medium**	**High**	**Total**	**Low**	**Medium**	**High**	**Total**
Agriculture	5.7	3.8	2.0	2.9	19.1	40.1	40.8	100.0
Mining	0.1	0.0	0.0	0.0	15.9	31.9	52.2	100.0
Food products	55.8	37.7	19.6	28.6	19.0	40.0	41.0	100.0
Textile products	9.3	10.2	5.9	7.6	12.1	41.1	46.8	100.0
Wood / paper	0.3	0.9	2.0	1.5	1.9	18.7	79.5	100.0
Chemicals	4.6	6.7	10.4	8.7	5.2	23.4	71.5	100.0
Non-metal minerals	0.1	0.1	0.1	0.1	6.6	28.4	65.0	100.0
Metal and machinery	0.8	2.0	2.9	2.4	3.2	24.6	72.2	100.0
Scientific equipment	0.2	0.7	1.5	1.1	2.1	18.2	79.7	100.0
Transport equipment	0.2	1.5	6.3	4.2	0.4	10.8	88.9	100.0
Other manufacturing	1.6	3.3	2.9	2.9	5.4	34.8	59.8	100.0
Electricity / water	3.5	2.3	1.8	2.1	16.1	33.0	50.9	100.0
Trade / catering	2.7	3.6	4.5	4.1	6.5	27.0	66.5	100.0
Transport / comm.	7.2	9.9	6.4	7.6	9.3	39.9	50.8	100.0
Financial services	3.4	8.1	21.4	15.6	2.1	15.7	82.2	100.0
Other services	4.6	8.8	11.9	10.2	4.4	26.2	69.5	100.0
Government services	0.1	0.3	0.3	0.3	5.0	30.0	64.9	100.0
Manufactures	72.9	63.1	51.7	57.2	16.6	38.6	44.8	100.0
Non-govern services	17.8	30.4	44.2	37.4	6.3	29.9	63.9	100.0
All commodities	100.0	100.0	100.0	100.0	9.8	30.4	59.8	100.0

Source: 1993 South African SAM.

The larger share of manufactured goods in lower income households' consumption spending might suggest that these households will benefit more from lower import prices. However, weighted import-intensities across households reveal that high-income households are more import-intensive in their consumption patterns.[31] Of total consumption spending by these households, 10.8 percent is on imported commodities. By contrast, the import-intensities of low-income households and all households are slightly lower at nine and 10.3 percent respectively.

The disaggregation of factor income shares across both factors and households permits an assessment of the effects of policy on poverty and inequality. Furthermore, identifying the different

[31] The formula for calculating the weighted institutional import intensity of demand is as follows:

$$I_i^m = \sum_c \left(\frac{QD_{ci}}{\sum_i QD_{ci}} \cdot I_c^m \right)$$

where I_i^m is the weighted import intensity of demand produced for institution i; QD_{ci} is the demand for commodity c by institution i; and I_c^m is the import intensity of commodity c; It is assumed that trade-intensities are identical across institutions (i.e. that I_c^m is constant across i).

consumption patterns of each representative household makes it possible to determine the impact of relative price changes on household real incomes and consumption.

3.5 Government

Government policies will affect revenues, which in turn may influence either the level of government spending or borrowing. Table 3.16 shows the composition of government income and expenditure. The largest sources of revenue for the government are direct taxes on households and corporations. Sales taxes also account for around one-third of total government income. By comparison, import tariffs generate only a small share of income for the government.

Table 3.16: Government Income and Expenditure (1993 and 2000)

Income	Share of Total		Expenditure	Share of Total	
	1993	2000		1993	2000
Import tariffs	3.9	3.6	Consumption	112.6	91.4
Sales taxes	34.5	31.2	Household transfers	16.0	13.0
Producer taxes	6.0	8.8	Rest of world	2.6	3.0
Personal taxes	41.0	42.6	Borrowing	-31.2	-7.5
Corporate taxes	13.7	13.0			
Household transfers	0.3	0.4			
Enterprise transfers	0.2	0.3			
Rest of world	0.4	0.2			
Total income	100.0	100.0	Total expenditure	100.0	100.0

Source: 1993 and 2000 South African SAMs.

Unlike government income, the structure of expenditure shifted between 1993 and 2000. Despite remaining the largest component of expenditure, government consumption no longer exceeded government income. This allowed for a substantial reduction in the budget deficit for this year.

Table 3.17 disaggregates government consumption spending across commodities. Manufacturing comprises the largest component of government consumption demand, which in turn comprises mainly chemicals, machinery, and equipments. The import-intensity of government consumption is substantially higher than that of households, with 18.4 percent of government demand being supplied by foreign producers in 1993. This import-intensity rose to 27.2 percent in 2000.

Table 3.17: Government Consumption Spending across Commodities (1993 and 2000)

Commodity	Share of Total		Commodity	Share of Total	
	1993	2000		1993	2000
Agriculture	0.8	0.6	Electricity / water	2.5	2.1
Mining	0.5	0.6	Construction	7.1	3.3
Food products	3.0	1.6	Trade / catering	7.5	3.2
Textile products	1.3	1.4	Transport / comm.	4.6	10.2
Wood / paper	3.4	4.0	Financial services	16.6	17.4
Chemicals	14.8	15.1	Other services	3.1	3.3
Non-metal minerals	2.1	1.5			
Metal and machinery	9.6	8.0			
Scientific equipment	8.4	6.1	Manufactures	57.4	59.4
Transport equipment	13.7	20.5	Services	31.7	34.1
Other manufacturing	1.1	1.0	Total	100.0	100.0

Source: 1993 and 2000 South African SAMs.

3.6 Savings, Investment, and the Current Account

Table 3.18 shows the composition of the savings-investment relationship. Corporate savings is clearly the largest source of loanable funds in South Africa, and exceeded investment demand in both 1993 and 2000. However, the size of the government and current account deficit declined considerably between 1993 and 2000, thereby relieving some of the pressure placed on corporate savings to finance investment.

Table 3.16: Government Income and Expenditure (1993 and 2000)

Savings	Share of Total		Investment	Share of Total	
	1993	2000		1993	2000
Corporate	138.6	108.0	Final demand	105.16	93.78
Household	17.6	1.6	Inventory changes	-5.16	6.22
Government	-48.0	-12.2			
Rest of world	-8.2	2.6			
Total savings	100.0	100.0	Total investment	100.00	100.00

Source: 1993 and 2000 South African SAMs.

Table 3.1 showed how investment demand generates 14.7 percent of GDP. The composition of this demand is described in Table 3.17, which disaggregates investment spending across commodities. Investment expenditure is highly concentrated, with machinery and metals, transport equipment, and construction comprising over 80 percent of total investment. Investment is also the most import-intensive component of final demand. In 1993 22.2 percent of investment demand was supplied by imports. However by 2000 this share had risen to 33.2 percent, due to a general increase in import-intensity throughout the economy and increased investment demand for communication equipment.

Table 3.17: Investment Demand (1993 and 2000)

	Share of Total Investment	
	1993	2000
Wood / paper	0.1	0.1
Chemicals	0.0	0.1
Non-metal minerals	2.5	1.8
Metal and machinery	32.3	27.4
Scientific equipment	6.0	10.8
Transport equipment	16.0	13.5
Other manufacturing	1.2	1.0
Construction	38.2	41.7
Business services	3.6	3.8
Manufacturing	58.2	54.6
Services	3.6	3.8
All commodities	100.0	100.0

Source: 1993 and 2000 South African SAMs.

Finally, South Africa's interactions with the rest of the world are summarised in Table 3.18. In both 1993 and 2000 South Africa ran a trade surplus, which was undermined by a net outflow of domestic profits. There was a reversal of the current account balance as a result of exports growing slower than imports over the last decade.

Table 3.18: Current Account (1993 and 2000)

Receipts	Share of Total		Payments	Share of Total	
	1993	2000		1993	2000
Exports	102.6	92.5	Imports	84.0	83.4
Factors remittances	2.7	5.8	Factor remittances	13.0	13.9
Households	0.1	0.1	Enterprises	0.1	0.0
Deficit	-5.8	1.4	Government	2.4	2.4
Total payments	100.0	100.0	Total receipts	100.0	100.0

Source: 1993 and 2000 South African SAMs.

Given that there are a number of avenues through which policies can impact on the economy, it seems appropriate to use an economy-wide approach that attempts to simultaneously account for all of these effects. Together sections 2 and 3 have described a dynamic CGE model for South Africa that can be used to assess the impact of both recent and future policy changes on the South African economy.

4. Applications of the Model and Areas for Further Research

This section concludes this paper by first discussing existing and potential applications of the South African model. In each case the core model is extended to allow for the appropriate treatment of the issue being analysed. However, beyond adjusting the model to address specific policy questions, it is also necessary for the model's specification be strengthened through continued research on its various components. Some of the supporting research that would improve the model's representation of the structure of the South African economy are discussed last.

Past and Potential Applications of the South African Model

A number of studies using the South African model have already been undertaken. These cover a wide range of issues, including health and health policy; social security and public finance; and labour market and trade policies. For example, Ramprasad and Thurlow (2003) use the model to consider the impact of HIV-AIDS and the provision of anti-retroviral treatment on the South African economy. As an extension of the work presented in Thurlow (2002), the author uses the dynamic model to assess the macroeconomic impact of implementing and financing a basic income grant. Davies (2002) considers the effects of alternative labour market policies on future levels of employment. Finally, Thurlow (2003a and 2003b) assesses the impact of trade liberalisation, reform, and the adoption of regional trading agreements on the South African economy.

Examples of other issues to which the model could be applied include: (i) the economic and welfare implications of investment and other developments within industrial sectors; (ii) the impact of broad and specific government fiscal policy on both economic performance and poverty; (iii) the economic and welfare implications of alternative government taxation schemes; and (iv) the influence of production and policy on the environment. Although the list of possible applications is far from exhaustive, it does indicate the broad scope of economy-wide modelling.

Areas for Further Supporting Research

A number of areas of the model require further research and development. Currently the model is run as a series of solutions, each one representing a single year. A better framework would allow the model to run simulations in a single solution. However, beyond the extension of the model to a single-solution framework, which is currently underway, the identification of the role of expectations in the real economy requires some attention before the model can be specified using inter-temporal optimisation dynamics. For example, more information is needed on the extent to which the investment allocation decision in South Africa is governed by forward-looking expectations rather than adaptive behaviour.

Currently the model employs a CES neoclassical production structure with constant returns to scale. More sectoral-level research that validates either the current specification or a more appropriate production structure would greatly improve the model's representation of the specific workings of the South African economy. For example, the model assumes that low-skilled and high-skilled labour is equally substitutable for capital. This is clearly an abstraction for the real workings of the factor markets. Beyond extending the model to include a more appropriate and flexible factor substitution function, which is currently underway, research is needed that estimates the parameters that would calibrate this new specification. The estimation of sectoral production functions would also cast light on the importance of scale economies within each sector, and the importance of excess capacity in production and labour demand. Information is also needed on the degree of factor mobility between sectors, and on the wage elasticity of labour supply.

Finally, the disaggregation of the public sector into the various functions of government would greatly improve the analysis of government policies. Similarly, the gradual inclusion of financial markets into the model would broaden the range of policy questions that could be addressed.

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Appendix A: Model Specification

The South African model is an extension of the standard static model used by the International Food Policy Research Institute (IFPRI) (Lofgren *et al*, 2002). A number of equations have been added to the IFPRI model that allows (i) the regional disaggregation of international trade; (ii) an upward-sloping factor supply curve; and (iii) factor-specific productivity adjustments. The addition of these features requires that some of the existing equations in the IFPRI model be adjusted and new equations added. These changes to the static model are described in the first section of this appendix. In extending the static model to a recursive dynamic model a number of equations and updating procedures are included in the South African model. These are described in the second section. The appendix ends with a complete listing of the model's variables, parameters and equations.

A.1 Additions to the Static Model

Regional Disaggregation of International Trade

Although it is not necessary to include regionally specific trade data in the South African model, the model's specification does allow for this additional information to be included during the calibration process. In the IFPRI model, imported and exported commodities were assigned to the sets *CM* and *CE* respectively. This assignment is retained in the South African model only for those commodities that are imported or exported but whose trade is *not* regional disaggregated. Imported and exported commodities that are regionally disaggregated are now assigned to the sets *CMR* and *CER*. These sets are two dimensional across commodities *and* regions, where the new set *R* contains a list of the trading regions included in the model. Although the set *R* contains regions for both imports and exports, it is not necessary for imports and exports to be disaggregated across the same regions. However, it is important that the trading regions identified for *either* imports or exports are mutually exclusive. For example, it is not permissible to regionally disaggregate imports across both the Southern African Development Community (SADC) and the Common Market for Eastern and Southern Africa (COMESA), since there are countries that are members of both trading regions. However, it is possible for example to include SADC as an export region and COMESA as an import region.

In describing the adjustments to the IFPRI model, the equation numbers refer to those found in Lofgren *et al* (2002) and equation letters refer to those found in the South African model. Equations

1 and 2 in the IFPRI model are now replaced with Equations A and B respectively. The difference between the two models is that these equations now refer to only those traded commodities that do not have regionally disaggregated trade data (i.e. *CMNR* and *CENR*).

$$PM_c = pwm_c \cdot (1+tm_c) \cdot EXR + \sum_{c' \in CT} PQ_{c'} \cdot icm_{c'c} \qquad c \in CMNR \qquad \text{A}$$

$$\begin{bmatrix} import \\ price \\ (LCU) \end{bmatrix} = \begin{bmatrix} import \\ price \\ (FCU) \end{bmatrix} \cdot \begin{bmatrix} tariff \\ adjust- \\ ment \end{bmatrix} \cdot \begin{bmatrix} exchange\ rate \\ (LCU per \\ FCU) \end{bmatrix} + \begin{bmatrix} cost\ of\ trade \\ inputs\ per \\ import\ unit \end{bmatrix}$$

$$PE_c = pwe_c \cdot EXR - \sum_{c' \in CT} PQ_c \cdot ice_{c'c} \qquad c \in CENR \qquad \text{C}$$

$$\begin{bmatrix} aggregate \\ export\ price \\ (LCU) \end{bmatrix} = \begin{bmatrix} world\ export \\ price \\ (FCU) \end{bmatrix} \cdot \begin{bmatrix} exchange rate \\ (LCU\ per \\ FCU) \end{bmatrix} - \begin{bmatrix} cost\ of\ trade \\ inputs\ per \\ export\ unit \end{bmatrix}$$

Three new equations are added to the model to allow for the regional disaggregation of exports. For those exported commodities that are regionally disaggregated the equation for the regional export price ($PER_{c\,r}$) is given in Equation D. Note that $PER_{c\,r}$ is analogous to PE_c except in its inclusion of a regional subscript. Under the small-country assumption, the regional price of an exported commodity is equal to that commodity's world export price ($pwer_{c\,r}$) times the exchange rate (EXR). Furthermore, since the export price represents the amount received by producers per unit sold abroad, the transaction costs per unit of output are removed from this price. This is equal to the share of transaction costs per commodity unit ($icer_{c'c\,r}$) multiplied by the market price at which these transaction commodities are sold (PQ_c).

