

**GOVERNMENT SOCIAL ASSISTANCE TRANSFERS, INCOME
INEQUALITY AND POVERTY IN SOUTH AFRICA: A
COMPUTABLE GENERAL EQUILIBRIUM (CGE) –
MICROSIMULATION (MS) MODEL**

Inaugural-Dissertation

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LIST OF ABBREVIATIONS

ADRS	Applied development research solutions
ANC	African national congress
ASCII	American standard code for information interchange
CDG	Care dependency grant
CES	Constant elasticity of substitution
CET	Constant elasticity of transformation
CGE	Computable general equilibrium
CPI	Consumer price index
CSG	Child support grant
DG	Disability grant
DPI	Producer price index
FCG	Foster care grant
FCU	Foreign currency unit
GDP	Gross domestic product
GL	Generalized Lorenz
Govt	Government
IES	Income and expenditure survey
IFPRI	International food policy research institute
IMR	Inverse mills ratio
Inv	Investment
LCU	Local currency unit
LES	Linear expenditure system
LFS	Labor force survey
MPC	Marginal propensity to consume
mps	Marginal propensity to save
MPT	Marginal propensity to transfer
MS	Microsimulation
NLSUR	Nonlinear seemingly unrelated regression
OLS	Ordinary least squares
ROW	Rest of the world
SAM	Social accounting matrix
SASSA	South African social security agency
SARS	South African revenue services
SOAP	Social old age pension
TD-BU	Top-down bottom-up model
UIF	Unemployment insurance fund

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ABSTRACT

Although social assistance transfers have grown at a faster pace in recent years after independence in South Africa, income inequality still remains one of the highest in the world. This thesis uses a top-down, bottom-up model which combines an econometrically-estimated microsimulation model of labor supply, a detailed tax-benefit module, and a computable general equilibrium model, in order to analyze the impact of government social assistance on income inequality and poverty in South Africa. The approach accounts for four important aspects. Firstly, it accounts for the fact that labor supply adjusts to changes in the tax-benefit schedule. Secondly, it accounts for general equilibrium effects, given that reforms are likely to have an impact on the whole economy. Thirdly, it accounts for the fact that the government budget should be balanced in simulations. Lastly it can fully take into account the heterogeneity of economic agents, since it uses a micro data set and also allows for the modeling of the intra-group income distribution. In the simulations, we vary government social assistance to low income households whilst maintaining a balanced government budget. Simulation results suggest that doubling of government social assistance causes significant reductions in both income inequality and poverty measures. Doubling social assistance leads to a 5.5% reduction in poverty if we use a relative poverty measure and a 7% reduction if we use an absolute poverty line of R322 per month. In the simulations financing social assistance by an increase in income taxes gives the strongest reduction in both, poverty and inequality measures in comparison to using commodity taxes. Lastly, we also find differences in poverty and inequality measures for the MS-only model and the linked TD-BU model. This confirms the importance of taking price changes from the CGE model to the MS model. Neglecting these price changes may slightly overestimate or underestimate inequality and poverty measures, depending on which financing option is used.

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CHAPTER 1

INTRODUCTION AND OBJECTIVES

Social assistance¹ has grown at a faster pace in recent years after independence in South Africa; however income inequality still remains one of the highest in the world. Over the first ten years after independence, the government increased social assistance² by more than 70% in real terms³ (Van der Berg et al., 2005), but income inequality as measured by the Gini-coefficient remains relatively high, at around 60%. This has prompted a debate on the South African policy arena, given that government resources are limited. The question remains whether these social assistance transfers are beneficial as a poverty reduction tool and also whether they will be sustainable in the long run. Van der Berg et al. (2005) suggested that, social assistance is nearing its limits to alleviate poverty⁴ due to fiscal constraints. Fiscal capacity constraints arise from the fact that social assistance spending already constitutes a high proportion of GDP (about 3.5%), while such social assistance transfers need to compete with other public spending.

This thesis will use a linked top-down, bottom-up (TD-BU) model (Savard, 2003) which combines an econometrically-estimated microsimulation (MS) model of labor supply, a detailed tax-benefit model and a computable general equilibrium (CGE) model, in order to analyze the impact of government social assistance on income inequality and poverty in South Africa. The approach differs from that of Savard (2003) in that it uses a detailed tax-benefit module. We are considering a different policy scenario, where increases in social assistance are financed by different types of taxes. This exercise is interesting as it accounts for four important aspects. Firstly, it accounts for the fact that the labor supply adjusts to

¹ The terms “social transfers”, “social benefits” and “social assistance” will be used interchangeably throughout the thesis.

² Social assistance are non contributory benefits, mainly offered to the most vulnerable population groups, such as the elderly, disabled and children.

³ For detailed trends in social assistance see Section 2.1

⁴ Social assistance already constitutes 3.5% of GDP, which is more than twice the median spending across developing and transitional economies (Woolard et al., 2010). In addition social assistance is financed by tax revenue and it also needs to compete with other social spending like health and education.

changes in the tax-benefit schedule. This is important since changes in social assistance can alter labor supply incentives. Secondly, it accounts for general equilibrium effects, given that reforms are likely to have an impact on the whole economy. Thirdly, it considers that the government's budget should be balanced in simulations. This is important as it allows us to perform budget neutral experiments when evaluating different financing options. Lastly, it fully takes into account the heterogeneity of economic agents, since it uses a micro-data set and also allows for assessing the intra-group income distribution.

All in all, the model utilizes the advantages of the two models (CGE and MS models) and compensates for the weaknesses of each of these independent models. Accordingly, it contributes insights to the ongoing debate on social assistance programs and income redistribution by capturing systematic (general equilibrium) effects arising from the endogenization of commodity and factor prices. To the best of our knowledge, there has been no research focusing on social assistance, poverty and inequality using such a bi-directional or 'top-down, bottom-up' linkage in South Africa so far.

Accordingly, the overall objective of this study is to use a linked top-down, bottom-up CGE-microsimulation in order to identify and quantify the impact of social assistance transfers on income inequality and poverty in South Africa. In this study we focus mainly on means-tested social assistance transfers, which are non-contributory cash social assistance provided by the government to vulnerable groups. In this regard we have

- developed a poverty focused top-down, bottom-up CGE-microsimulation model for South Africa⁵,
- carried out simulations in order to quantify the impact of social assistance transfers on income inequality and poverty in South Africa,
- assessed the impact of different financing options on income inequality and poverty,
- analyzed the impact of these social assistance transfers on the labor supply and

⁵ Detailed do-files can be obtained from the author on request. Email address: charisoc@yahoo.com.

- compared results from the linked (top-down, bottom-up) model with a standard unlinked model (MS model).

The remainder of the thesis is organized as follows; Chapter 2 introduces the South African tax-benefit system. Chapter 3 reviews results from previous literature. Chapter 4 gives a detailed description of the research methodology used. It starts by giving a detailed structure of the CGE model, then moves on to explain the MS model, which includes both a tax-benefit module and a discrete labor supply model and the final part of the same chapter gives a detailed description of the linked model, which combines an econometrically-estimated MS model of labor supply, a detailed tax-benefit module, and a computable general equilibrium model. Chapter 5 gives the imputation, estimation and calibration of model parameters. The first part of this section gives an explanation of the data used in the model. The second part of the same chapter gives an explanation of the tax-benefit module, while the last section gives calibration and estimation of linear expenditure system parameters and discrete labor supply parameters. Simulation results, inequality and poverty analysis results are presented in Chapter 6. Finally, Chapter 7 provides a summary of research findings, recommendations, limitations of the study and concluding remarks.