Regional export prices and quantities ($QER_{c\,r}$) are combined under a CES function to arrive at an aggregate export price (PE_c) and quantity (QE_c). This aggregation is shown in Equations E and F. The ease at which exports can shift between regions is governed by the elasticity of substitution, which is a transformation of r_c^e.

$$PER_{c\,r} = pwer_{c\,r} \cdot EXR - \sum_{c' \in CT} PQ_c \cdot icer_{c'c\,r} \qquad \begin{matrix} c \in CER \\ r \in R \end{matrix} \qquad \text{D}$$

$$\begin{bmatrix} regional\ export \\ price \\ (LCU) \end{bmatrix} = \begin{bmatrix} regional\ export \\ price \\ (FCU) \end{bmatrix} \cdot \begin{bmatrix} exchange\ rate \\ (LCU\ per \\ FCU) \end{bmatrix} - \begin{bmatrix} regional\ cost\ of \\ trade\ inputs\ per \\ export\ unit \end{bmatrix}$$

$$QE_c = a_c^e \cdot \left(\sum_{r \in R} d_{cr}^e \cdot \left(QER_{cr} \right)^{-r_c^e} \right)^{-\frac{1}{r_c^e}} \qquad c \in CER,\ r \in R \qquad \text{E}$$

$$\begin{bmatrix} aggregate \\ export \\ quantity \end{bmatrix} = CES \begin{bmatrix} regional \\ export \\ quantity \end{bmatrix}$$

$$\frac{PER_{cr}}{PE_c} = QER_{cr} \cdot \left(\sum_{r' \in R} d_{cr'}^e \cdot \left(QER_{cr'} \right)^{-r_c^e} \right)^{-1} \cdot d_{cr}^e \cdot \left(QER_{cr} \right)^{-r_c^e - 1} \qquad c \in CER,\ r \in R,\ r' \in R \qquad \text{F}$$

$$\begin{bmatrix} regional\ to \\ aggregate\ export \\ price\ ratio \end{bmatrix} = f \begin{bmatrix} regional\ to \\ aggregate\ export \\ supply\ ratio \end{bmatrix}$$

Three new equations are also added to the model to allow for the regional disaggregation of imports. In Equation G, the price of a regionally imported commodity (PMR_{cr}) is equal to the commodity's world import price ($pwmr_{cr}$) multiplied by the exchange rate (EXR) and any region-specific import tariffs (tmr_{cr}). Any additional transactions costs are added, and are equal to the share of these costs per commodity unit ($icmr_{c'cr}$) multiplied by the market price at which these transaction commodities are sold (PQ_c).

Regional import prices and quantities (QMR_{cr}) are combined under a CES function to arrive at an aggregate import price (PM_c) and quantity (QM_c). This aggregation is shown in Equations H and I. The ease at which exports can shift between regions is governed by the elasticity of substitution, which is a transformation of r_c^m.

$$PMR_{cr} = pwmr_{cr} \cdot \left(1 + tmr_{cr} \right) \cdot EXR - \sum_{c' \in CT} PQ_c \cdot icmr_{c'cr} \qquad c \in CMR,\ r \in R \qquad \text{G}$$

$$\begin{bmatrix} regional\ import \\ price \\ (LCU) \end{bmatrix} = \begin{bmatrix} regional\ import \\ price \\ (FCU) \end{bmatrix} \cdot \begin{bmatrix} exchange\ rate \\ (LCU\ per \\ FCU) \end{bmatrix} - \begin{bmatrix} regional\ cost\ of \\ trade\ inputs\ per \\ import\ unit \end{bmatrix}$$

$$QM_c = a_c^m \cdot \left(\sum_{r \in R} d_{cr}^m \cdot \left(QMR_{cr} \right)^{-r_c^m} \right)^{-\frac{1}{r_c^m}} \qquad c \in CMR,\ r \in R \qquad \text{H}$$

$$\begin{bmatrix} aggregate \\ import \\ quantity \end{bmatrix} = CES \begin{bmatrix} regional \\ import \\ quantity \end{bmatrix}$$

$$\frac{PMR_{cr}}{PM_c} = QMR_{cr} \cdot \left(\sum_{r' \in R'} d_{cr'}^m \cdot \left(QMR_{cr'} \right)^{-r_c^m} \right)^{-1} \cdot d_{cr}^m \cdot \left(QMR_{cr} \right)^{-r_c^m - 1} \qquad c \in CMR,\ r \in R,\ r' \in R \qquad \text{I}$$

$$\begin{bmatrix} regional\ to \\ aggregate\ import \\ price\ ratio \end{bmatrix} = f \begin{bmatrix} regional\ to \\ aggregate\ import \\ supply\ ratio \end{bmatrix}$$

Since tariff revenue and import earnings are now disaggregated across regions for some commodities, it is also necessary to adjust the government income and current account equations in the IFPRI model. Equations 37 and 41 in the IFPRI model are replaced with Equations J and K below.

$$YG = \sum_{i \in INSDNG} tins_i \cdot YI_i + \sum_{a \in A} ta_a \cdot PA_a \cdot QA_a + \sum_{c \in CMNR} tm_c \cdot pwm_c \cdot QM_c \cdot EXR + \sum_{r \in R} \sum_{c \in CMR} tmr_{cr} \cdot pwmr_{cr} \cdot QMR_{cr} \cdot EXR + \sum_{c \in C} tq_c \cdot PQ_c \cdot QQ_c + \sum_{f \in F} YF_{gov\,f} + trnsfr_{govrow} \cdot EXR \qquad \text{J}$$

$$\begin{bmatrix} government \\ revenue \end{bmatrix} = \begin{bmatrix} direct\ taxes \\ from \\ institutions \end{bmatrix} + \begin{bmatrix} activity \\ tax \end{bmatrix} + \begin{bmatrix} import \\ tariffs \end{bmatrix} + \begin{bmatrix} sales \\ tax \end{bmatrix} + \begin{bmatrix} factor \\ income \end{bmatrix} + \begin{bmatrix} transfers \\ from \\ RoW \end{bmatrix}$$

$$\sum_{c \in CMNR} pwm_c \cdot QM_c + \sum_{r \in R} \sum_{c \in CMR} pwmr_{cr} \cdot QMR_{cr} \cdot \sum_{f \in F} trnsfr_{row\,f} = \sum_{c \in CENR} pwe_c \cdot QE_c + \sum_{r \in R} \sum_{c \in CER} pwer_{cr} \cdot QER_{cr} + \sum_{i \in INSD} trnsfr_{irow} + FSAV \qquad \text{K}$$

$$\begin{bmatrix} import \\ spending \end{bmatrix} + \begin{bmatrix} factor \\ transfers \\ to\ RoW \end{bmatrix} = \begin{bmatrix} export \\ revenue \end{bmatrix} + \begin{bmatrix} institutional \\ transfers \\ from\ RoW \end{bmatrix} + \begin{bmatrix} foreign \\ savings \end{bmatrix}$$

Upward-Sloping Factor Supply Curve

Two new equations are included in the model to allow for a factor closure in which both supply and real wages are endogenously determined. Equation L allows factor supply to adjust from its original level (QFS_f^0) according to changes in the real average wage (RWF_f), with its responsiveness being governed by the wage elasticity of factor supply ($etals_f$). The real average wage is defined in Equation M.

$$QFS_f \Big/ QFS_f^0 = \left(RWF_f \Big/ RWF_f^0 \right)^{etals_f} \qquad f \in F \qquad \text{L}$$

$$\begin{bmatrix} factor\ f \\ supply\ ratio \end{bmatrix} = f \begin{bmatrix} real\ wage \\ ratio \end{bmatrix}$$

$$RWF_f = \left(\frac{YF_f}{QFS_f} \right) \Big/ \left(\frac{CPI}{CPI^0} \right) \qquad f \in F \qquad \text{M}$$

$$\begin{bmatrix} average\ real\ wage \\ per\ factor\ unit \end{bmatrix} = \begin{bmatrix} average\ wage \\ per\ factor\ unit \end{bmatrix} / \begin{bmatrix} consumer\ price \\ index\ ratio \end{bmatrix}$$

Factor-Specific Productivity

Equations 15 and 16 in the IFPRI model are replaced by Equations N and O below. The only difference between the equations is the inclusion below of a factor-specific productivity adjustment term ($a_{f\,a}^{vaf}$). In the initial equilibrium or base year the value of this term is set one.

$$QVA_a = a_a^{va} \cdot \left(\sum_{f \in F} d_{f\,a}^{va} \cdot \left(a_{f\,a}^{vaf} \cdot QF_{f\,a} \right)^{-r_a^{va}} \right)^{-\frac{1}{r_a^{va}}} \qquad a \in A \qquad \text{N}$$

$$\begin{bmatrix} quantity\, of\;\; aggregate \\ value\text{-}added \end{bmatrix} = CES \begin{bmatrix} factor \\ inputs \end{bmatrix}$$

$$W_f \cdot WFDIST_{fa} = PVA_a \cdot (1 - tva_a) \cdot QVA_a \cdot \left(\sum_{f \in F'} d_{f\,a}^{va} \cdot \left(a_{f\,a}^{vaf} \cdot QF_{f\,a} \right)^{-r_a^{va}} \right)^{-1} \cdot$$

$$d_{f\,a}^{va} \cdot \left(a_{f\,a}^{vaf} \cdot QF_{f\,a} \right)^{-r_a^{va} - 1} \qquad \begin{matrix} a \in A \\ f \in F \end{matrix} \qquad \text{O}$$

$$\begin{bmatrix} marginal\;\; cost\, of \\ factor\, f\, in\;\; activity\;\; a \end{bmatrix} = \begin{bmatrix} marginal\;\; revenue\, product \\ of\, factor\, f\;\; in\, activity\;\; a \end{bmatrix}$$

A.2 Dynamic Model Specification

Section 2.1 described the within-period or static component of the South African CGE model. However, the impact of policy-changes includes dynamic aspects, such as the inter-temporal effects of changes in investment and the rate of capital accumulation. In order to investigate in more detail the relationship between policy-changes, factor accumulation, and productivity changes, the static model is extended to a dynamic recursive model. The static model is solved as a series of equilibriums, each one representing a distinct period, typically a single year.

Over the time period being analysed a number of policy-independent changes are assumed to take place. Together these effects form a projected or counterfactual growth path for the economy. These inter-period adjustments include population and labour force growth, capital accumulation, factor productivity changes, and changes in government expenditure. This section describes the dynamic extensions of the static model with reference to the mathematical equations presented in the previous section and Lofgren *et al* (2002). This is done for each of the inter-period adjustments.

Population Growth

As described Section 2.1, each representative household consumes commodities under a Linear Expenditure System (LES) of demand. Equation 33 from the IFPRI model is shown below. This system allows for an income-independent level of consumption ($PQ_c \cdot g^m_{ch}$) measured as the market value of each household's consumption of each commodity that is unaffected by changes in disposable income. The remaining terms in Equation 33 determine the level of additional consumption demand that adjusts with changes in income.

$$PQ_c \cdot QH_{ch} = PQ_c \cdot g^m_{ch} + b^m_{ch} \cdot \left(EH_h - \sum_{c' \in C} PQ_{c'} \cdot g^m_{c'h} \right) \qquad c \in C,\ h \in H \qquad 33$$

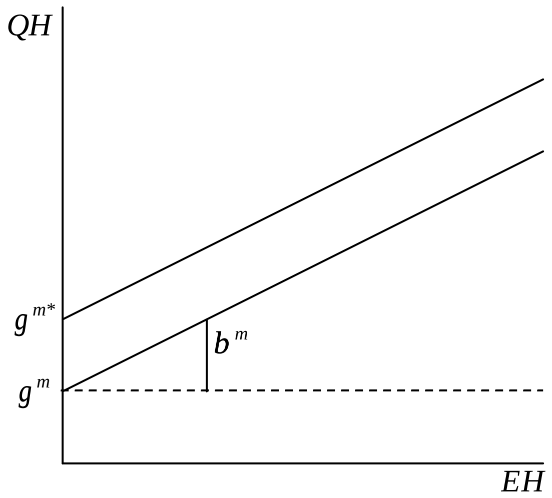
$$\begin{bmatrix} \textit{household consumption} \\ \textit{spending on market} \\ \textit{commodity c} \end{bmatrix} = f \begin{bmatrix} \textit{total household consumption} \\ \textit{spending, market price of c, other} \\ \textit{commodity prices (market and home)} \end{bmatrix}$$

Population growth is assumed to enter the model through its direct and positive affect on the level of private consumption spending. During the dynamic updating process and as the population grows, the level of each household's consumption of a particular commodity is adjusted upwards to account for greater consumption demand. This is achieved by increasing the quantity of income-independent demand (g^m_{ch}) at the same rate as population growth.

Equation 33 is represented graphically in Figure A.1 for a single representative household's consumption of a particular commodity (QH_{ch}). This is then related to the household's level of total consumption spending (EH_h). The upward-sloping consumption demand curve reflects the positive relationship between the household's disposable income and the level of consumption. Initially the level of income-independent consumption is given by g^m. Under the LES specification there is a linear relationship between income and consumption, and this is reflected in the constant slope (b^m) of the consumption curve.

In the dynamic model, population growth increases the value of g^m proportionately and causes the consumption curve to shift upwards to reflect the higher level of minimum consumption (g^{m*}). As seen in the figure, it is assumed that the slope of the consumption curve (b^m) remains unchanged. Therefore population growth is assumed to affect only average, and not marginal, consumption demand. Accordingly, new consumers are assumed to share the same consumption preferences as existing consumers.

Figure A.1: Household Consumption Demand and Population Growth



Labour Force Growth

The method of updating the relevant parameters to reflect changes in labour supply in the current model depends on the labour market closure adopted for each labour category. Four alternative closure options are possible for each factor market. In the first case, labour supply is flexible but constrained in its ability to adjust by the real wage elasticity of labour supply. No exogenous updating of labour supply (QFS_f) is necessary, since labour supply adjusts endogenously to determine final employment and wages.[32] However, if labour supply for this factor is growing exogenously then QFS_f^0 in Equation L is adjusted accordingly. In the second closure option, sectoral demand for a labour category is held fixed, and any adjustments in demand following changes in labour supply are exogenous. In this case it is assumed that growth in supply is the same across all sectors. In the third closure option, labour is assumed to be unemployed at a fixed real wage. This represents a special case of the first closure option when the wage elasticity of labour supply ($etals_f$) is infinity. Therefore the exogenous adjustment of labour supply (QFS_f) is unnecessary since there are no constraints on factor supply. Rather it is necessary to exogenously adjust real wages. The fourth closure option assumes that factor supply is fixed and the real wage adjusts to equate demand and supply. This final closure implies full employment. Between-periods

[32] As seen in Equations L and M, changes in labour supply and real wages are dependent on these variables' previous-period values. As such these values are updated between periods.

the fixed level of labour supply is adjusted exogenously. This also represents a special case of the first closure where the wage elasticity of labour supply ($etals_f$) is zero.

Capital Accumulation

Unlike labour supply, which is either determined exogenously or by market closure, all changes in total capital supply are endogenous in the dynamic model. In a given time period the total available capital is determined by the previous period's capital stock and investment spending. However, what remains to be decided is how the new capital stock resulting from previous investment is to be allocated across sectors.

An extreme specification of the model would allocate investment in proportion to each sector's share in aggregate capital income or profits. However, in the current dynamic model, these proportions are adjusted by the ratio of each sector's profit rate to the average profit rate for the economy as a whole. Sectors with a higher-than-average profit rate receive a larger share of investment than their share in aggregate profits. This updating process involves four steps.

Equation N describes the first step at which the average economy-wide rental rate of capital ($AWF^a_{f\,t}$) is calculated for time period t. This is equal to the sum of the rental rates of each sector weighted by the sector's share of total capital factor demand.[33]

$$AWF^a_{f\,t} = \sum_a \left[\left(\frac{QF_{f\,a\,t}}{\sum_{a'} QF_{f\,a'\,t}} \right) \cdot WF_{f\,t} \cdot WFDIST_{f\,a\,t} \right] \qquad \begin{matrix} f \ is capital \\ a \in A \\ a' \in A \\ t \in T \end{matrix} \qquad \text{P}$$

$$\begin{bmatrix} average capital \\ rental\ rate \end{bmatrix} = \begin{bmatrix} weighted\ sum\ of\ sectors' \\ capital\ rental\ rates \end{bmatrix}$$

In the second step each sector's share of the new capital investment ($h^a_{f\,a\,t}$) is calculated by comparing its rental rate to the economy-wide average. For those sectors with above average rental rates, the second term on the right-hand side of Equation O will be greater than one. The converse would be true for sectors with rental rates that are below average. This term is then multiplied by the existing share of capital stock to arrive at a sectoral distribution for new capital. The inter-sectoral mobility of investment is indicated by b^a. In the extreme case where b^a is zero there is no

[33] Although there is only a single capital factor in the South African model, the subscript *f* is maintained in order to remain consistent with the notation of the static model described in Lofgren *et al* (2002).

inter-sectoral mobility of investment funds, and all investment can be thought of as being funded by retained profits.

$$h^{a}_{f\,a\,t} = \left(\frac{QF_{f\,a\,t}}{\sum_{a'} QF_{f\,a'\,t}} \right) \cdot \left(b^{a} \cdot \left(\frac{WF_{f,t} \cdot WFDIST_{f\,a\,t}}{AWF^{a}_{f\,t}} - 1 \right) + 1 \right) \qquad \begin{array}{c} f \ iscapital \\ a \in A \\ a' \in A \\ t \in T \end{array} \qquad \text{Q}$$

$$\begin{bmatrix} \textit{share of} \\ \textit{new capital} \end{bmatrix} = \begin{bmatrix} \textit{share of} \\ \textit{existing capital} \end{bmatrix} \cdot \begin{bmatrix} \textit{capital rental} \\ \textit{rate ratio} \end{bmatrix}$$

Equation P shows the third step of the updating procedure in which the quantity of new capital is calculated as the value of gross fixed capital formation divided by the price of capital ($PK_{f\,t}$). This is then multiplied by each sector's share of new capital ($h^{a}_{f\,a\,t}$) to arrive at a final quantity allocated to each sector ($\Delta K^{a}_{f\,a\,t}$). The determination of the unit capital price is shown in Equation Q.

$$\Delta K^{a}_{f\,a\,t} = h^{a}_{f\,a\,t} \cdot \left(\frac{\sum_{c} PQ_{c\,t} \cdot QINV_{c\,t}}{PK_{f\,t}} \right) \qquad \begin{array}{c} f \ iscapital \\ a \in A \\ c \in C \\ t \in T \end{array} \qquad \text{R}$$

$$\begin{bmatrix} \textit{quantity of new} \\ \textit{capital by sector} \end{bmatrix} = \begin{bmatrix} \textit{share of} \\ \textit{new capital} \end{bmatrix} \cdot \begin{bmatrix} \textit{total quantity of} \\ \textit{new capital} \end{bmatrix}$$

$$PK_{f\,t} = \sum_{c} PQ_{c\,t} \cdot \frac{QINV_{c\,t}}{\sum_{c'} QINV_{c'\,t}} \qquad \begin{array}{c} f \ iscapital \\ a \in A \\ c \in C \\ c' \in C \\ t \in T \end{array} \qquad \text{S}$$

$$\begin{bmatrix} \textit{unit price} \\ \textit{of capital} \end{bmatrix} = \begin{bmatrix} \textit{weighted market price} \\ \textit{of investment commodities} \end{bmatrix}$$

In the final step the new aggregate quantity of capital ($QFS_{f\,t+1}$) and the sectoral quantities of capital ($QF_{f\,a\,t+1}$) are adjusted from their previous levels to include new additions to the capital stock. Over and above these changes there is also a loss of capital to account for depreciation (u_f).

$$QF_{f\,a\,t+1} = QF_{f\,a\,t} \cdot \left(1 + \frac{\Delta K^{a}_{f\,a\,t}}{QF_{f\,a\,t}} - u_f \right) \qquad \begin{array}{c} f \ iscapital \\ a \in A \\ t \in T \end{array} \qquad \text{T}$$

$$\begin{bmatrix} \textit{averagecapital} \\ \textit{rentalrate} \end{bmatrix} = \begin{bmatrix} \textit{weighted sum of sectors'} \\ \textit{capital rental rates} \end{bmatrix}$$

$$QFS_{f\,t+1} = QFS_{f\,t} \cdot \left(1 + \frac{\sum_{a} \Delta K_{f\,a\,t}}{QFS_{f\,t}} - u_f \right) \qquad \begin{array}{c} f \ iscapital \\ a \in A \\ t \in T \end{array} \qquad \text{U}$$

$$\begin{bmatrix} \textit{averagecapital} \\ \textit{rental rate} \end{bmatrix} = \begin{bmatrix} \textit{weighted sum of sectors'} \\ \textit{capital rental rates} \end{bmatrix}$$

The above specification of capital accumulation and allocation is not fully inter-temporal. It is assumed that any expectations that influence the level and distribution of investment are based on past experience. While this is an assumption, it does greatly simplify the dynamics of the model and avoids the specification of inter-temporal optimisation.

Total and Factor-Specific Productivity Growth

Along with changes in factor supply, the dynamic model also takes into consideration changes in factor productivity. This is done by multiplying either the a_a^{va} parameter in Equation N by the percentage change in total factor productivity (TFP), or d_{fa}^{va} in the case of factor-specific productivity.

Government Consumption and Transfer Spending

Since government consumption spending and transfers to households are fixed in real terms within a particular period it is necessary to exogenously increase these payments between periods. This done by increasing the value of qg_c in Equation 36 in the IFPRI model in the case of government consumption spending, and $trnsfr_{igov}$ in Equation 38 in the case of government transfers to households.

A.3 Complete Model Listing

The following tables provide a complete listing of the model's variables, parameters and equations. Although these tables describe the South African model, it is largely based on the equation listing found in Lofgren *et al* (2002). However, the equation numbers do not correspond to those found in Lofgren *et al* (2002). Rather the ordering of equations follows the description of the model found in Section 2 of this paper.

Table A1: Model Sets, Parameters, and Variables

Symbol	Explanation	Symbol	Explanation
Sets			
$a \in A$	Activities	$c \in CMR(\subset C)$	Regionally imported commodities
$a \in ALEO(\subset A)$	Activities with a Leontief function at the top of the technology nest	$c \in CMNR(\subset C)$	Non-regionally imported commodities
$c \in C$	Commodities	$c \in CT(\subset C)$	Transaction service commodities
$c \in CD(\subset C)$	Commodities with domestic sales of domestic output	$c \in CX(\subset C)$	Commodities with domestic production
$c \in CDN(\subset C)$	Commodities not in *CD*	$f \in F$	Factors
$c \in CE(\subset C)$	Exported commodities	$i \in INS$	Institutions (domestic and rest of world)
$c \in CEN(\subset C)$	Commodities not in *CE*	$i \in INSD(\subset INS)$	Domestic institutions
$c \in CM(\subset C)$	Aggregate imported commodities	$i \in INSDNG(\subset INSD)$	Domestic non-government institutions
$c \in CMN(\subset C)$	Commodities not in *CM*	$h \in H(\subset INSDNG)$	Households
Parameters			
$cwts_c$	Weight of commodity c in the CPI	pwm_c	Import price (foreign currency)
$dwts_c$	Weight of commodity c in the producer price index	$pwmr_{cr}$	Import price by region (foreign currency)
ica_{ca}	Quantity of c as intermediate input per unit of activity a	$qdst_c$	Quantity of stock change
$icd_{cc'}$	Quantity of commodity c as trade input per unit of c' produced and sold domestically	$\overline{qg}_c$	Base-year quantity of government demand
$ice_{cc'}$	Quantity of commodity c as trade input per exported unit of c'	$\overline{qinv}_c$	Base-year quantity of private investment demand
$icer_{cc'r}$	Quantity of commodity c as trade input per exported unit of c' from region r	$shif_{if}$	Share for domestic institution i in income of factor f
$icm_{cc'}$	Quantity of commodity c as trade input per imported unit of c'	$shii_{ii'}$	Share of net income of i' to i (i' ∈ INSDNG'; i ∈ INSDNG)
$icmr_{cc'r}$	Quantity of commodity c as trade input per imported unit of c' from region r	ta_a	Tax rate for activity a
$inta_a$	Quantity of aggregate intermediate input per activity unit	$\overline{tins}_i$	Exogenous direct tax rate for domestic institution i
iva_a	Quantity of aggregate intermediate input per activity unit	$tins01_i$	0-1 parameter with 1 for institutions with potentially flexed direct tax rates
$\overline{mps}_i$	Base savings rate for domestic institution i	tm_c	Import tariff rate
$mps01_i$	0-1 parameter with 1 for institutions with potentially flexed direct tax rates	tmr_{cr}	Regional import tariff
pwe_c	Export price (foreign currency)	tq_c	Rate of sales tax
$pwer_{cr}$	Export price by region (foreign currency)	$trnsfr_{if}$	Transfer from factor f to institution i

Source: South African Model and Lofgren *et al* (2002).

Table A1 continued: Model Sets, Parameters, and Variables

Symbol	Explanation	Symbol	Explanation
Greek Symbols			
a_a^a	Efficiency parameter in the CES activity function	d_c^t	CET function share parameter
a_a^{va}	Efficiency parameter in the CES value-added function	d_{fa}^{va}	CES value-added function share parameter for factor *f* in activity *a*
a_c^{ac}	Shift parameter for domestic commodity aggregation function	g_{ch}^m	Subsistence consumption of marketed commodity c for household h
a_c^q	Armington function shift parameter	q_{ac}	Yield of output c per unit of activity a
a_c^t	CET function shift parameter	r_a^a	CES production function exponent
a_c^m	Shift parameter in the CES regional import function	r_a^{va}	CES value-added function exponent
a_c^e	Shift parameter in the CES regional export function	r_c^{ac}	Domestic commodity aggregation function exponent
b^a	Capital sectoral mobility factor	r_c^q	Armington function exponent
b_{ch}^m	Marginal share of consumption spending on marketed commodity c for household h	r_c^t	CET function exponent
d_a^a	CES activity function share parameter	r_c^m	Regional imports aggregation function exponent
d_{ac}^{ac}	Share parameter for domestic commodity aggregation function	r_c^e	Regional exports aggregation function exponent
d_c^q	Armington function share parameter	h_{fat}^a	Sector share of new capital
u_f	Capital depreciation rate		
Exogenous Variables			
$\overline{CPI}$	Consumer price index	$\overline{MPSADJ}$	Savings rate scaling factor (= 0 for base)
$\overline{DTINS}$	Change in domestic institution tax share (= 0 for base; exogenous variable)	$\overline{QFS}_f$	Quantity supplied of factor
$\overline{FSAV}$	Foreign savings (FCU)	$\overline{TINSADJ}$	Direct tax scaling factor (= 0 for base; exogenous variable)
$\overline{GADJ}$	Government consumption adjustment factor	$\overline{WFDIST}_{fa}$	Wage distortion factor for factor f in activity a
$\overline{IADJ}$	Investment adjustment factor		
Endogenous Variables			
AWF_{ft}^a	Average capital rental rate in time period t	QF_{fa}	Quantity demanded of factor f from activity a
$DMPS$	Change in domestic institution savings rates (= 0 for base; exogenous variable)	QG_c	Government consumption demand for commodity
DPI	Producer price index for domestically marketed output	QH_{ch}	Quantity consumed of commodity c by household h
EG	Government expenditures	QHA_{ach}	Quantity of household home consumption of commodity c from activity a for household h
EH_h	Consumption spending for household	$QINTA_a$	Quantity of aggregate intermediate input
EXR	Exchange rate (LCU per unit of FCU)	$QINT_{ca}$	Quantity of commodity c as intermediate input to activity a
$GOVSHR$	Government consumption share in nominal absorption	$QINV_c$	Quantity of investment demand for commodity
$GSAV$	Government savings	QM_c	Quantity of imports of commodity c
$INVSHR$	Investment share in nominal absorption	QMR_{cr}	Quantity of imports of commodity c by region r

Source: South African Model and Lofgren *et al* (2002).