CHAPTER 2

SOCIAL SECURITY AND TAXES IN SOUTH AFRICA

2.1 Social assistance background

2.1.1 History of social assistance programs in South Africa

South Africa inherited a fragmented social security system, which was started during the apartheid era, mainly for white people to protect themselves from various unexpected future emergencies (Van der Berg, 2002). The South African social assistance program started with the establishment of the Children's Protection Act of 1913, which provided maintenance assistance for children. These assistances were mainly restricted to non-Africans and no assistance was given to rural Africans (Bhorat, 1995). In 1928, the Old Age Pension Act was enacted, which provided social (non-contributory) pension assistance to Coloureds (people of mixed race) and Whites. At first, Africans and Indians were excluded from the scheme. The scheme was only extended to Africans and Indians in 1944, but still the value of assistance received differed across racial groups (Bhorat, 1995). In 1937 a Disability Grant was also established and was only extended to Africans and Indians in 1947.

After independence in 1994, the South African government faced the challenge of transforming the existing fragmented social assistance programs into one based on comprehensive coverage of the whole population, in an equitable and non-racial manner. The Lund Committee in 1996 recommended that the amount for children's assistance should be reduced and restricted to children less than seven years old, so as to cover a large number of recipients. The recommendation was accepted by the cabinet, and this led to the introduction of the Child Support Grant which replaced the maintenance grant in 1998. The system has remained unchanged since the implementation of the Child Support Assistance in 1998, with adjustments only to grant sizes and age eligibility.

2.1.2 Current social assistance programs in South Africa

The main objective of the social assistance programs in South Africa is to reduce poverty among people vulnerable to low income, such as the elderly, children, and people with disabilities who cannot participate (fully) in the labor market (see SASSA website). South Africa has a well-developed social assistance program compared to other African countries. In South Africa the social assistance programs are administered by the South African Social Security Agency (SASSA).

There are five main non-contributory social assistance transfers in South Africa. Social assistance is mainly given as income support to eligible poor and vulnerable individuals, mostly the elderly, people with disabilities and children. It is a state-funded system, also referred to as social grants in South Africa, which is financed entirely from government revenue. This scheme is means-tested and the responsibility is upon individuals to prove that they are in need of support. Over 13 million people (i.e. about a quarter of the total population) received social assistance transfers in 2009.

The five non-contributory social assistance⁶ transfers include the following; Social Old Age Pensions (SOAP), Disability Grant (DG), Child Support Grant (CSG), Care Dependency Grant (CDG) and Foster Care Grant (FCG). The Social Old Age Pension is a means-tested benefit, payable to people of retirement age or older. The applicant must not be maintained or cared for in a state institution or be in receipt of another social grant. Disability Grant is a means-tested grant paid to disabled people, over 18 years of age but below retirement age, subject to medical eligibility criteria. The Child Support Grant is paid to primary caregivers of children in need. Eligibility is determined by a means test which measures the caregiver's financial ability to provide necessary support for the children. Initially, the program covered only children less than seven years old, but it was extended in 2005 and now covers up to children less than 15 years old. The Care Dependency Grant is a means-tested grant payable to children under the age of 18 years who are in permanent home care and suffering from severe mental and

⁶ Social assistance refers to the sum of all non- contributory grants

physical disability. Finally the Foster Care Grant is given to foster parents. Following court's approval, a child can be placed under the custody of suitable foster parents, under the supervision of a social worker. The aim of the grant is to help foster parents cover the costs of caring for a child. Table 2.1 gives a summary of non-contributory social assistance in South Africa, for the year 2000.

Table 2.1: social assistance transfers description and eligibility

Name of grant	Description	Requirements	Amounts per month
Child Support Grant	Social assistance offered to primary caregivers of children if combined income of caregiver and spouse is below a certain threshold.	Age limit: 0-7 years Income means test: R800 per month for those in Urban areas. R1100 per month for those in rural areas or informal dwellings.	R100 per month
Foster Care Grant	Following the court's approval a child is placed under the custody of a foster parent (maybe due to the death of both parents).	Age limit: 18 years	R390 per month
Care Dependency Grant	Payable to parents of children under 18 years suffering from severe mental or physical disability.	Age limit: 18 years Income means test: Annual household income not greater than R48000.	R540 per month
Disability Grant	Means-tested grant given to disabled people, subject to a medical doctor's confirmation or report.	Age limit: 18-59 years for females 18-64 years for males Income means test: R1250(single) per month R2500(Couples) per month	R540 per month
Social Old Age Grant	Means-tested benefit paid to people of retirement age.	Age limit: Males over 64 years Females Over 59 years	R540 per month

Source: National Treasury, South Africa (August 2004).

Note: Details apply to the year 2000.

In the years after independence, the South African government has developed policies designed to reduce poverty and income inequality. In the year 2007/2008, over 12 million South Africans received social assistance, which is approximately 25% of the population. The next table shows the number of grant beneficiaries and growth rates from the year 1999 to 2009.

Table 2.2: Social assistance recipients 1999/00 to 2008/09

Year	Total grant recipients	Growth rate (%)
1999/00	2 687 169	5.8
2000/01	3 773 998	40.4
2001/02	3 982 801	5.5
2002/03	4 913 275	23.4
2003/04	6 476 587	31.8
2004/05	7 869 143	21.5
2005/06	10 947 116	39.1
2006/07	11 983 141	9.5
2007/08	12 386 396	3.4
2008/09	13 026 104	5.2
2009/10	13 779 000	5.8
2010/11	14 625 000	6.1
2011/12	15 198 000	4.0

Sources 1: *South African Social Security Agency (SASSA), annual statistical report on social assistance 2008/10.*

Source 2: *National Treasury, South Africa: 2013 Budget Review (2009/10-2011/12)*

Note: *Growth rates refer to year on year growth rates in total grant recipients.*

Table 2.2 suggests that there has been a significant increase in the number of grant recipients since 1999. The government increased social assistance by more than 70 percent in real terms over a 10 year period after independence (Van der Berg et al., 2005). The growth in social assistance was driven mainly by an increase in the number of beneficiaries for both Child Support Grant and Disability Grant. The increase in Child Support Grant was mainly due to an increase in the take-up rate and also to extension of the grant from children less than 7 years to children less than 15 years in 2005.

Table 2.3 shows social assistance expenditure by type of grant from the year 2001 to 2010.

Table 2.3: Social assistance expenditures by type of assistance 2001/02 to 2009/10

Grant type R' Million	2001/02	2002/03	2003/04	2004/05	2005/06
SOAP	12 954	15 285	17 146	18 504	19 996
DG	4 585	7 201	10 329	12 570	14 438
FCG	364	787	1 142	1 563	2 044
CDG	226	309	639	760	938
CSG	2 400	4 558	7 690	11 431	14 483
Other	24	28	36	56	29
Total	20 553	28 168	36 982	44 885	51 927

Continued...

R' Million	2006/07	2007/08	2008/09	2009/10
SOAP	21 222	22 801	25 934	29 991
DG	14 261	15 280	16 474	16 853
FCG	2 851	3 414	3 934	4 362
CDG	1 006	1 132	1 292	1 356
CSG	17 559	1 925	22 348	27 273
Other	133	215	733	260
Total	57 032	62 467	70 715	80 080

Source 1: *Provincial Budgets and Expenditures Review: 2001/02 – 2007/08.*

Source 2: *Year 2006 onwards: Woolard et al., 2010.*

Note: *Statistics taken from two different sources.*

Table 2.3 shows that there has been a sharp increase in most social assistance over the period 2001 to 2010. Social Old Age Pension, Child Support Grant and Disability Grant are the largest grant types in terms of overall expenditure. Over the years, the share of spending on the Child Support Grant has increased relative to that of other social assistance. In 2001/02 the expenditure on the Child Support Grant accounted for about 11.6 % of total social grant expenditures, but by the year 2009/10 it accounted for over 30.5 % of total social grant expenditures.