Table A1 concluded: Model Sets, Parameters, and Variables

Symbol	Explanation	Symbol	Explanation
Endogenous Variables Continued			
MPS_i	Marginal propensity to save for domestic non-government institution (exogenous variable)	QER_{cr}	Quantity of exports of commodity c to region r
PA_a	Activity price (unit gross revenue)	QQ_c	Quantity of goods supplied to domestic market (composite supply)
PDD_c	Demand price for commodity produced and sold domestically	QT_c	Quantity of commodity demanded as trade input
PDS_c	Supply price for commodity produced and sold domestically	QVA_a	Quantity of (aggregate) value-added
PE_c	Export price (domestic currency)	QX_c	Aggregated quantity of domestic output of commodity
PER_{cr}	Export price by region (domestic currency)	$QXAC_{ac}$	Quantity of output of commodity c from activity a
$PINTA_a$	Aggregate intermediate input price for activity a	RWF_f	Real average factor price
PK_{ft}	Unit price of capital in time period t	$TABS$	Total nominal absorption
PM_c	Import price (domestic currency)	$TINS_i$	Direct tax rate for institution i ($i \in$ INSDNG)
PMR_{cr}	Import price by region (domestic currency)	$TRII_{ii'}$	Transfers from institution i' to i (both in the set INSDNG)
PQ_c	Composite commodity price	WF_f	Average price of factor
PVA_a	Value-added price (factor income per unit of activity)	YF_f	Income of factor f
PX_c	Aggregate producer price for commodity	YG	Government revenue
$PXAC_{ac}$	Producer price of commodity c for activity a	YI_i	Income of domestic non-government institution
QA_a	Quantity (level) of activity	YIF_{if}	Income to domestic institution i from factor f
QD_c	Quantity sold domestically of domestic output	ΔK^{a}_{fat}	Quantity of new capital by activity a for time period t
QE_c	Quantity of exports		

Source: South African Model and Lofgren *et al* (2002).

Table A2: Model Equations

Production and Price Equations	
$QINT_{c\,a} = ica_{c\,a} \cdot QINTA_a$	(1)
$PINTA_a = \sum_{c \in C} PQ_c \cdot ica_{ca}$	(2)
$QVA_a = a_a^{va} \cdot \left(\sum_{f \in F} d_{f\,a}^{va} \cdot \left(a_{f\,a}^{vaf} \cdot QF_{f\,a} \right)^{-r_a^{va}} \right)^{-\frac{1}{r_a^{va}}}$	(3)
$W_f \cdot \overline{WFDIST}_{fa} = PVA_a \cdot (1 - tva_a) \cdot QVA_a \cdot \left(\sum_{f \in F'} d_{f\,a}^{va} \cdot \left(a_{f\,a}^{vaf} \cdot QF_{f\,a} \right)^{-r_a^{va}} \right)^{-1} \cdot d_{f\,a}^{va} \cdot \left(a_{f\,a}^{vaf} \cdot QF_{f\,a} \right)^{-r_a^{va}-1}$	(4)
$QVA_a = iva_a \cdot QA_a$	(5)
$QINTA_a = inta_a \cdot QA_a$	(6)
$PA_a \cdot (1 - ta_a) \cdot QA_a = PVA_a \cdot QVA_a + PINTA_a \cdot QINTA_a$	(7)
$QXAC_{a\,c} = q_{a\,c} \cdot QA_a$	(8)
$PA_a = \sum_{c \in C} PXAC_{ac} \cdot q_{ac}$	(9)
$QX_c = a_c^{ac} \cdot \left(\sum_{a \in A} d_{a\,c}^{ac} \cdot QXAC_{a\,c}^{-r_c^{ac}} \right)^{-\frac{1}{r_c^{ac}-1}}$	(10)
$PXAC_{a\,c} = PX_c \cdot QX_c \left(\sum_{a \in A'} d_{a\,c}^{ac} \cdot QXAC_{a\,c}^{-r_c^{ac}} \right)^{-1} \cdot d_{a\,c}^{ac} \cdot QXAC_{a\,c}^{-r_c^{ac}-1}$	(11)
$PER_{c\,r} = pwer_{c\,r} \cdot EXR - \sum_{c' \in CT} PQ_c \cdot icer_{c'c\,r}$	(12)
$QE_c = a_c^e \cdot \left(\sum_{r \in R} d_{c\,r}^e \cdot \left(QER_{c\,r} \right)^{-r_c^e} \right)^{-\frac{1}{r_c^e}}$	(13)
$\frac{PER_{c\,r}}{PE_c} = QER_{c\,r} \cdot \left(\sum_{r' \in R} d_{c\,r'}^e \cdot \left(QER_{c\,r'} \right)^{-r_c^e} \right)^{-1} \cdot d_{c\,r}^e \cdot \left(QER_{c\,r} \right)^{-r_c^e-1}$	(14)
$PE_c = pwe_c \cdot EXR - \sum_{c' \in CT} PQ_c \cdot ice_{c'c}$	(15)
$QX_c = a_c^t \cdot \left(d_c^t \cdot QE_c^{r_c^t} + (1\text{-}d_c^t) \cdot QD_c^{r_c^t} \right)^{\frac{1}{r_c^t}}$	(16)
$\frac{QE_c}{QD_c} = \left(\frac{PE_c}{PDS_c} \cdot \frac{1\text{-}d_c^t}{d_c^t} \right)^{\frac{1}{r_c^t-1}}$	(17)
$QX_c = QD_c + QE_c$	(18)
$PX_c \cdot QX_c = PDS_c \cdot QD_c + PE_c \cdot QE_c$	(19)
$PDD_c = PDS_c + \sum_{c' \in CT} PQ_{c'} \cdot icd_{c'c}$	(20)

Source: South African Model and Lofgren *et al* (2002).

Table A2 continued: Model Equations

Production and Price Equations Continued	
$PMR_{cr} = pwmr_{cr} \cdot \left(1+tmr_{cr}\right) \cdot EXR - \sum_{c' \in CT} PQ_c \cdot icmr_{c'cr}$	(21)
$QM_c = a_c^m \cdot \left(\sum_{r \in R} d_{cr}^m \cdot \left(QMR_{cr}\right)^{-r_c^m} \right)^{-\frac{1}{r_c^m}}$	(22)
$\frac{PMR_{cr}}{PM_c} = QMR_{cr} \cdot \left(\sum_{r' \in R'} d_{cr'}^m \cdot \left(QMR_{cr'}\right)^{-r_c^m} \right)^{-1} \cdot d_{cr}^m \cdot \left(QMR_{cr}\right)^{-r_c^m - 1}$	(23)
$PM_c = pwm_c \cdot (1+tm_c) \cdot EXR + \sum_{c' \in CT} PQ_{c'} \cdot icm_{c'c}$	(24)
$QQ_c = a_c^q \cdot \left(d_c^q \cdot QM_c^{-r_c^q} + (1-d_c^q) \cdot QD_c^{-r_c^q} \right)^{-\frac{1}{r_c^q}}$	(25)
$\frac{QM_c}{QD_c} = \left(\frac{PDD_c}{PM_c} \cdot \frac{d_c^q}{1-d_c^q} \right)^{\frac{1}{1+r_c^q}}$	(26)
$QQ_c = QD_c + QM_c$	(27)
$PQ_c \cdot (1-tq_c) \cdot QQ_c = PDD_c \cdot QD_c + PM_c \cdot QM_c$	(28)
$QT_c = \sum_{c' \in C'} \left(icm_{cc'} \cdot QM_{c'} + icmr_{cc'} \cdot QMR_{c'} + ice_{cc'} \cdot QE_{c'} + icer_{cc'} \cdot QER_{c'} + icd_{cc'} \cdot QD_{c'} \right)$	(29)
$\overline{CPI} = \sum_{c \in C} PQ_c \cdot cwts_c$	(30)
$DPI = \sum_{c \in C} PDS_c \cdot dwts_c$	(31)
Institutional Incomes and Domestic Demand Equations	
$YF_f = \sum_{a \in A} WF_f \cdot \overline{WFDIST}_{fa} \cdot QF_{fa}$	(32)
$YIF_{if} = shif_{if} \cdot \left[YF_f - trnsfr_{row\,f} \cdot EXR \right]$	(33)
$YI_i = \sum_{f \in F} YIF_{if} + \sum_{i' \in INSDNG'} TRII_{ii'} + trnsfr_{i\,gov} \cdot \overline{CPI} + trnsfr_{i\,row} \cdot EXR$	(34)
$TRII_{ii'} = shii_{ii'} \cdot (1-MPS_{i'}) \cdot (1-\overline{tins}_{i'}) \cdot YI_{i'}$	(35)
$EH_h = \left(1 - \sum_{i \in INSDNG} shii_{ih} \right) \cdot \left(1-MPS_h\right) \cdot (1-\overline{tins}_h) \cdot YI_h$	(36)
$PQ_c \cdot QH_{ch} = PQ_c \cdot g_{ch}^m + b_{ch}^m \cdot \left(EH_h - \sum_{c' \in C} PQ_{c'} \cdot g_{c'h}^m \right)$	(37)
$QINV_c = IADJ \cdot \overline{qinv}_c$	(38)
$QG_c = \overline{GADJ} \cdot \overline{qg}_c$	(39)
$EG = \sum_{c \in C} PQ_c \cdot QG_c + \sum_{i \in INSDNG} trnsfr_{i\,gov} \cdot \overline{CPI}$	(40)

Source: South African Model and Lofgren *et al* (2002).

Table A2 concluded: Model Equations

Equation	No.
Institutional Incomes and Domestic Demand Equations Continued	
$YG = \sum_{i \in INSDNG} \overline{tins_i} \cdot YI_i + \sum_{a \in A} ta_a \cdot PA_a \cdot QA_a + \sum_{c \in CMNR} tm_c \cdot pwm_c \cdot QM_c \cdot EXR + \sum_{r \in R} \sum_{c \in CMR} tmr_{cr} \cdot pwmr_{cr} \cdot QMR_{cr} \cdot EXR + \sum_{c \in C} tq_c \cdot PQ_c \cdot QQ_c + \sum_{f \in F} YF_{govf} + trnsfr_{govrow} \cdot EXR$	(41)
System Constraints and Macroeconomic Closures	
$QQ_c = \sum_{a \in A} QINT_{ca} + \sum_{h \in H} QH_{ch} + QG_c + QINV_c + qdst_c + QT_c$	(42)
$\sum_{a \in A} QF_{fa} = QFS_f$	(43)
$QFS_f / QFS_f^0 = \left(RWF_f / RWF_f^0 \right)^{etals_f}$	(44)
$RWF_f = \left(\frac{YF_f}{QFS_f} \right) / \left(\frac{CPI}{CPI^0} \right)$	(45)
$YG = EG + GSAV$	(46)
$\sum_{c \in CMNR} pwm_c \cdot QM_c + \sum_{r \in R} \sum_{c \in CMR} pwmr_{cr} \cdot QMR_{cr} \cdot \sum_{f \in F} trnsfr_{row\,f} = \sum_{c \in CENR} pwe_c \cdot QE_c + \sum_{r \in R} \sum_{c \in CER} pwer_{cr} \cdot QER_{cr} + \sum_{i \in INSD} trnsfr_{irow} + FSAV$	(47)
$\sum_{i \in INSDNG} MPS_i \cdot \left(1 - \overline{tins_i}\right) \cdot YI_i + GSAV + EXR \cdot FSAV = \sum_{c \in C} PQ_c \cdot QINV_c + \sum_{c \in C} PQ_c \cdot qdst_c$	(48)
$MPS_i = \overline{mps}_i \cdot (1 + MPSADJ)$	(49)
Capital Accumulation and Allocation Equations	
$AWF_{ft}^{a} = \sum_{a} \left[\left(\frac{QF_{fat}}{\sum_{a'} QF_{fa't}} \right) \cdot WF_{ft} \cdot WFDIST_{fat} \right]$	(50)
$h_{fat}^{a} = \left(\frac{QF_{fat}}{\sum_{a'} QF_{fa't}} \right) \cdot \left(b^{a} \cdot \left(\frac{WF_{f,t} \cdot WFDIST_{fat}}{AWF_{ft}^{a}} - 1 \right) + 1 \right)$	(51)
$\Delta K_{fat}^{a} = h_{fat}^{a} \cdot \left(\frac{\sum_{c} PQ_{ct} \cdot QINV_{ct}}{PK_{ft}} \right)$	(52)
$PK_{ft} = \sum_{c} PQ_{ct} \cdot \frac{QINV_{ct}}{\sum_{c'} QINV_{c't}}$	(53)
$QF_{fat+1} = QF_{fat} \cdot \left(1 + \frac{\Delta K_{fat}^{a}}{QF_{fat}} - u_f \right)$	(54)
$QFS_{ft+1} = QFS_{ft} \cdot \left(1 + \frac{\sum_{a} \Delta K_{fat}}{QFS_{ft}} - u_f \right)$	(55)

Source: South African Model and Lofgren *et al* (2002).

Appendix B: Construction of the Social Accounting Matrices

Implementing the CGE model described in Section 2 requires the construction of economy-wide databases that benchmark the model to the observed structure of the South African economy. The typical framework for such a database is a social accounting matrix (SAM), which is a comprehensive economy-wide database reflecting the structure of an economy. Two South African SAMs are described in this appendix and are built on the framework presented in Thurlow and van Seventer (2002). This appendix reviews in detail the process and data sources used to construct the SAMs.

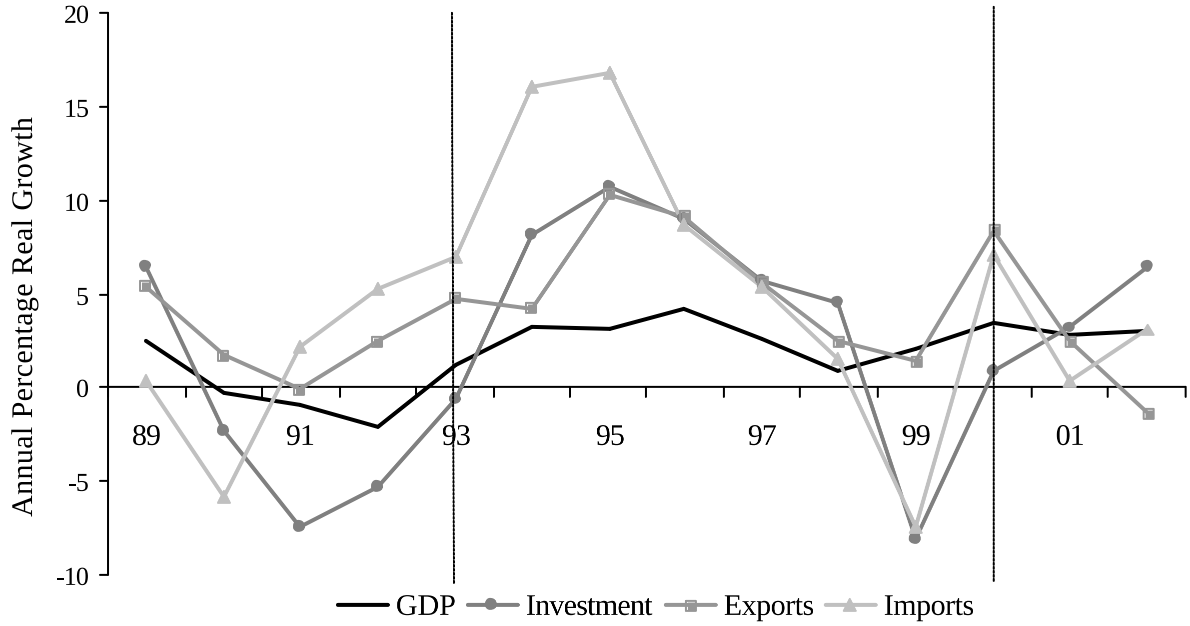
B.1 Selecting Base Years

The decision to calibrate the current South African model on SAMs for 1993 and 2000 is based largely on two considerations. First, it is important that the SAM be a 'typical' year for the country since this is taken to be the initial 'equilibrium' position for the model. Secondly, given that the construction of a SAM is a highly data-intensive procedure, the availability of data is also a significant determining factor. Figure B.1 features some of the indicators that informed that selection of the model's base years.

In terms of gross domestic product (GDP), South Africa underwent a prolonged recession during the early 1990s. This was the combined result of low investor confidence, a worldwide slowdown in economic growth, and a severe drought in Southern Africa. However, by 1993 these negative conditions had largely been overcome and the economy had begun to grow again, albeit relatively slowly. Therefore based on overall economic performance, it would be inappropriate to use a base year for a SAM within the recession period 1990 to 1992.

What is also evident from the figure is the strong resurgence in investment spending during the middle of the last decade. Investment had been declining dramatically during the late 1980s and early 1990s. Following improved political and world economic conditions, investment started to grow again after 1992. However, the high investment growth of the mid-1990s appears to have been temporary. Investment growth peaked in 1995 and then fell sharply over subsequent years. Therefore using a base year within the period 1994 to 1996 would inappropriately capture these temporarily high levels of investment growth. Based on the above discussion and in order to facilitate the assessment of past policies, 1993 was selected as the first base year for the model.

Figure B.1: Selection of Base Years (1989 to 2002)



Source: Own calculations using South African Reserve Bank (SARB, 2003).

A current lack of adequate data prevents using 2001 and 2002 as base years. Furthermore, given that the South African economy slowed down dramatically during the Asian crisis, it would be inappropriate to use 1999 as a base year. The 1998 SAM produced by Thurlow and van Seventer (2002) does not differ considerably from the decade averages for the indicators selected above. However, it was decided that a more recent year should be chosen for the model. Given that the most recent supply-use table for South Africa is for 2000, it was decided to use this as the second base year for the model. This year is also closely reflects the decade averages for the indicators shown in Figure B.1.

B.2 Macro SAM and Disaggregation

Table B.1 presents the aggregate Macro SAMs for South Africa. The top value in each cell is for 1993, while the bottom value is for 2000. All values are in millions of current Rands. The following section describes the meaning and sources of the data contained in each cell.

Intermediate Demand… (COM, ACT)

Aggregate intermediate demand was taken from the use tables produced by Statistics South Africa (StatsSA, 1996 and 2003). The value of both purchased intermediates and intermediates transferred between producers is measured at purchaser or market prices.

Table B.1: Macro Social Accounting Matrix for South Africa (1993 and 2000)

	ACT	COM	TRC	CAP	LAB	ENT	HHD	ATX	DTX	ITX	TAR	GOV	INV	STK	ROW	TOT
ACT		801,409 1,660,539														801,409 1,660,539
COM	392,807 808,735		86,239 171,965				265,392 556,652					103,312 209,893	62,601 131,848	-3,073 8,741	86,686 249,064	993,963 2,136,898
TRC		86,239 171,965														86,239 171,965
CAP	184,939 406,657														2,286 15,701	187,225 422,358
LAB	218,158 424,958															218,158 424,958
ENT				178,030 386,635												178,030 386,635
HHD					216,368 423,263	82,649 204,293						14,660 29,871			86 260	313,763 657,687
ATX	5,504 20,189															5,504 20,189
DTX						12,579 29,824	37,599 97,825									50,178 127,649
ITX		31,668 71,623														31,668 71,623
TAR		3,623 8,193														3,623 8,193
GOV						199 579	278 807	5,504 20,189	50,178 127,649	31,668 71,623	3,623 8,193				330 481	91,780 229,521
SAV						82,520 151,859	10,468 2,275					-28,593 -17,198			-4,867 3,653	59,528 140,589
STK													-3,073 8,741			-3,073 8,741
ROW		71,025 224,578		9,195 35,723	1,790 1,695	84 80	26 128					2,401 6,955				84,521 269,159
TOT	801,409 1,660,539	993,963 2,136,898	86,239 171,965	187,225 422,358	218,158 424,958	178,030 386,635	313,763 657,687	5,504 20,189	50,178 127,649	31,668 71,623	3,623 8,193	91,780 229,521	59,528 140,589	-3,073 8,741	84,521 269,159	

Note: 1993 and 2000 SAMs for South Africa; Values are millions of current South African Rands; ACT: activities; COM: commodities; TRC: transactions costs; CAP: capital; LAB: labour; ENT: enterprises; HHD: households; ATX: activity tax; DTX: direct taxes; ITX: indirect taxes; TAR: import tariffs; GOV: government; SAV: savings; INV: investment; STK: change in inventories; ROW: rest of world; TOT: total.

Capital Value-Added… (CAP, ACT)

Capital value-added (or operating surplus) was initially taken from the use tables produced by Statistics South Africa (StatsSA, 1996 and 2003). These values were adjusted to include the allowance for capital depreciation. Therefore the value that appears in the SAM is gross rather than net operating surplus, as is typical is most country SAMs. Government services' capital value-added includes interest on government debt (RB6255J), which was taken from the South African Reserve Bank Quarterly Bulletin (SARB, 2003). Therefore it assumed that interest repayments form part of the operating cost of the government services sector.

Labour Value-Added… (LAB, ACT)

Aggregate sectoral labour value-added (or labour remuneration) was taken from the use tables produced by Statistics South Africa (StatsSA, 1996 and 2003). Labour value-added was disaggregated across occupational categories using the distribution found the World Bank's SAM for South Africa (World Bank, 1997). This distribution was based on information taken from the 1995 Income and Expenditure Survey (StatsSA, 1997) and from the October Household Survey (StatsSA, 1997). Since capital-value-added is gross operating surplus, the summation of labour and capital value-added in the SAM determines gross domestic product (GDP) at factor cost.

Activity Taxes… (ATX, ACT)

Taxes and subsidies paid and received by producers must be added to GDP at factor cost to arrive at GDP at basic prices. The aggregate value and sectoral disaggregation of such taxes were taken from the use table produced by Statistics South Africa (StatsSA, 1996 and 2003). According to this source, activity taxes consist of taxes on the ownership of land, buildings or other assets used in production or on labour employed, taxes on payroll or work force, and business or professional licenses. This deviates from the usual separation of factor taxes within SAMs, which would normally appear as a tax payment by factors to the government. The aggregation of factor and producer taxes, and their current position in the SAM, implies that the model treats factor taxes as a fixed portion of output, rather than a fixed portion of factor employment. However, payroll taxes in South Africa are likely to be substantially smaller than producer taxes, thus reducing the severity of this limitation.

Marketed Output… (ACT, COM)

Market output represents the conversion of activity output into marketed commodities. Unlike previous SAMs for South Africa, the current SAMs account for the distinction between activities and commodities. Information on the disaggregation of activity output into commodity output was taken from the supply table produced by Statistics South Africa (StatsSA, 1996 and 2003).

Transaction Costs… (TRC, COM) (COM, TRC)

Transaction costs represent the costs incurred in supplying goods to the purchasing market. Aggregate sectoral transactions costs (TRC, COM) were taken from supply table produced by Statistics South Africa (StatsSA, 1996 and 2003). The current SAM further distinguishes between the transactions costs of importing and exporting commodities, and the supply of domestically produced commodities to the domestic market. Import transaction costs represent the cost of transporting goods from the domestic border and preparing goods for sale on the domestic market. Export transactions costs are the cost of transporting goods to the domestic border and preparing goods for sale on the foreign market. The transaction costs incurred through the sale of individual commodities generates demand for trade and transport services. This demand reflects the cost of supplying goods to consumers, rather than the intermediate demand for trade and transportation services generated during production. The latter appear in the intermediate demand cell (COM, ACT). The disaggregation of an individual commodity's transaction costs across domestic, imported, and exported commodities is based on the share of domestic, imported, and exported goods in the total value of these goods. The disaggregation of transaction costs (TRC, COM) across the demand for trade and transport services (COM, TRC) is taken from the supply table produced by Statistics South Africa (StatsSA, 1996 and 2003). A RAS balancing procedure was use to reconcile aggregate trade and transport demand, with disaggregated commodity-specific transaction costs.[34]

[34] The RAS balancing method iteratively adjusts row and column values proportionally to achieve a set of exogenously determined row and column totals. A more advanced method that better preserves the information contained in the initial unbalanced matrix is the cross-entropy estimation technique described in Robinson *et al* (2003). However, the small size of both this sub-matrix and its initial imbalances suggests that a simpler RAS method is adequate. For an application of the cross-entropy technique see Thurlow and Wobst (2003).

Sales Taxes and Customs Duties… (ITX, COM) (TAR, COM)

Sales taxes (ITX, COM) are paid per unit of good sold on the domestic market and apply to both imports and non-exported domestic production. Customs duties or tariffs (TAR, COM) apply to only imports. The most important sales taxes in South Africa are the value-added tax (VAT) and excise duties. Sales taxes and customs duties were taken from the supply table produced by Statistics South Africa (StatsSA, 1996 and 2003).

Imports… (ROW, COM)

Imports are measured free-on-board (f.o.b.) and therefore exclude the insurance and freight costs of transporting goods and services from the domestic border to the border of the importing country. Import data was taken from the supply table produced by Statistics South Africa (StatsSA, 1996 and 2003).

Capital Income to Enterprises… (ENT, CAP)

Capital income to enterprises represents gross operating surplus generated during production less activity taxes, and the cost of intermediates and labour remuneration. These payments include capital factor income with allowance for capital depreciation (CAP, ACT), and remitted profits received from the rest of the world (CAP, ROW), and exclude untaxed remitted profits (ROW, CAP). This cell is therefore a residual balancing item for the capital account.

Factors Transfers with Rest of the World… (ROW, CAP) (ROW, LAB) (CAP, ROW)

These cell entries represent the international transfer of profits in the case of capital, and labour income in the case of labour. Foreign factor transfers were taken from the South African Reserve Bank Quarterly Bulletin (SARB, 2003). Capital transfer received (CAP, ROW) is total foreign income received (RB5680J). Capital transfer paid (ROW, CAP) is the difference between total foreign payments (the sum of income payments (RB5681J) and compensation of residents (RB6240J)) and compensation of employees (RB6000J). Labour transfer received (ROW, LAB) is the difference between compensation of employees (RB6000J) and compensation of residents (RB6240J).

Labour Income to Households… (HHD, LAB)

Total labour income to households is the compensation of residents (RB6240J) taken from the South African Reserve Bank Quarterly Bulletin (SARB, 2003). This is disaggregated across the household categories using data taken from the World Bank's SAM for South Africa (World Bank, 1997). This distribution was based on information taken from the 1995 Income and Expenditure Survey (StatsSA, 1997) and from the October Household Survey (StatsSA, 1997). A RAS balancing method was used to reconcile total labour income with disaggregated household income from labour.