The next table shows social assistance expenditures as a percentage of gross domestic product (GDP).

Table 2.4: Social assistance expenditures as a percentage of GDP, 2000/01 to 2009/0

Year	Social expenditure (R' million)	% of GDP
2001/02	20 553	2.0
2002/03	28 168	2.4
2003/04	36 982	2.9
2004/05	44 885	3.2
2005/06	51 927	3.4
2006/07	57 032	3.3
2007/08	62 467	3.2
2008/09	70 715	3.2
2009/10	89 368	3.5
2010/11	92 806	3.4
2011/12	101 320	3.4

Source 1: *Provincial Budgets and Expenditure Review: 2001/02 – 2007/08.*

Source 2: *Year 2006 onwards: Woolard et al., 2010.*

Source 3: *National Treasury, South Africa: 2013 Budget Review (2009/10-2011/12)*

Note: *Statistics taken from three different sources.*

Total social assistance expenditures have risen from R20.6 billion (2.0% of GDP) in 2001/02 to R101.3 billion (3.4% of GDP) in 2011/12. This translates to about a 392% increase in overall social assistance expenditures (in nominal terms). Expenditures on social assistance almost doubled from 2% of GDP in 1994 to about 3.4% of GDP in 2012. The level of social assistance spending in South Africa at present is extremely high, even in comparison to that of other middle income countries and countries in transition. According to Weigand and Grosh (2008), social assistance as a percentage of GDP is about 1% in Mexico and below 2% in Brazil. Therefore it's clear that South Africa has a sizeable social assistance program in comparison to that of other middle income and transitional countries, implying that it has a well-developed social assistance program.

Non-contributory social assistance (cash) transfers are an important source of income for poor households (HH) in South Africa. Social assistance represents a larger proportion of income for the poor, as highlighted by the next table.

Table 2.5: Composition of income by household type

Income category	Low income (%)	High income (%)	Total (%)
Highly skilled labor	1.750	34.726	31.188
Skilled labor	19.681	23.679	23.250
Low skilled labor	19.722	6.935	8.306
Capital income	18.302	31.036	29.670
Inter household transfers	16.577	1.007	2.677
Social assistance	23.877	2.587	4.871
Rest of the world	0.09	0.030	0.038
Total	100	100	100

Source: Own calculations using the income and expenditure household survey (IES-2000).

Note: Equivalized income was used as explained in the footnote number 7 below.

From Table 2.5 above, low income households (those with lowest 40% of equivalized gross income⁷) get 24% of their total income from social or government transfers, while high income households (those with highest 60% of equivalized gross income) get only 2%. Hence, government spending on social assistance in South Africa appears to be well targeted. To support this, Woolard (2003) explains that in the year 2000, 66% of total income of the poorest 20% of the South African population was social assistance, while less than 1% of income of the richest 20% of population was social assistance income.

2.2 South African tax system

2.2.1 Overview of the South African tax system

The South African Revenue Services (SARS) is responsible for collecting and administering all taxes in order to ensure compliance with tax law. The following tax types are in operation in South Africa: income tax, corporate income tax, capital gains tax, value added tax, excise duty, transfer duty, estate duty, stamp

⁷ We used adjusted total income figures or equivalized income which takes into account differences in the size and structure of household. This equivalence scale was calculated as follows:

$$\text{Adult equivalized scale: } E = (A + \varpi K)^\theta.$$

Where A is number of adults in the household, ϖ is fraction representation of children (K) in adult equivalized scale and θ is a scale parameter (capturing economies of scale).

duty, skills development levy, air passenger tax, donations tax, retirement fund tax, unemployment insurance fund (UIF) and other taxes.

Personal income tax is the government's main source of revenue, contributing 34.3% to total revenue for the 2009/2010 fiscal year (*Innovative Medicines South Africa, 2011*). We will focus mainly on personal income since it is the one which will be used as the main source of financing increase in government transfers. The following table shows personal income tax expenditure as a percentage of GDP.

Table 2.6: Personal income tax value as a percentage of total revenue and GDP (1994-2010)

Year	Value (R' million)	As a % of total revenue	As a % of GDP
1994/95	44 972.8	39.5	9.0
1995/96	51 179.3	40.2	9.1
1996/97	59 519.8	40.4	9.4
1997/98	68 342.4	41.3	9.8
1998/99	77 733.9	42.1	10.3
1999/00	85 883.8	42.7	10.3
2000/01	86 478.0	39.3	9.1
2001/02	90 389.5	35.8	8.6
2002/03	94 336.7	33.5	7.9
2003/04	98 495.1	32.6	7.6
2004/05	110 982	31.3	7.7
2005/06	125 645	30.1	7.8
2006/07	140 578	28.4	7.7
2007/08	168 774	29.5	8.1
2008/09	195 115	31.2	8.4
2009/10	205 145	34.3	8.4

Source: South African Revenue Services.

Note: Values given in nominal terms.

From the table above it can be seen that there have been slight reductions in personal income tax revenue as a percentage of GDP, from the year 1999 to 2010.

2.2.2 Personal income tax calculations in South Africa

In South Africa, income tax is levied according to the 'Income Tax Act' 58 of 1962. Since 1995, the tax rate has been applied to all individuals, irrespective of

gender, marital status or number of children. Personal income tax is one of the government's main sources of revenue. In January 2001, South Africa changed from a source based tax system to a resident based tax system⁸. That is, residents⁹ are subject to tax in South Africa on their worldwide income and capital gains, while non-residents are taxed on their South African-source income and capital gains on immovable assets situated in South Africa. Tax rates on individuals are progressive, that is tax rate increases as the taxable income increases.

Individuals receive most of their income from, among others, labor (salaries and wages), capital (interest and dividends) and business income (sole proprietor and partners) which are taxable as personal income. All these form what is called "gross income" or "total income". The next table summarizes how tax payable is calculated in South Africa.

Table 2.7: Income Tax calculations

Income Tax calculations
Gross income (total income from different sources)
Less exemption (accruals and receipts of government organizations, local authorities)
= Income
Less deductions (pension and retirement contributions, medical aid contributions charitable contributions, dividends, donations made, losses incurred, depreciation)
=Taxable income
Apply tax rules to get payable tax values
Less tax rebates
=Net tax paid

Source: South African Revenue Services.

Note: Tax rebate is a refund offered when people pay more taxes than they owe. Details of the tax schedule are given in Appendix A.

⁸ Under the resident system, income which is accrued to a resident of a country should be subject to taxes of that country. Whereas under a source based system, income is taxed in the country where it originates regardless of physical resident of income recipient.

⁹ A person is considered resident for tax purposes if he or she is ordinarily resident in South Africa or is not ordinarily resident in South Africa but has been physically present in South Africa for at least 91 days during each of the current and preceding 5 tax years and more than 915 days in total during the previous 5 tax years.

Exemptions and deductions are subtracted from gross income in order to get taxable income (tax base). The tax schedule is then applied in order to get the actual tax paid.

2.3 Inequality background

South Africa is statistically a middle income country with an average per capita income that is one of the highest on the continent, but its income inequality is among the highest in the world, with the overall Gini coefficient of around 60 percent (Pauw and Mncube, 2007) using household gross income. The South African income inequality dates back to the apartheid era, where exclusions were made based on race and class, but now it is increasingly determined by inequality within population groups. The next diagram shows the trends in South African income inequality as measured by the Gini coefficient.