Corporate Dividends… (HHD, ENT)

Corporate dividends represent indirect capital payments to households and are taken from the South African Reserve Bank Quarterly Bulletin (SARB, 2003). These payments comprise income from property (RB6241J) and current transfers to households (RB6231J). This is disaggregated across household categories using data taken from the World Bank's SAM for South Africa (World Bank, 1997).

Corporate and Personal Taxes… (DTX, ENT) (DTX, HHD)

Total direct taxes on enterprises and households are taken from the South African Reserve Bank Quarterly Bulletin (SARB, 2003). Corporate taxes on enterprises (DTX, ENT) and personal income taxes on households (DTX, HHD) measure current taxes on income and wealth (RB6230J and RB6245J respectively). Household personal tax was disaggregated across households using data taken from the World Bank's SAM for South Africa (World Bank, 1997).

Enterprise and Household Transfers to Government… (GOV, ENT) (GOV, HHD)

Enterprise and household transfers to government reflect payments for the ownership of land or buildings, and are taken from the South African Reserve Bank Quarterly Bulletin (SARB, 2003). Enterprise transfers (GOV, ENT) include current transfers to general government (RB6232J). Household transfers (GOV, HHD) include current transfers to and from households (RB6252J). Household transfers to government were disaggregated across households using data taken from the World Bank's SAM for South Africa (World Bank, 1997).

Government Transfers to Households… (HHD, GOV)

Government transfers to households largely reflect social security payments in the form of state pensions, and child and disability grants. This data is taken from the South African Reserve Bank Quarterly Bulletin (SARB, 2003), and is measured as current transfers to households (RB6257J). Total household transfers from government were disaggregated across households using data taken from the World Bank's SAM for South Africa (World Bank, 1997).

Private Transfers to the Rest of the World… (ROW, ENT) (ROW, HHD)

Enterprise and household transfers to the rest of the world are taken from the South African Reserve Bank Quarterly Bulletin (SARB, 2003). Enterprise transfers (ROW, ENT) reflect post-tax remitted profits (RB6233J). Household transfers (ROW, HHD) reflect post-tax remitted income (RB6248J). Total household transfers to the rest of the world were disaggregated across households using data taken from the World Bank's SAM for South Africa (World Bank, 1997).

Household Consumption Demand… (COM, HHD)

Total household consumption demand across commodities was taken from the use table produced by Statistics South Africa (StatsSA, 1996 and 2003). Payments by households to residents and non-residents was included in this value and were distributed proportionately across households according to initial consumption shares. Total household consumption was disaggregated across households using data taken from the World Bank's SAM for South Africa (World Bank, 1997). The commodity distribution contained in both the supply table and the World Bank SAM were based on the 1995 Income and Expenditure Survey (StatsSA, 1997).

Private Savings… (SAV, ENT) (SAV, HHD)

Information on enterprise (RB6201J) and household savings (RB6200J) was taken from the South African Reserve Bank Quarterly Bulletin (SARB, 2003). Enterprise savings (SAV, ENT) is treated as the residual balancing item for the enterprise account. Final enterprise savings therefore equals not only corporate savings (RB6201J) but also income from property and interest on government debt. This final component implies that the government borrows exclusively from domestic financial institutions, as is largely the case in South Africa.

Tax Payments to Government… (GOV, ATX) (GOV, DTX) (GOV, ITX) (GOV, TAR)

Since the taxes imposed on producers, imports, and domestic institutions have been collected individually in their respective accounts, it is necessary to transfer these tax receipts to the government. These cells therefore have no economic meaning and merely represent government's receipt of aggregate taxes from each form of taxation.

Government Consumption Demand… (COM, GOV)

Government consumption demand is taken from the use table produced by Statistics South Africa (StatsSA, 1996 and 2003), and represents government's consumption of the output of the government services activity. Since capital value-added for the government services activity includes interest payments on public debt, the value appearing in the SAM is higher than the value appearing in the supply table.

Government Savings… (SAV, GOV)

Government savings (or borrowing as in the case of the current South African SAMs) is taken from the South African Reserve Bank Quarterly Bulletin (SARB, 2003). This value is equal to the total saving of general government (RB6202J).

Investment Demand… (COM, INV)

Investment demand reflects the commodity composition of investment spending, and not the sectoral allocation of new capital stock. The latter does not feature within the SAM, which represents the flow of funds at a particular point in time. Investment demand for each commodity is taken from the use table produced by Statistics South Africa (StatsSA, 1996 and 2003). In its calculation the use table excluded investment spending on mineral exploration, computer software, and cultivated assets.

Changes in Inventories… (COM, STK) (STK, INV)

Changes in inventories apply to raw materials, work-in-progress and finished goods. The value and commodity distribution of these stock changes were taken from the use table produced by Statistics South Africa (StatsSA, 1996 and 2003).

Exports… (COM, ROW)

Exports are measured free-on-board (f.o.b.) and therefore exclude the insurance and freight costs of transporting goods and services from the domestic border of the border of the importing country. Export data was taken from the use table produced by Statistics South Africa (StatsSA, 1996 and 2003).

Transfers from the Rest of the World to Households… (HHD, ROW)

Household transfers from the rest of the world are taken from the South African Reserve Bank Quarterly Bulletin (SARB, 2003). Total household transfers (RB6243J) to the rest of the world were disaggregated across households using data taken from the World Bank's SAM for South Africa (World Bank, 1997).

Current Account Balance… (SAV, ROW)

The balance on the current account reflects the difference between total foreign receipts and expenditures. This is taken from the South African Reserve Bank Quarterly Bulletin (SARB, 2003), where it is termed 'foreign investment' (RB6206J).

B.3 Balancing the SAM

No estimation technique was used to balance the South African SAMs, since for the most part the data sources that were used form part of a consistent national accounting framework. Although some discrepancies between the data sources were discovered, mostly as a result of recent revisions of national accounts, the choice of two residual cells in the SAM was sufficient to account for these differences. As already mentioned, these residual items include capital income to enterprises (ENT, CAP), and corporate savings (SAV, ENT). If the conceptual differences between the SAMs and national accounts are ignored, then the adjustment required to balance the SAM is relatively small.

Appendix C: Disaggregated Tables from the Social Accounting Matrices

Table C.1: Production Structure (1993 and 2000)

	Share of Total Value-Added		**Capital's Share of Total Value-Added**		**Share of Value-Added in Total Output**	
	1993	**2000**	**1993**	**2000**	**1993**	**2000**
Agriculture	4.2	3.1	70.5	66.1	58.0	49.0
Coal mining	1.2	1.2	50.7	54.4	51.7	50.8
Gold mining	3.6	2.0	42.2	29.3	62.1	57.3
Other mining	2.2	3.1	52.3	66.1	56.0	51.7
Food processing	2.1	1.7	42.1	44.0	22.8	22.0
Beverage / tobacco	1.2	1.2	67.4	71.1	35.8	39.4
Textiles	0.6	0.4	34.9	21.4	31.7	29.7
Clothing	0.6	0.4	21.3	13.2	36.4	40.5
Leather products	0.0	0.0	30.4	46.6	18.6	18.7
Footwear	0.2	0.1	17.8	49.2	33.7	35.0
Wood products	0.4	0.4	46.4	30.5	32.5	35.7
Paper products	0.8	0.8	45.3	55.0	29.1	28.8
Printing / publishing	0.7	0.6	32.2	24.0	39.1	43.2
Petroleum products	1.0	1.1	76.1	85.6	38.2	32.1
Chemicals	0.9	0.9	48.5	61.9	28.0	28.6
Other chemicals	1.1	1.1	44.6	33.5	29.1	27.4
Rubber products	0.3	0.2	35.4	29.7	37.3	32.5
Plastic products	0.5	0.5	39.4	10.2	35.4	40.3
Glass products	0.2	0.1	39.6	29.0	41.1	40.2
Non-metal minerals	0.7	0.6	37.5	65.3	40.3	39.5
Iron and steel	1.0	1.1	31.8	51.1	29.1	25.8
Non-ferrous metals	0.6	1.0	52.0	81.5	32.0	39.6
Metal products	1.3	0.9	32.1	33.4	32.2	34.3
Machinery	1.2	0.8	31.8	19.3	32.0	30.9
Electrical machinery	0.6	0.6	38.4	47.7	34.4	32.1
Comm. equipment	0.2	0.2	31.6	27.2	28.2	32.6
Scientific equipment	0.1	0.1	47.1	28.6	32.8	32.3
Vehicles	1.3	1.3	41.3	44.3	22.6	19.5
Transport equipment	0.3	0.1	33.5	7.6	45.2	29.1
Furniture	0.4	0.3	24.3	28.3	37.6	31.9
Other manufacturing	1.2	0.2	79.4	46.9	55.1	22.4
Electricity / gas	2.9	2.2	71.4	65.2	68.4	62.1
Water	0.4	0.4	73.2	67.2	41.3	31.6
Construction	3.4	3.1	21.4	40.1	29.9	31.1
Trade services	12.2	10.6	44.4	45.5	56.9	54.9
Hotels / catering	1.2	1.5	66.5	76.8	60.1	66.1
Transport services	6.4	5.9	52.1	55.5	57.4	54.2
Comm. services	1.9	3.7	30.9	60.2	65.1	57.8
Financial services	6.7	8.8	55.0	60.8	65.6	60.8
Business services	8.4	9.6	73.9	69.0	64.4	67.2
Other services	1.3	1.8	49.2	49.3	49.8	49.7
Other producers	4.7	5.2	16.5	15.6	64.7	68.0
Government services	19.8	21.0	30.7	33.7	71.5	78.3
All sectors	100.0	100.0	45.9	48.9	50.6	50.7

Source: 1993 and 2000 South African SAMs

Table C.2: International Trade (1993 and 2000)

	Export Share		**Export-Output Ratio**		**Import Share**		**Import-Demand Share**	
	1993	**2000**	**1993**	**2000**	**1993**	**2000**	**1993**	**2000**
Agriculture	3.7	2.7	10.3	11.7	3.1	1.6	7.9	7.7
Coal mining	6.2	3.4	53.6	41.5	0.2	0.2	2.5	3.3
Gold mining	26.5	10.1	97.1	86.0	0.0	0.0	0.0	0.0
Other mining	8.3	19.9	40.9	96.6	1.7	10.0	11.3	93.4
Food processing	5.9	3.6	10.4	10.9	4.9	3.6	9.2	13.0
Beverage / tobacco	1.2	1.6	6.0	12.2	1.6	1.0	7.5	8.5
Textiles	1.2	0.9	10.2	15.4	2.5	1.7	19.4	28.7
Clothing	1.0	0.7	7.5	9.4	1.0	0.8	8.3	13.9
Leather products	0.3	0.4	31.3	52.1	0.2	0.2	25.6	38.4
Footwear	0.2	0.1	5.6	6.8	0.9	0.8	21.5	36.7
Wood products	0.4	0.8	6.4	19.7	0.7	0.5	10.1	14.8
Paper products	2.3	2.4	15.4	22.6	1.8	1.2	13.0	14.6
Printing / publishing	0.3	0.4	2.9	7.5	2.5	1.0	19.4	18.8
Petroleum products	1.2	3.5	7.9	25.4	2.1	1.2	10.9	10.4
Chemicals	3.4	3.8	22.5	33.0	6.2	4.6	31.9	38.7
Other chemicals	1.3	1.9	5.3	11.1	5.4	5.1	19.7	28.4
Rubber products	0.3	0.5	8.0	20.4	0.8	0.8	21.7	37.8
Plastic products	0.3	0.3	3.9	7.4	1.0	0.9	13.5	19.8
Glass products	0.2	0.2	11.0	13.5	0.4	0.3	19.5	24.6
Non-metal minerals	0.4	0.4	5.1	7.0	0.9	1.0	10.2	17.9
Iron and steel	7.9	7.2	48.4	44.1	1.2	1.0	11.0	10.7
Non-ferrous metals	2.8	3.5	30.9	41.9	0.9	1.7	11.7	26.8
Metal products	1.0	1.1	4.7	11.6	1.8	1.7	8.2	18.1
Machinery	2.1	4.6	9.5	42.2	16.7	13.1	44.7	68.0
Electrical machinery	0.6	1.0	5.6	13.7	3.0	2.5	25.1	32.7
Comm. equipment	0.3	0.7	7.5	34.6	3.3	5.5	47.6	80.6
Scientific equipment	0.2	0.4	6.5	33.2	3.2	2.7	52.5	70.3
Vehicles	3.0	5.0	9.4	20.5	11.0	12.2	28.1	40.9
Transport equipment	0.6	1.1	14.5	63.0	2.6	3.2	41.0	83.2
Furniture	0.5	1.1	5.9	23.0	0.3	0.4	5.7	13.2
Other manufacturing	3.5	1.5	27.4	38.0	3.1	1.4	24.9	39.6
Electricity / gas	0.4	0.5	2.1	3.8	0.1	0.1	0.6	1.1
Water	0.0	0.0	0.5	0.5	0.0	0.0	0.6	0.8
Construction	0.0	0.1	0.1	0.2	0.2	0.3	0.4	0.9
Trade services	0.2	0.2	0.2	0.3	0.2	0.2	0.1	0.3
Hotels / catering	2.2	2.6	23.4	33.6	2.7	1.9	23.4	26.6
Transport services	4.4	5.3	8.4	14.4	5.5	8.8	8.6	20.2
Comm. services	0.9	1.1	6.6	5.2	1.5	1.6	8.7	7.1
Financial services	2.4	3.0	4.9	6.0	1.5	1.9	2.7	3.5
Business services	1.2	1.0	1.8	1.9	1.6	1.7	1.9	3.0
Other services	0.4	0.3	3.2	2.8	0.4	0.4	2.4	2.9
Other producers	0.9	0.9	2.4	3.1	1.2	1.3	2.5	4.4
Government services	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
All sectors	100.0	100.0	10.0	13.7	100.0	100.0	9.8	15.2

Source: 1993 and 2000 South African SAMs

Table C.3: Regional Imports (2000)

	Percentage Share of Commodity Imports								
	SADC	**USA**	**Mer-cosur**	**EU**	**India**	**China**	**Japan**	**Rest of World**	**Total**
Agriculture	24.4	11.7	11.0	10.3	2.8	2.7	0.2	36.9	100.0
Coal mining	0.0	16.4	0.0	0.5	0.0	2.1	0.0	81.0	100.0
Other mining	0.9	0.2	0.1	10.2	0.1	0.3	0.1	88.3	100.0
Food processing	2.9	7.9	21.3	22.7	3.7	2.1	0.2	39.4	100.0
Beverage / tobacco	1.8	4.1	0.4	76.7	0.0	0.4	0.0	16.5	100.0
Textiles	4.2	6.0	0.6	22.9	5.8	11.3	0.8	48.5	100.0
Clothing	13.1	1.8	0.1	11.3	7.6	37.3	0.1	28.7	100.0
Leather products	3.0	5.1	10.4	24.0	16.4	18.3	0.1	22.6	100.0
Footwear	1.7	3.0	1.2	9.6	3.5	46.1	0.0	34.9	100.0
Wood products	9.0	14.9	4.5	31.5	0.3	2.9	0.0	36.8	100.0
Paper products	0.5	14.2	2.2	59.7	0.2	0.4	1.4	21.3	100.0
Printing / publishing	0.3	28.5	0.1	58.3	0.6	1.2	1.6	9.4	100.0
Petroleum products	3.3	23.6	1.2	23.9	0.9	8.9	0.3	37.9	100.0
Chemicals	0.5	16.1	2.5	47.6	1.6	3.6	3.6	24.7	100.0
Other chemicals	0.3	15.6	1.1	60.1	1.1	1.6	4.0	16.2	100.0
Rubber products	1.1	10.2	0.8	41.2	1.8	2.5	21.7	20.8	100.0
Plastic products	0.4	15.3	0.2	49.3	0.9	7.9	4.1	21.9	100.0
Glass products	1.7	6.9	3.9	45.6	1.7	6.4	2.9	30.9	100.0
Non-metal minerals	1.4	14.0	2.6	55.3	1.2	7.5	8.6	9.4	100.0
Iron and steel	3.4	4.3	8.6	42.7	3.4	3.3	7.6	26.6	100.0
Non-ferrous metals	7.1	2.3	0.8	17.8	0.4	1.7	1.7	68.1	100.0
Metal products	2.9	11.9	0.7	43.5	2.9	8.7	3.8	25.6	100.0
Machinery	0.9	14.2	0.9	48.4	0.3	4.4	8.2	22.5	100.0
Electrical machinery	1.3	13.2	1.6	49.1	1.1	5.5	6.9	21.5	100.0
Comm. equipment	0.4	9.5	0.2	52.4	0.1	4.3	4.9	28.2	100.0
Scientific equipment	0.7	28.2	0.2	43.6	0.3	2.7	6.4	17.9	100.0
Vehicles	0.3	5.1	2.2	54.7	0.3	0.2	28.9	8.3	100.0
Transport equipment	3.6	63.9	2.8	16.5	0.2	1.0	2.4	9.5	100.0
Furniture	7.1	4.4	0.7	57.6	0.7	6.8	0.6	22.0	100.0
Other manufacturing	4.8	13.0	0.3	29.9	2.4	19.4	5.2	25.0	100.0
All non-services	2.0	12.3	2.4	40.0	1.0	3.9	7.7	30.8	100.0

Source: 1993 and 2000 South African SAMs

Table C.4: Regional Exports (2000)

	Percentage Share of Commodity Imports								
	SADC	**USA**	**Mer-cosur**	**EU**	**India**	**China**	**Japan**	**Rest of World**	**Total**
Agriculture	10.1	4.6	0.4	54.8	0.2	1.0	8.0	20.9	100.0
Coal mining	2.3	1.0	2.6	64.4	4.7	0.2	2.6	22.3	100.0
Other mining	1.3	10.4	0.7	56.5	0.2	5.7	7.6	17.8	100.0
Food processing	22.6	5.0	0.3	25.7	0.3	0.2	7.8	38.2	100.0
Beverage / tobacco	25.1	4.6	1.3	45.3	0.1	0.0	1.0	22.5	100.0
Textiles	21.6	8.9	1.2	38.6	0.5	4.4	3.4	21.5	100.0
Clothing	8.2	56.0	0.4	24.6	0.0	0.1	0.6	10.1	100.0
Leather products	0.9	12.3	0.8	45.2	0.2	0.2	19.4	21.0	100.0
Footwear	43.7	1.0	0.4	35.2	0.3	0.1	0.7	18.8	100.0
Wood products	6.0	4.1	0.5	23.6	0.1	0.4	55.1	10.2	100.0
Paper products	11.0	4.7	3.5	33.3	3.9	1.9	2.0	39.6	100.0
Printing / publishing	44.4	7.8	0.1	23.0	0.8	0.1	0.1	23.9	100.0
Petroleum products	36.3	3.0	0.2	4.2	0.5	0.1	0.4	55.4	100.0
Chemicals	16.4	18.0	4.1	18.3	8.7	1.6	4.9	28.0	100.0
Other chemicals	37.3	6.7	3.1	23.7	1.5	0.6	0.6	26.5	100.0
Rubber products	31.0	10.3	0.5	38.4	0.4	0.0	0.2	19.3	100.0
Plastic products	40.5	7.2	1.1	29.3	0.5	0.1	0.2	21.1	100.0
Glass products	25.3	21.1	2.8	36.2	0.1	0.0	0.3	14.3	100.0
Non-metal minerals	32.6	5.7	0.9	30.2	0.3	2.5	6.5	21.4	100.0
Iron and steel	6.3	15.8	1.3	29.5	1.8	2.8	8.0	34.5	100.0
Non-ferrous metals	0.5	2.5	0.5	4.4	0.7	0.3	4.9	86.3	100.0
Metal products	35.6	5.6	1.8	22.4	0.7	0.2	2.7	31.0	100.0
Machinery	20.3	13.8	0.6	47.8	0.3	2.1	0.4	14.8	100.0
Electrical machinery	27.2	8.3	0.2	40.5	1.1	0.3	0.2	22.2	100.0
Comm. equipment	22.3	5.6	0.2	28.3	1.5	0.7	0.1	41.5	100.0
Scientific equipment	25.6	8.4	1.8	30.0	1.0	0.2	0.1	32.8	100.0
Vehicles	10.4	11.6	0.5	48.4	0.3	4.3	6.9	17.6	100.0
Transport equipment	13.1	22.1	1.1	33.3	0.1	0.4	0.3	29.6	100.0
Furniture	6.1	2.2	0.1	83.2	0.0	0.0	2.6	5.8	100.0
Other manufacturing	3.0	14.7	0.2	46.6	0.7	0.9	0.8	33.1	100.0
All non-services	11.8	9.8	1.1	40.2	1.2	2.6	5.5	27.9	100.0

Source: 1993 and 2000 South African SAMs

Table C.5: Trade Elasticities

Commodity	Armington Aggregation	Regional Aggregation	Commodity	Armington Aggregation	Regional Aggregation
Agriculture	1.60	4.40	Metal products	1.77	5.60
Coal mining	1.03	5.60	Machinery	0.49	5.60
Gold mining	0.50	-	Electrical machinery	0.75	5.60
Other mining	1.03	5.60	Comm. equipment	0.75	5.60
Food processing	0.74	4.40	Scientific equipment	0.95	5.60
Beverage / tobacco	2.33	6.20	Vehicles	4.26	5.60
Textiles	2.81	4.40	Transport equipment	4.26	10.40
Clothing	2.48	8.80	Furniture	2.30	5.60
Leather products	4.41	8.80	Other manufacturing	0.95	5.60
Footwear	6.80	8.80	Electricity / gas	0.50	-
Wood products	0.69	5.60	Water	0.50	-
Paper products	3.67	3.60	Construction	0.50	-
Printing / publishing	3.19	3.60	Trade services	0.50	-
Petroleum products	1.53	3.80	Hotels / catering	0.50	-
Chemicals	1.53	3.80	Transport services	1.78	-
Other chemicals	1.53	3.80	Comm. services	0.50	-
Rubber products	1.50	3.80	Financial services	0.50	-
Plastic products	1.50	3.80	Business services	0.50	-
Glass products	0.57	5.60	Other services	0.50	-
Non-metal minerals	0.57	5.60	Other producers	0.50	-
Iron and steel	0.84	5.60	Government services	0.50	-
Non-ferrous metals	0.84	5.60	All sectors	1.09	5.37

Source: IDC (2000) for Armingtons; Jomini *et al* (1991) for regional aggregation.

Table C.6: Factor Shares across Sectors (1993 and 2000)

	Capital		Labour						All Factors	
			Low Skilled		Skilled		High Skilled			
	1993	2000	1993	2000	1993	2000	1993	2000	1993	2000
Agriculture	6.6	4.3	5.4	5.5	1.4	1.2	1.0	0.9	4.3	3.2
Coal mining	1.4	1.4	2.4	2.6	0.8	0.7	0.6	0.6	1.2	1.2
Gold mining	3.5	1.2	12.5	9.8	1.2	0.8	0.8	0.6	3.8	2.0
Other mining	2.7	4.4	5.6	6.5	0.8	0.9	0.8	0.8	2.4	3.2
Food processing	2.1	1.6	4.4	4.0	1.9	1.5	1.4	1.1	2.2	1.8
Beverage / tobacco	1.9	1.9	1.1	1.1	0.6	0.5	0.8	0.8	1.3	1.3
Textiles	0.5	0.2	2.4	2.2	0.3	0.2	0.3	0.2	0.7	0.4
Clothing	0.3	0.1	2.4	2.3	0.3	0.3	0.3	0.2	0.6	0.4
Leather products	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Footwear	0.1	0.1	0.9	0.5	0.1	0.0	0.1	0.0	0.2	0.1
Wood products	0.4	0.3	1.0	1.6	0.3	0.4	0.1	0.2	0.4	0.4
Paper products	0.8	1.0	1.4	1.4	0.8	0.7	0.5	0.5	0.8	0.9
Printing / publishing	0.6	0.3	0.6	0.7	1.1	1.1	1.2	1.2	0.8	0.7
Petroleum products	2.0	2.4	0.6	0.5	0.4	0.3	0.7	0.5	1.2	1.4
Chemicals	0.9	1.2	0.9	0.9	0.5	0.5	1.0	0.9	0.8	0.9
Other chemicals	1.1	0.8	1.3	1.8	0.8	0.9	1.5	1.8	1.1	1.1
Rubber products	0.2	0.1	0.7	0.6	0.2	0.1	0.2	0.2	0.3	0.2
Plastic products	0.5	0.1	1.3	2.2	0.3	0.5	0.4	0.6	0.6	0.5
Glass products	0.1	0.1	0.4	0.4	0.1	0.1	0.1	0.1	0.2	0.1
Non-metal minerals	0.6	0.8	1.7	1.0	0.4	0.2	0.5	0.3	0.7	0.6
Iron and steel	0.8	1.2	2.6	2.2	1.2	0.8	1.0	0.7	1.2	1.2
Non-ferrous metals	0.5	1.6	0.7	0.7	0.3	0.3	0.3	0.2	0.5	1.0
Metal products	1.0	0.8	3.7	3.4	1.2	1.0	0.8	0.7	1.4	1.1
Machinery	0.9	0.3	2.2	2.0	1.4	1.2	1.3	1.0	1.3	0.8
Electrical machinery	0.5	0.5	1.3	1.2	0.4	0.3	0.6	0.5	0.6	0.5
Comm. equipment	0.1	0.1	0.5	0.7	0.1	0.1	0.2	0.2	0.2	0.2
Scientific equipment	0.1	0.0	0.2	0.2	0.1	0.0	0.1	0.1	0.1	0.1
Vehicles	1.2	1.2	2.3	2.7	1.0	0.9	1.4	1.3	1.3	1.4
Transport equipment	0.3	0.0	0.7	0.4	0.3	0.2	0.4	0.2	0.4	0.1
Furniture	0.2	0.2	1.2	1.0	0.3	0.2	0.2	0.1	0.4	0.3
Other manufacturing	2.1	0.2	0.8	0.3	0.4	0.2	0.3	0.1	1.2	0.2
Electricity / gas	4.7	3.1	1.6	1.8	1.1	1.0	2.2	2.1	3.0	2.3
Water	0.6	0.5	0.2	0.2	0.1	0.2	0.3	0.4	0.4	0.4
Construction	1.4	2.3	10.3	8.7	2.1	1.6	2.5	1.8	3.0	2.8
Trade services	11.6	9.8	8.1	8.3	16.9	15.0	10.4	9.0	12.0	10.5
Hotels / catering	2.4	3.0	0.4	0.4	1.8	1.5	0.6	0.5	1.6	1.9
Transport services	7.3	6.7	4.7	4.8	8.6	7.5	3.2	2.7	6.4	5.9
Comm. services	1.3	4.6	1.3	1.7	4.0	4.5	1.7	1.8	1.9	3.7
Financial services	8.7	11.9	0.4	0.5	10.5	12.5	5.2	6.1	7.2	9.6
Business services	12.1	12.1	0.3	0.5	4.3	6.0	5.4	7.4	7.5	8.6
Other services	1.4	1.8	0.7	1.2	0.7	0.9	2.3	3.2	1.3	1.8
Other producers	1.2	1.3	3.9	5.4	5.7	6.8	6.0	6.9	3.5	3.9
Government services	13.2	14.4	4.9	6.0	25.4	26.6	40.7	41.6	19.8	21.0
All sectors	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: 1993 and 2000 South African SAMs

Table C.7: Factor Shares within Sectors (1993 and 2000)