Table 2.8: Trends in South African Inequality as measured by Gini coefficient

Year	Gini Coefficient
1970	51
1980	49
1993	59
1995	59
2000	58
2005	58

Source: *United Nations University-World Institute for Development Economics Research database (UNU-WIDER).*

Note: *Using household incomes from various surveys.*

From Table 2.8 it can be seen that inequality stagnates at high level after 1993, despite the increase in social assistance transfers. Different studies using different datasets have confirmed that income inequality has remained relatively constant after independence (Statistics South Africa 2002, Hoogeveen and Özler, 2004, Van der Berg et al., 2004, Ardington et al., 2005, Leibbrandt et al., 2006, Yu, 2010). Van der Berg (2010) summarized the trends in inequality by highlighting that there was a strong upward trend in inequality as measured by

Gini-coefficient in the second half of the 90's and stable inequality thereafter, but still inequality remains high.

CHAPTER 3

LITERATURE REVIEW

3.1 Theoretical literature review

Public or government policies have two main roles; achieving efficiency by correcting market failures and improving the distribution of income and poverty outcomes that would result from a market-based allocation of resources. This thesis mainly concentrates on the second role.

Pigou-Dalton's 'principle of transfers', play a central role in the literature of income redistribution. The principle states that a progressive transfer¹⁰ of income between two persons reduces income inequality and enhances social welfare (Dalton, 1920). Sen (1976) introduced the 'transfer axiom', which is a limited form of the 'principle of transfer' in poverty measurement. The axiom states that a transfer of income from a poor person to someone poorer reduces poverty.

Atkinson et al. (1995) argued that poverty reduction and income redistribution are not the only purposes of social assistance transfer systems. Other reasons include provision of insurance, which is not provided by the private sector and to provide distribution of family income through time (for example through unemployment benefits). Nevertheless, poverty reduction and income redistribution are the main objectives of such schemes. However there are varying beliefs concerning the effectiveness of social assistance transfers on income inequality. Well-targeted social assistance transfers are expected to reduce income inequality since they transfer from high income groups to low income groups. The main critique of social assistance transfers stem from the 'welfare dependency' theory. It is argued that tax and transfer programs interfere with incentives to work, save and invest. Redistributive programs may foster dependence on social assistance and thereby increase the poverty rate (Lee, 1987 and Murray, 1984). According to this argument, for many poor individuals with unskilled labor it makes sense financially to live off social assistance transfers rather than take a

¹⁰ Transfer from high income to low income earners.

low-wage job. In addition, means-tested social assistance can reduce incentives to work by requiring beneficiaries and their spouses to fall below a certain income threshold.

Some researchers argue that social assistance policies undermine economic growth and thereby fail to reduce the number of poor in the long run, even if they do provide some temporary near-term assistance (Alesina and Perotti, 1997 and Arrow, 1979). In addition, others argue that social assistance transfers can crowd out assistance from private institutions and charitable organizations (see Cox, Hansen, Jimenez, 1999). Lastly other researchers argue that too little of the money reaches the poor (vertical targeting or efficiency) (Lee, 1987). It is certainly true that a substantial share of the government social assistance tend to go to the middle and upper classes rather than to the poor. Closely related to this is the view that social assistance may not reach all poor people (horizontal targeting or efficiency). On the other hand, having an assured stream of income could help individuals cover some of their job search costs, and can also be used to finance small enterprise creation, which will ensure a normal stream of income later and help reduce income inequality. Any adverse impact of income redistribution, such as crowding out of investment or reduction of work effort, may be offset or even outweighed by these and other beneficial effects (Kenworthy, 1998 and Perotti, 1996). In view of all these differences of opinion, there is still need to explore more in this area.

3.2 Empirical review

3.2.1 Studies from other developing and middle – income countries

In developing and middle income economies a lot of independent models have been used to analyze the impact of social assistance on inequality and poverty. Empirical results from these studies can provide important lessons for South Africa, since they belong to the same income group. Bourguignon et al. (2002) carried out an ex-ante evaluation of a conditional cash transfer program using

Brazil's *Bolsa Escola* program as a case study. They found that the program would reduce poverty incidences by only one percentage point and the Gini coefficient by half a percentage point. They concluded that governments should make more substantial transfers to make a big impact. Chia et al. (1994) analyzed poverty reduction targeting programs using a general equilibrium model for Cote d'Ivoire. They found that when general equilibrium effects are considered it is more difficult to eliminate poverty, since prices of products bought by poor people increase and they bear some of the financing burden through indirect taxes. In addition, they found that at the national level a targeting program to all which redistributes income from high income to low income households will have the greatest effect, reducing poverty by seven percentage points. Coady and Harris (2001) used a CGE model to evaluate targeted cash transfers for Mexico, and found that combining transfer programs with efficient tax reforms benefited poor households through general equilibrium changes in income and prices.

Lehman (2010) used the Mexican's *Progresa* program to analyze the impact of government social assistance transfers on rural inequality. He concluded that the impact of such government transfer programs on reducing rural inequality may be lower than previously thought. This stems from the fact that the program-eligible lower tail and the program-ineligible upper tail of the community do not behave in isolation from each other. He showed that interactions in credit and insurance, as well as factor and commodity markets led to a situation whereby government social assistance transfers granted to the lower tail of the village led to welfare improvements at the program's ineligible upper tail¹¹. Hence, this will only lead to a modest effect on reducing inequality.

¹¹ First, low income households of the community reallocate part of the transfers to higher income households in the form of credit and gifts. Second, the higher income households accrue additional income from supplying commodities which are consumed in higher proportion by those in low income.

3.2.2 South African studies

For empirical applications to South Africa, Thompson and Schoeman (2007) developed a static microsimulation model. Their model only considers personal income taxes and not social assistance. In addition, the model is a static model without any behavioral changes and does not model macro variables. There is also a tax-benefit model called SAMOD, which was developed by the Centre for the Analysis of South African Social Policy at Oxford University. This is also a partial equilibrium model, which does not consider general equilibrium effects.

In addition many other partial equilibrium models have been used to study the impact of an increase in social assistance transfers on income inequality and poverty in South Africa. Samson et al. (2004) used a microsimulation model in order to analyze the social and economic impact of South Africa's Social Security System. They found that full take-up of social assistance transfers would lead to a 3 percentage point reduction in Gini coefficient and also that South Africa's social assistance reduce poverty headcount measure by 4.3%. Armstrong and Burger (2008) used a decomposition technique to investigate the impact of social assistance on poverty and inequality in South Africa. They found that social assistance programs have a considerable impact on poverty, since they are effective in pushing the poor closer to the poverty line. However, they found that social assistance have a negligible impact on inequality. The main reason for this is that inequality is mainly driven by the upper end of income distribution, a group that does not receive social assistance. Haarman (2000) modeled the impact of existing social assistance on poverty in South Africa and tested the impact of potential reforms using a microsimulation model. He found that if the system was to work with a 100% efficiency it would be able to close the poverty gap by 36.8% in the first two quintiles.

Overall there seem to be a consensus on the impact of social assistance programs on poverty, which ranges from single digit to double digit figures depending on which poverty indicator is used, either poverty headcounts or poverty gaps. The figures also depend on whether or not the study covered only

program participants or measured the impact on national poverty. There are somehow mixed perceptions in relation to the impact of government social assistance transfers on income inequality, ranging from slight to significant reductions. In addition, most of these models are partial equilibrium models or only CGE models, which have many shortcomings from the discussion given in the next chapter. The two should be regarded as complements in order to combine the strength of the two models. This analysis will be very useful in filling this gap.

CHAPTER 4

RESEARCH METHODOLOGY

This chapter gives a detailed description of the research methodology used in this thesis. The first part gives a review of different methodologies, while the second part describes the computable general equilibrium model, and the third part of the same chapter deals with the microsimulation model. The last part gives the linked or top-down, bottom-up model.

4.1 Review of different methodologies

Both microsimulation and computable general equilibrium models have been used separately to assess distributional effects of social assistance. Microsimulations are tools that allow the simulation of the effects of a policy on a sample of economic agents (individual, households, and firms) at the individual level and they originated with Orcutt in 1957. One main disadvantage of a static arithmetic microsimulation is that it does not take into account changes in behavior of consumers; it only captures the so called “first round effects” of policy reform. This led to the development of behavioral microsimulation models. These include a detailed representation of behavioral responses of consumers (see Creedy and Duncan, 2002 and Van Soest, 1995). A particular strength of microsimulation is that it fully takes into account the heterogeneity of economic agents, since it deals with micro data sets. It is possible to include great detail of characteristics in behavioral equations. However, microsimulation models in general are typically partial equilibrium models that do not take into account changes in relative prices even though they directly affect household welfare on the consumption side and household income on the production side. This approach can be misleading when evaluating the effects of some policies that aim precisely at reallocating output more efficiently and assessing the poverty impact of such policies.

Computable general equilibrium models have also been applied to income distribution (Adelman and Robinson, 1978 and Coady and Harris, 2001). Coady and Harris (2001) pointed out that CGE modeling is justified if social assistance

transfers are large in size and also to address the economic impact that originates in the tax structure used to finance transfers. Its main advantage is that it explicitly considers general equilibrium effects; however, CGE models typically include a limited number of households (representative households) and hence cannot explicitly deal with intra-group income distribution. Yet since poverty may affect people in groups differently, it is also important to study intra-group income distribution (Decaluwé et al., 1999a). Cockburn (2002) reiterated this point by stating that there is increasing evidence that households in a given category are affected differently by different policy reforms. Parametric distributions have been used to measure intra-group variations, for example by assuming households' income distribution follows beta, lognormal or gamma distribution, but choice of distribution is arbitrary since there is no economic behavior behind this change in intra-group distribution (Savard, 2003). Researchers in South Africa suggested that intra-group inequality makes a substantial contribution to overall inequality (Bhorat et al., 2001). In addition, certain types of equations that are commonly included in a behavioral model, such as switching regime equations like occupational choice equations, are not easily modeled within the standard CGE modeling software (Savard, 2003).

Researchers now work with CGE-microsimulation models in order to combine the strength of both CGE and microsimulation models. There are various ways to link these models. The first is the integrated approach, where representative household groups in the CGE model are substituted by as many households as can be found in the household survey (Cockburn, 2002 and Cogneau and Robilliard, 2007).

The integrated approach avoids the use of representative households and considers intra-group inequalities. When using this approach full reconciliation between micro and macro data is essential, and this can lead to changes in the structure of either the social accounting matrix (SAM)¹² data or the household

¹² A social accounting matrix is the main database for the CGE model. It is a square matrix that shows the transactions taking place in an economy during an accounting period, usually one year.

survey data. The main disadvantage of using this approach is that it imposes limits in modeling of microeconomic household behaviors.

The second approach is the top-down (sequential) approach, where initially a CGE model is run and then changes of some selected variables are passed on to the microsimulation model (Robilliard et al., 2001 and Haurat, 2005).

Still, just like the prior approach, it avoids the use of representative households and considers intra-group inequalities. The main advantage of using this approach compared to the previous one is that there is flexibility in household behavior specification. Unlike the first approach, full reconciliation of the micro and macro data sets is not required, which according to Haurat (2005) also implies lack of theoretical consistency since nothing guarantees coherence between the two models. The main drawback of this approach according to Savard (2003) is that the MS model does not provide feedback to the CGE model, though partial and not complete feedback effects of household behavior can be taken into account by computing aggregate elasticities from household survey data to the CGE model. The approach is also considered inappropriate when policy changes are specified at the household level, like with cash transfer programs (Bourguignon et al., 2008).

The third approach is the so called top-down, bottom-up approach. A loop is used to run both models iteratively until convergence is achieved (Savard, 2003). According to Savard (2003), the approach is mainly useful because feedback effects provided by the household model do not correspond to aggregate behavior of the representative households in the CGE model, hence the need to take back these feedback effects from the household model to the CGE model. Further details of this approach will be given in Section 4.4.

Other general advantages of this linked model are as follows: Firstly, there is no obligation of scaling survey data to national accounts since the approach uses percentage changes (variations) from one model to the other. Secondly, there is a higher degree in choices of functional forms since the two models run separately. For example the MS model can include discrete choice integer behavior which might be difficult to incorporate in a CGE model. Lastly it allows for feedback

effects from the MS model to the CGE model. Feedback effects provided by the microsimulation model do not always correspond to aggregate behavior of representative households in the CGE model. Savard (2003) highlighted that aggregation error is a key element in determining the importance of information lost from lack of feedback effect. He went on to say that if the behavior of representative households in the CGE is perfect aggregation of behavior in the microsimulation model, then there is no value added in taking back feedback effects.

All in all, more could be explained on the impact of social assistance transfers on income inequality and poverty if we make use of a CGE-microsimulation model. This will contribute to the current debate on social assistance programs and income distribution by capturing systematic effects that were not captured by other techniques before. Changes in transfer programs imply alterations in both relative prices and quantities that cannot be ignored.

4.2 CGE model

In this section we build a CGE model which will be used to analyze the impact of social assistance transfers on income inequality and poverty. We will use two different versions of the CGE model, version 1 and version 2. Version 1 of the CGE model will be used for the CGE-only model while version 2 will be used for the linked TD-BU model. In the empirical analysis section, we start by using the CGE-only model before applying the linked TD-BU model. This is done for two main reasons. Firstly, in order to fully explain what happens in the CGE model as we increase social assistance transfers to poor households before we link the two models (CGE and microsimulation model). Secondly, in this model (CGE-only model), we are using more household groups which are disaggregated according to exogenous household characteristics and not only according to income level (which is the case in the linked TD-BU model, mainly to simplify the analysis¹³). Roberts and Zolkiewski (1996) argued that for purposes of simulation analysis,

¹³ Since at this point the linkage is done manually.

homogeneity of behavior and interests may be more important than homogeneity of income.

The two versions of the CGE model mainly differ in terms of closure rules¹⁴. In version 1 of the CGE model we use an investment-driven closure, where savings adjust to maintain a fixed level of investment. Having a fixed level of investment (investment-driven closure) in single period CGE analysis is argued to prevent misleading welfare effects that arise from diminishing capital stock in later periods. On the other hand in version 2 we have a savings-driven closure rule, where investment adjusts in order to maintain a fixed level of savings. This was done in order to facilitate the linkage where we initially fix marginal propensity to save (mps) and then relax it later after changing the hypothesis of the CGE model in order to make it fully determined (see Section 4.4 for detailed explanation of the linked TD-BU model). The details of the two versions of the CGE model are given in Section 4.2.1 and Section 4.2.2 respectively.