	Capital		Labour						All Factors	
			Low Skilled		Skilled		High Skilled			
	1993	2000	1993	2000	1993	2000	1993	2000	1993	2000
Agriculture	70.5	66.1	18.0	20.7	6.9	8.0	4.6	5.2	100.0	100.0
Coal mining	50.7	54.4	27.2	25.1	12.9	11.9	9.3	8.6	100.0	100.0
Gold mining	42.2	29.3	46.9	57.4	6.7	8.2	4.2	5.1	100.0	100.0
Other mining	52.3	66.1	33.8	24.0	7.6	5.4	6.3	4.5	100.0	100.0
Food processing	42.1	44.0	27.9	27.0	18.1	17.5	11.8	11.5	100.0	100.0
Beverage / tobacco	67.4	71.1	11.6	10.3	9.0	8.0	12.0	10.6	100.0	100.0
Textiles	34.9	21.4	49.0	59.2	8.3	10.0	7.8	9.5	100.0	100.0
Clothing	21.3	13.2	58.6	64.6	11.1	12.3	9.0	10.0	100.0	100.0
Leather products	30.4	46.6	58.0	44.5	5.1	3.9	6.5	5.0	100.0	100.0
Footwear	17.8	49.2	66.2	41.0	7.6	4.7	8.4	5.2	100.0	100.0
Wood products	46.4	30.5	32.8	42.5	15.2	19.7	5.6	7.3	100.0	100.0
Paper products	45.3	55.0	23.6	19.4	19.0	15.6	12.1	9.9	100.0	100.0
Printing / publishing	32.2	24.0	10.6	11.9	28.7	32.2	28.4	31.9	100.0	100.0
Petroleum products	76.1	85.6	7.0	4.2	6.3	3.8	10.7	6.5	100.0	100.0
Chemicals	48.5	61.9	15.0	11.1	13.5	10.0	23.1	17.1	100.0	100.0
Other chemicals	44.6	33.5	16.1	19.3	14.5	17.4	24.8	29.8	100.0	100.0
Rubber products	35.4	29.7	34.5	37.5	14.0	15.2	16.1	17.5	100.0	100.0
Plastic products	39.4	10.2	32.4	47.9	13.1	19.5	15.1	22.4	100.0	100.0
Glass products	39.6	29.0	34.0	40.0	12.5	14.8	13.8	16.3	100.0	100.0
Non-metal minerals	37.5	65.3	35.2	19.5	13.0	7.2	14.3	7.9	100.0	100.0
Iron and steel	31.8	51.1	31.5	22.6	20.4	14.6	16.3	11.7	100.0	100.0
Non-ferrous metals	52.0	81.5	22.1	8.5	14.4	5.5	11.5	4.4	100.0	100.0
Metal products	32.1	33.4	37.9	37.2	18.8	18.4	11.3	11.1	100.0	100.0
Machinery	31.8	19.3	24.5	29.0	24.2	28.6	19.5	23.1	100.0	100.0
Electrical machinery	38.4	47.7	29.6	25.2	13.1	11.2	18.8	16.0	100.0	100.0
Comm. equipment	31.6	27.2	36.3	38.6	13.7	14.6	18.4	19.6	100.0	100.0
Scientific equipment	47.1	28.6	28.1	37.9	10.6	14.3	14.2	19.2	100.0	100.0
Vehicles	41.3	44.3	24.6	23.3	15.0	14.3	19.1	18.1	100.0	100.0
Transport equipment	33.5	7.6	27.8	38.7	17.0	23.7	21.6	30.1	100.0	100.0
Furniture	24.3	28.3	48.1	45.6	17.5	16.6	10.1	9.5	100.0	100.0
Other manufacturing	79.4	46.9	8.7	22.5	7.5	19.5	4.3	11.1	100.0	100.0
Electricity / gas	71.4	65.2	7.4	9.0	7.4	9.0	13.8	16.9	100.0	100.0
Water	73.2	67.2	5.9	7.2	6.6	8.0	14.3	17.5	100.0	100.0
Construction	21.4	40.1	48.2	36.8	14.8	11.3	15.5	11.8	100.0	100.0
Trade services	44.4	45.5	9.6	9.4	29.8	29.2	16.3	15.9	100.0	100.0
Hotels / catering	66.5	76.8	3.5	2.4	23.4	16.2	6.6	4.6	100.0	100.0
Transport services	52.1	55.5	10.4	9.7	28.2	26.2	9.3	8.6	100.0	100.0
Comm. services	30.9	60.2	9.6	5.5	43.3	24.9	16.1	9.3	100.0	100.0
Financial services	55.0	60.8	0.7	0.6	30.8	26.8	13.5	11.8	100.0	100.0
Business services	73.9	69.0	0.6	0.7	12.1	14.3	13.5	16.0	100.0	100.0
Other services	49.2	49.3	7.5	7.5	10.4	10.4	32.8	32.8	100.0	100.0
Other producers	16.5	15.6	16.1	16.3	35.0	35.4	32.3	32.7	100.0	100.0
Government services	30.7	33.7	3.5	3.4	27.2	26.1	38.5	36.9	100.0	100.0
All sectors	45.9	48.9	14.2	11.9	21.2	20.6	18.7	18.6	100.0	100.0

Source: 1993 and 2000 South African SAMs

Appendix D: Description and Use of Code Files

The CGE model is programmed using the General Algebraic Modeling System (GAMS). As with the IFPRI 'standard' static model, the South African dynamic model is comprised of two core program files: one model (SAmod.gms) and one simulation (SAsim.gms) file. These two files are discussed in detail below and follow the flowchart shown in Figure D1.

The Model File

The generic IFPRI recursive dynamic model was designed such that its model file was the same as that of the IFPRI static model. In adapting the IFPRI recursive dynamic model to the South African context there was some adjustment to the core model file (as described in Appendix A). Despite these changes, a user that is familiar with the IFPRI static model will recognise the core model file of the South African model.

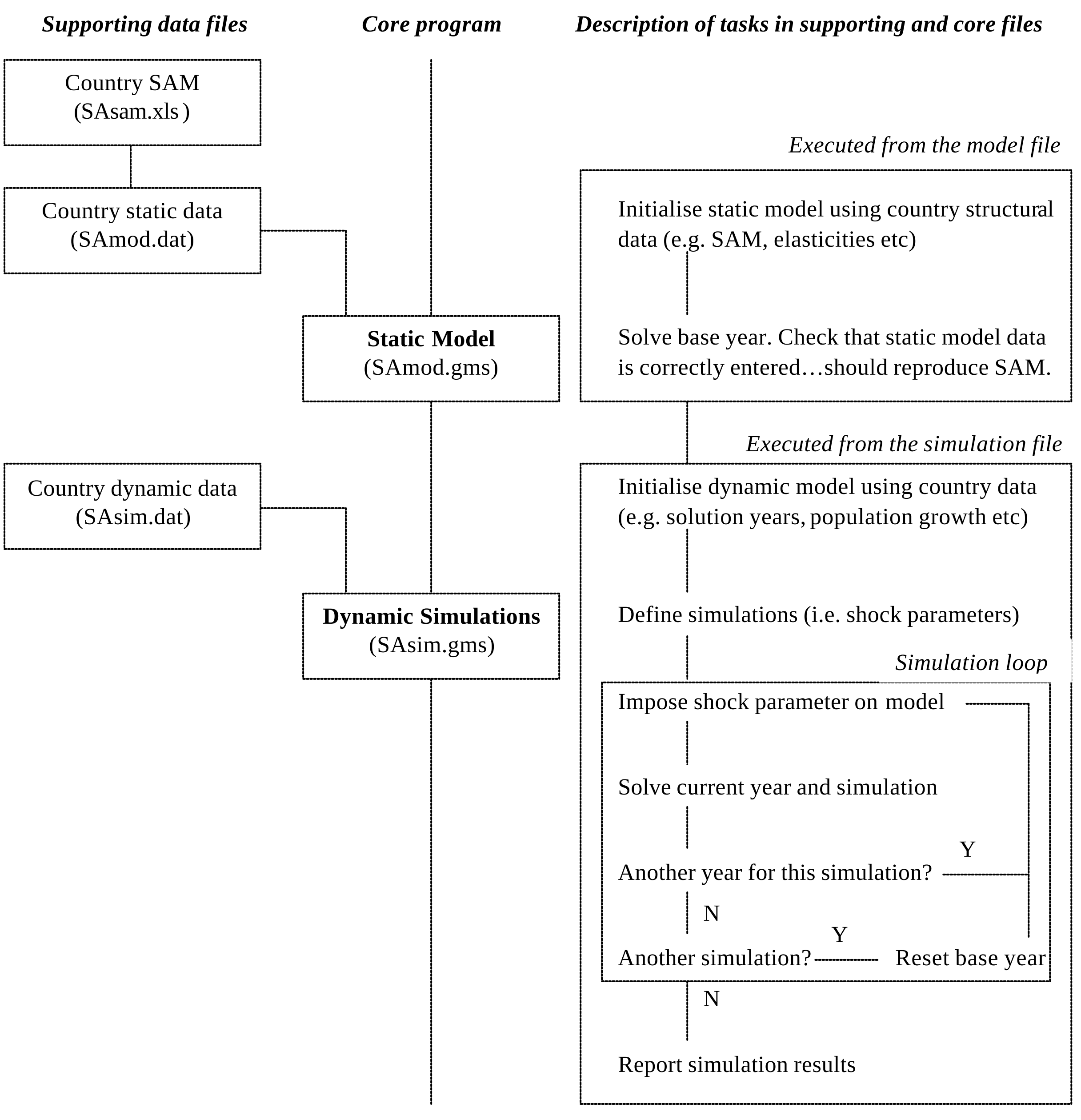
The model or 'mod' file contains the specification and calibration of the static or within-period model. The file initially reads in the country data from the data or 'dat' file (SAmod.dat), and then returns to the model file to calibrate the model's variables and parameters. Only users that are familiar with CGE modelling and GAMS should make changes to the 'mod' file (SAmod.gms). Rather users who have their own country data should enter this into the 'dat' file.[35] One of the key sources of information for the calibration process is the data that is contained in the SAM (SAsam.xls). The importing of the SAM from Microsoft Excel™ is done in the 'dat' file. If the imported SAM is not balanced (i.e. rows do not equal columns) then the 'dat' file will execute a cross-entropy balancing program. This balancing program is not designed for the construction of a SAM, but rather to ensure balance at the high level of accuracy required by GAMS.[36]

After having entered the country data into the 'dat' file the user can then execute the 'mod' file. This file will set up the within-period model and then solve it for the base year (i.e. the year of the SAM). Provided there is no problem with the data the model should not need to iterate in order to produce the base year solution (which is the initial equilibrium as depicted

[35] Most users will only be interested in using the model for policy analysis. As such these users need not make any adjustments to the 'dat' file.
[36] If the user needs to update or adjust the SAM then using the full IFPRI cross-entropy balancing program is recommended (see Robinson *et al*, 2001).

in the SAM). If the model solves without iterating then the user can proceed to the simulation file. However, before moving on it is necessary for the simulation file to 'know' the information contained in the 'mod' file. This transfer of information between GAMS files is known as a 'save/restart'. When executing the 'mod' file it is necessary to enter the following line into the command line box: 's=save/base'.

Figure D1: Flowchart of Model and Simulation Files



The Simulation File

The simulation or 'sim' file contains or controls information on the dynamics of the model, the specification of the simulations, the solving of the simulations, and the reporting of results. Data on the dynamics of the model are entered into the simulation 'dat' file (SAsim.dat). The sort of information contained in this file includes: the years over which the model should be run; the rate of TFP and population growth; and the specification of the capital accumulation process.

Returning to the 'sim' file, the users now enter information on their simulations. Simulations are imposed in the model in the following way. First, add the name of the new simulation to both the set 'sim' and 'simcur'. The second set identifies which of the simulations in the first set are active (i.e. to be solved).

```
SIM                All simulations /
      INITIAL      Used for reporting only (do not remove)
      BASE         Projected dynamic path without shock
      TAR50        50% cut in tariffs
/

SIMCUR(SIM)        active simulations /
      BASE         Projected dynamic path without shock
      TAR50        50% cut in tariffs
/
```

Next define a 'shock' parameter which initially has the same dimensions as the model parameter. Add two new dimensions to the parameters list of sets: one called 'SIM' and one called 'YR'. This shock parameter will contain information on the value of this model parameter for each year within each simulation.

```
PARAMETER TMSIM(C,SIM,YR);
```

Since the shock parameter must have a value for each year within each simulation, it is important to initially assign to it the base year value (in the 'mod' calibration procedure all base year parameters, as opposed to variables, have zeros at the end).

```
TMSIM(C,SIM,YR) = TM0(C);
```

Then adjust the shock parameter to reflect the value you want to assign to the model's parameter for the shock simulation. Remember not to change the value of the first year since you want to start in equilibrium for the initial year.

```
TMSIM(C,'TAR50',YR)$(NOT YR1(YR)) = TM0(C) * 0.50;
```

The final stage of setting up a simulation involves imposing the shock on the model. Since there are a number of simulations, each solving across a number of years, the 'sim' file loops across years and active simulations. Within the 'sim' file loop the current year and simulation are known as 'YRCUR' and 'SIMCUR'. Imposing the shock involves setting the model's parameter to the value contained inside the shock parameter that was defined above.

```
PWE.FX(C) = TMSIM(C,SIMCUR,YRCUR);
```

The user can now solve the 'sim' file. As already mentioned it is necessary for the 'sim' file to know the information contained in the 'mod' file. When running the 'mod' file the user saved the information using the 'save' command. The user should now enter the following into the 'sim' file's command line: 'r=save\base'. This restores the previously saved model information and allows it to be used by the simulation file.

After the model has found solutions for each of the simulations it will report the results in the simulation results or 'list' file (SAsim.lst). The user can search for the results for any of the variables found in the model. The reporting convention that is adhered to for each report parameter is shown in Table D1.

Table D1: Reporting Conventions

Parameters ending with…	**Contain values for …**	**Example**
X	Every year	PWEX
XV	Final year only	PWEXV
XP	Percentage change between first and final year	PWEXP
XPY	Average annual growth rate between first and final year	PWEXY