4.2.1 CGE Model version 1

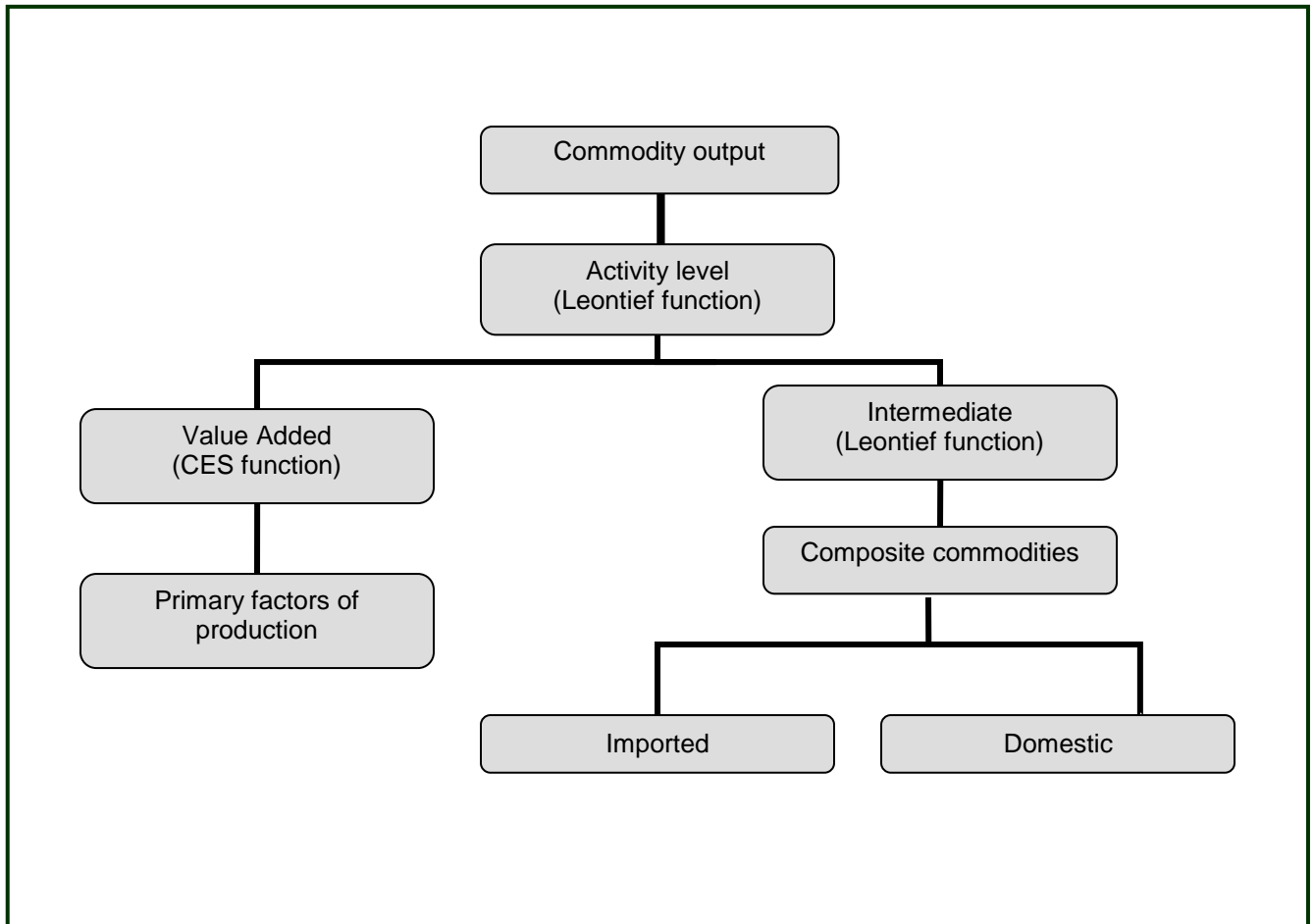
4.2.1.1 Basic model

We use a standard computable general equilibrium, which was developed by the international food policy research institute (Lofgren et al., 2002). The model is a static, single period CGE model. It can be classified as a neoclassical structuralist model, originally presented in Dervis de Melo and Robinson (1982). The neoclassical economic school of thought typically involves rational utility maximization or profit maximization using available information. The model was used because it has features which are of particular relevance to a developing economy, such as home consumption of non-marketed goods, the explicit treatment of transaction costs and separation between production activities and commodities that permit any activities to produce multiple commodities (e.g. dairy activity can produce commodities cheese, yoghurt and milk) and any commodity to be produced by multiple activities.

¹⁴ See Section 4.2.1.3 for detailed explanations of closure rules.

The main features of the model are standard so the description here is brief (see Lofgren et al., 2002 for a detailed description). Producers, each represented by a sector or activity, are assumed to maximize profits subject to their existing production technology. A nested structure of production is adopted. At the top level the producer must decide on the combination of intermediate inputs and factors of production (value added and intermediaries) to be used in the production process. For this purpose a Leontief function is used, hence intermediate input demands are in fixed proportions relative to the output of each activity. At a lower level of production, the producer decides on how to combine different factors of production, and for this purpose a constant elasticity of substitution (CES) function is used. Figure 4.1 gives a summary of the production structure.

Figure 4.1: Production technology



Source: Lofgren, 2002.

Final demand is met through either domestically produced goods or imported goods. Supply of these two is combined to form a composite good. Following Armington (1969), imported and domestic products are imperfect substitutes which allow for intra-trade. Substitution possibilities also 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 differentiates between exported and domestic goods. Under the small-country assumption, South Africa is assumed to face a perfectly elastic world demand at a fixed world price.

Households receive income from returns to factors of production and transfers from other institutions, for example transfers from the government, the rest of the world and from other households. They use this income to pay taxes, save, consume and to make transfers to other institutions. Household consumption is apportioned across different products according to a linear expenditure system (LES), derived from maximization of a Stone-Geary utility function. In the basic model, direct taxes and transfers to other institutions (apart from inter-household transfers) are defined as fixed shares of household income, whereas savings shares are flexible. All transfers to and from the rest of the world (ROW) are fixed in foreign currency. The government receives income from taxes and transfers from the rest of the world, which it spends on consumption and transfers. The enterprise receives income from factors of production and transfers from other institutions. It uses this income to pay for direct taxes, savings and transfers to other institutions.

A key feature of the CGE model is that it can only determine relative prices, making it necessary to choose some price or price index to define a *numéraire*. The producer price index (DPI) acts as a *numéraire* in the model.

4.2.1.2 Changes made to the standard Lofgren model

The present model modifies the standard Lofgren model in several respects.

Modification 1: Endogenous commodity taxes

Firstly, contrary to the Lofgren model which allows only direct taxes by firms and households to vary (being the only endogenous tax variable) thereby automatically becoming the only adjustable source of financing transfers, we endogenized commodity taxes, so that they can be used as an additional adjustable source of public revenue. This enables us to study different financing options. To do this the following equation was added to the standard Lofgren model:

$$tQ = \bar{tQ} * (1 + tQr), \quad (4.1)$$

where tQ is commodity tax rate, \bar{tQ} is the exogenous part of commodity tax rate, tQr is the scaling factor for commodity tax¹⁵.

Modification 2: Endogenous inter-household transfers

Secondly, given that inter-household transfers constitute a greater proportion (17% of total income for low income households; see Table 2.5 in Chapter 2) of the overall income of poor people in South Africa, these transfers were endogenized in the model¹⁶. This was done by calibrating a marginal propensity to transfer for all payers of transfers (MPT) and these transfers were then pooled into an aggregate amount which was then distributed according to a proportion for each household receiver.

Modification 3: Introduction of the wage curve

Thirdly, South Africa is an economy with high levels of unemployment; therefore we have incorporated imperfections in the labor market by a wage curve (Blanchflower and Oswald, 1990)¹⁷. The following wage curve equation was used:

¹⁵ The tax base is the quantity of commodity.

¹⁶ As proposed by Boccanfuso et al. (2013). However the main weakness of using this approach in endogenising household transfers is that transfers will only increase with income of the donors, whereas the income of the receivers plays no role.

¹⁷ The wage curve postulates a negative relationship between real wages and unemployment. The negative relationship can be explained by both the efficiency wage model and the wage bargaining power. According to the efficiency wage model, the firm motivates workers to be efficient by means of attractive salaries, but in situations of high unemployment the fear of losing their jobs forces workers to be more efficient. According to the bargaining power theory, trade unions are worried about both employed and

$$\frac{W}{CPI} = \Omega UN^\theta, \quad (4.2)$$

where W is the average wage rate, CPI is the consumer price index, UN is the unemployment rate, Ω is a scale parameter and θ is the unemployment elasticity of wages¹⁸. Parameter θ which describes marginal changes in the level of real wages following a change in unemployment is by assumption negative (See Blanchflower and Oswald (1995) for a graphical representation of the wage curve).

The wage curve was used instead of the conventional way of fixing nominal wage rate in CGE modeling, mainly because it gives a better reflection of reality. Mabugu et al. (2007) experimented with the conventional approach of modeling unemployment in CGE models of nominally fixing the wage rate for unskilled labor and found it unsatisfactory, since it leads to very high volatility and instability in skilled wage rates and the return on capital, as they are forced to handle more than their share of the factor market adjustment burden.

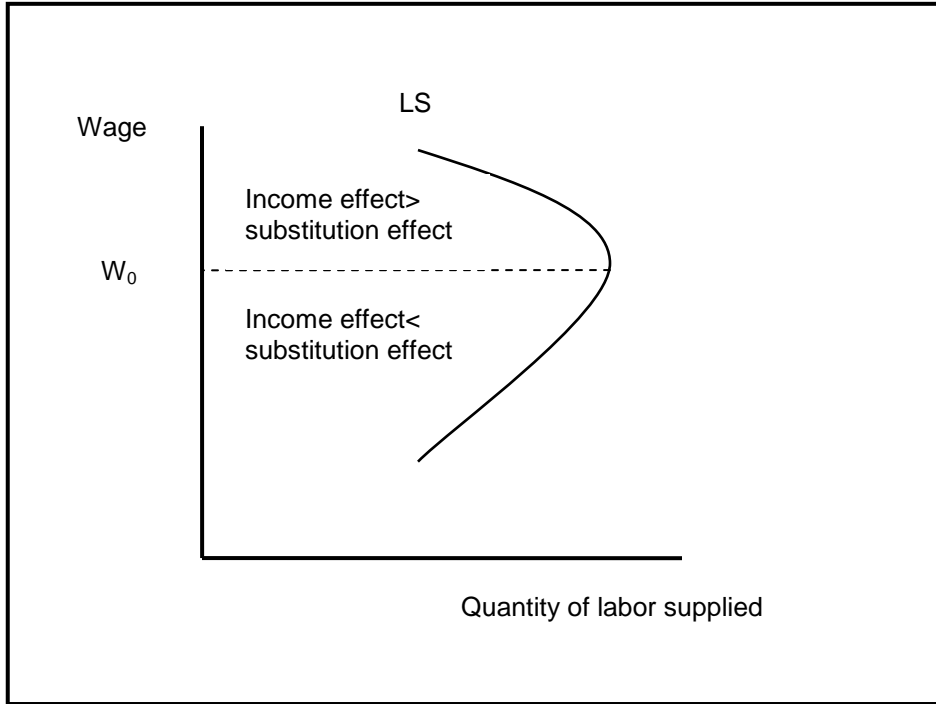
Modification 4: Endogenous labor supply

Lastly, labor supply was made endogenous in the model in order to capture its variations due to changes in disposable income. Endogenous labor supply was introduced into the model by extending a set of consumer goods to include leisure (see Annabi, 2003). Leisure is treated as a normal good, with an opportunity cost equal to the wage rate. An increase in the wage rate has both a substitution effect (SE) and an income effect (IE). An increase in the wage rate raises the opportunity cost of leisure and induces the consumer to work more (substitution effect), while on the other hand, an increase in the wage rate raises real income, thus increasing the consumption of normal goods, including leisure (income effect), and

unemployed members. High unemployment means that more of their members are likely to be unemployed and it will be difficult for those laid off to get a job. Hence an increase in unemployment may change unions' preferences towards increases in the number of jobs, which implies low pay.

decreasing the quantity of labor supply. Typically, the total effect takes the form of a backward bending labor supply curve.

Figure 4.2: Backward bending Labor supply curve



Source: Annabi, 2003.

Households maximize a Stone-Geary utility function subject to their budget constraints, yielding linear expenditure system demands. The consumer chooses between consumption of different consumer goods (C_{Hq}) and leisure time (l_H) as follows:

$$\text{Maximize: } U_H = \sum_{q=1}^n \beta_{Hq} \ln(C_{Hq} - \lambda_{Hq}) + \delta \ln(l_H - l^{\min}), \quad (4.3)$$

$$\text{Subject to: } Y_H^* = \sum_{q=1}^n P_q C_{Hq} + w l_H \quad (4.4)$$

$$\text{With } \sum_{q=1}^n \beta_{Hq} + \delta = 1, \quad (4.5)$$

where H denotes household groups and q denotes categories of goods. In addition, λ_{Hq} is minimum expenditure of good q , β_{Hq} is marginal budget share for good q , δ represents share of leisure in utility function¹⁹, P_q is price level, Y_H^* is potential income of household group H and l^{\min} is minimum leisure time²⁰.

This will yield the following consumer and leisure demand functions:

$$C_{Hq} = \lambda_{Hq} + \frac{\beta_{Hq}}{P_q} \left[Y_H^* - \sum_j P_j \lambda_{Hj} - w l^{\min} \right], \quad (4.6)$$

$$l_H = l^{\min} + \frac{\delta}{w} \left[Y_H^* - \sum_j P_j \lambda_{Hj} - w l^{\min} \right], \quad (4.7)$$

where $Y_H^* = Y_H + w l$, subscript j denotes all other goods and Y_H is total income.

The resulting demand functions are the sum of minimal and discretionary components (what is in parenthesis). Discretionary or supernumerary income represents income available after satisfaction of minimal consumption. From the maximization problem one derives consumer demand and leisure demand. Then labor supply can be derived from leisure demand, making use of the fact that total hours (T) are equal to working time plus leisure time (l).

4.2.1.3 Closure rules

In order to bring about equilibrium in various macro accounts, it is necessary to specify a set of macro-closure rules, which provide a mechanism through which adjustment is assumed to take place. In mathematical terms closure rules basically refer to different specifications of endogenous and exogenous variables²¹ (Weiss and Khan, 2006). The model includes three broad macroeconomic accounts: the

¹⁹ Parameters β and δ are assumed positive.

²⁰ Please note that δ and l^{\min} are not household specific, as we could not find household specific elasticity of labor supply (from previous studies) which is needed in order to calibrate these parameters. In addition labor supply is modelled according to skill type or labor category and not according to household groups in the model; this also explains why the wage rate is not household specific.

²¹ Closure rules ensure the equality of endogenous variables and equations.

government balance, the current account, and the savings and investment account. The specifications of the macro closures of the CGE model form an essential part of the process of adapting a real CGE model for macro analysis. Below is a brief description of these macro closure rules.

First, for external balance:

$$M + \text{transf}(\text{net}) - X = e\bar{F}, \quad (4.8)$$

where M denotes imports of goods and services, $\text{transf}(\text{net})$ is net foreign transfers (showing the net of both factor transfers to ROW and institutional transfers from ROW), X is exports of goods and services, F is capital import, i.e. savings or deficit of foreigners in the domestic country and Upper-case letters with a bar represents exogenous variables. In the model we are assuming a flexible exchange rate in order to maintain a fixed level of foreign savings. In other words, the external balance is held fixed in foreign currency. The trade balance is effectively held constant, since the remaining components of the external balance (i.e. transfers between the rest of the world and other domestic institutions) are all fixed in the model²². For example, if foreign savings are below the exogenous level this would induce depreciation in the real exchange rate, and this would result in a fall in imports and a rise in exports until the trade balance is restored to its original level.

Secondly, for savings and investment balance:

$$S_N + S_G + S_F = \sum_j P_j \bar{I}_j, \quad (4.9)$$

where S_N is non-governmental savings, S_G is government savings, S_F is foreign savings and I is investment. An investment-driven closure is assumed, in that the overall savings rate adjusts to maintain a fixed level of investment. In order to generate sufficient savings to equal the cost of investment, the savings rates of selected non-governmental institutions are adjusted until a balance is reached. In Johansen closure it is assumed that savings adjust through some forced savings mechanism imposed by the government. For example, the central bank can increase private banks' reserve requirement ratio, thereby forcing up interest rates

²² Apart from the exchange rate.

and promoting savings, or the government may be able to manage inflation and induce people to save. Johansen closure is argued to avoid misleading welfare effects that appear when foreign savings increase or real investment decrease since a single period analysis does not capture welfare losses in later periods that arise from a larger foreign debt or smaller capital stock.

Thirdly, the government balance equation can be written as follows:

$$R_G = E_G + \overline{S}_G, \quad (4.10)$$

$$\text{with } E_G = \sum_j P_j \overline{C}_{Gj}, \quad (4.11)$$

where R_G is government revenue, E_G is government spending, S_G is government savings, C_G is government consumption and P_j is the price vector of government consumption goods.

Government balance depends on the financing options used. The government closure calls for social assistance transfers to be financed by a reduction of funds available for other activities in the economy. We are keeping a balanced government deficit in all financing options. This helps to reduce some of the long term side effects of a large budget deficit such as inflation, high interest rates and the crowding out of private investment. The key government closure is subdivided into two different closure rules, each characterized by the flexibility of one tax scaling factor, while keeping the other fixed. In the first option all government items are fixed except for direct taxes to institutions. In the second option, commodity taxes are flexible. Government balance is held fixed in all two options.

Labor is assumed to be perfectly mobile across sectors, and is segmented by skill. Capital is fixed and fully employed, so the capital return is the equilibrating variable. Labor supply is endogenous and unemployment is present in every labor market segment. Both labor market employment and wages can vary after a shock. Labor market closure is made per type of labor, rather than per sector.

4.2.2 CGE Model version 2

The second CGE version differs only in terms of the closure rules, as explained in Section 4.2 before. CGE model (version 2) will be used for the linked TD-BU model. In this second version, we initially fix marginal propensity to save (which was flexible in the first version of the model) and then relax it later when we changed the hypothesis of the CGE model in order to make it fully determined (details of which will be given in the empirical section). Savings follows from fixed consumption and variable income and then investment in turn follows from savings. Lastly, in this version, labor supply and demand functions are exogenous, being taken from the MS model.

4.3 *Microsimulation model*

In this section we give a detailed description of the microsimulation model, which includes both the discrete choice model and the tax-benefit model. Here we will explain the basic model, while the details of the tax-benefit model will be given in Appendix A.

4.3.1 Basic microsimulation model

The model is a behavioral model which includes a discrete labor participation model and a detailed tax-benefit model. It closely follows that of Colombo (2010). The main difference is that given the topic under consideration, we have included a detailed tax benefit module. In addition the household expenditure system is modeled by a linear expenditure demand system, rather than a Cobb Douglas demand system. This was done mainly to increase the degree of heterogeneity between households²³. The model can be summarized by the following main equations:

$$YRD_h = \frac{1}{CPI_h} \left(\left[\sum_{i=1}^N \exp(LW_{hi}) * Z_{hi} + YK_h + TR_h + GT_h \right] - taxes_h \right), \quad (4.13)$$

²³ Linear expenditure demand system can accommodate non-unitary elasticities of demand and also allows for the representation of subsistence or minimum consumption. Savard (2010) argued that LES allows for the introduction of greater household heterogeneity by means of marginal budget shares, which can be household specific, unlike the Cobb Douglas demand system.

$$LW_{hi} = \alpha + \beta X'_{hi} + u_{hi} , \quad (4.14)$$

$$Z_{hi} = \text{ind} \left[\sigma + \gamma V'_{hi} + \pi_{hi} > 0 \right], \quad (4.15)$$

$$P_q C_{hq} = P_q \lambda_{h^* q} + \beta_{h^* q} (E_h - \sum_j P_j \lambda_{h^* j}) + \varepsilon_{hq}, \quad (4.16)$$

where subscripts are defined as follows:

h denotes households,

h^* denotes racial groups of households²⁴ ,

q denotes categories of goods,

i denote individual members of household h and

j denote all other goods.

Real disposable income²⁵, YRD_h (Equation 4.13) is calculated by subtracting taxes from total income and dividing by a household specific price index (CPI_h), and subtracting income taxes²⁶. LW_{hi} is log of wage earnings of individual i of household h , YK_h is capital income of household h , E_h is household expenditure, GT_h is government social assistance transfers and TR_h represents all other transfers (includes net transfer to rest of the world and net inter-household transfers).

Equation 4.14 is the wage earnings equation, where log of wage earnings (LW_{hi}) of individual i , of household h , is assumed to depend on a vector of observable personal or individual characteristics (X'_{hi}) and unobservable factor (u_{hi}). The participation or selection equation (Equation 4.15) is a binomial probit model, which consists of a vector of observable characteristics, V'_{hi} and

²⁴ The LES estimation was done separately for different racial groups, hence both marginal budget shares and minimum expenditure differ per racial group (see detailed explanation and results in Appendix C).

²⁵ Real disposable income is needed for inequality and poverty analysis.

²⁶ Tax was calculated from the tax module (we applied South African tax rules and regulations to calculate respective household taxes). See next chapter for a detailed description of the tax module.

unobservable part π_{hi} . The vector of observable part V'_{hi} consists of different individual characteristics together with disposable predicted wage rate (see Appendix B for a detailed description of variables included).

Household consumption expenditure is modeled by a linear expenditure system, where the demand function (Equation 4.16) is the sum of the minimal (λ_q) and discretionary components (what is in the parenthesis).

Income variables in Equation 4.13 are derived by summing up individual data for all members of each household. For example, capital income of household h (YK_h) is calculated as follows:

$$YK_h = \sum_{i=1}^N YK_{hi}, \quad (4.17)$$

where N is total number of household members .

Capital income for each household is calculated by multiplying capital stock of each household by the return on capital PK as follows:

$$YK_h = PK * KS_h. \quad (4.18)$$

Initial values of both capital stock (KS) and labor endowment (L) are obtained from survey data, making use of the working assumption that all prices and returns are equal to one at the benchmark. Household specific consumer price index (CPI) is derived by multiplying household consumption shares φ_{hq} by the price level (P_q):

$$CPI_h = \sum_{q=1}^n \varphi_{hq} * P_q, \quad (4.19)$$

$$\text{where } \varphi_{hq} = \frac{P_q * C_q}{E_h}. \quad (4.20)$$

Savings of household h (S_h) are assumed to be a fixed share of household disposable income YD_h , as follows:

$$S_h = mps_h * YD_h, \quad (4.21)$$

where YD_h is defined as follows:

$$YD_h = YRD_h * CPI_h. \quad (4.22)$$

To get marginal propensity to save, the initial data from the survey were used as follows:

$$mps_h = \frac{S_h}{YD_h}. \quad (4.23)$$

Household consumption budgets were derived by subtracting savings from disposable income:

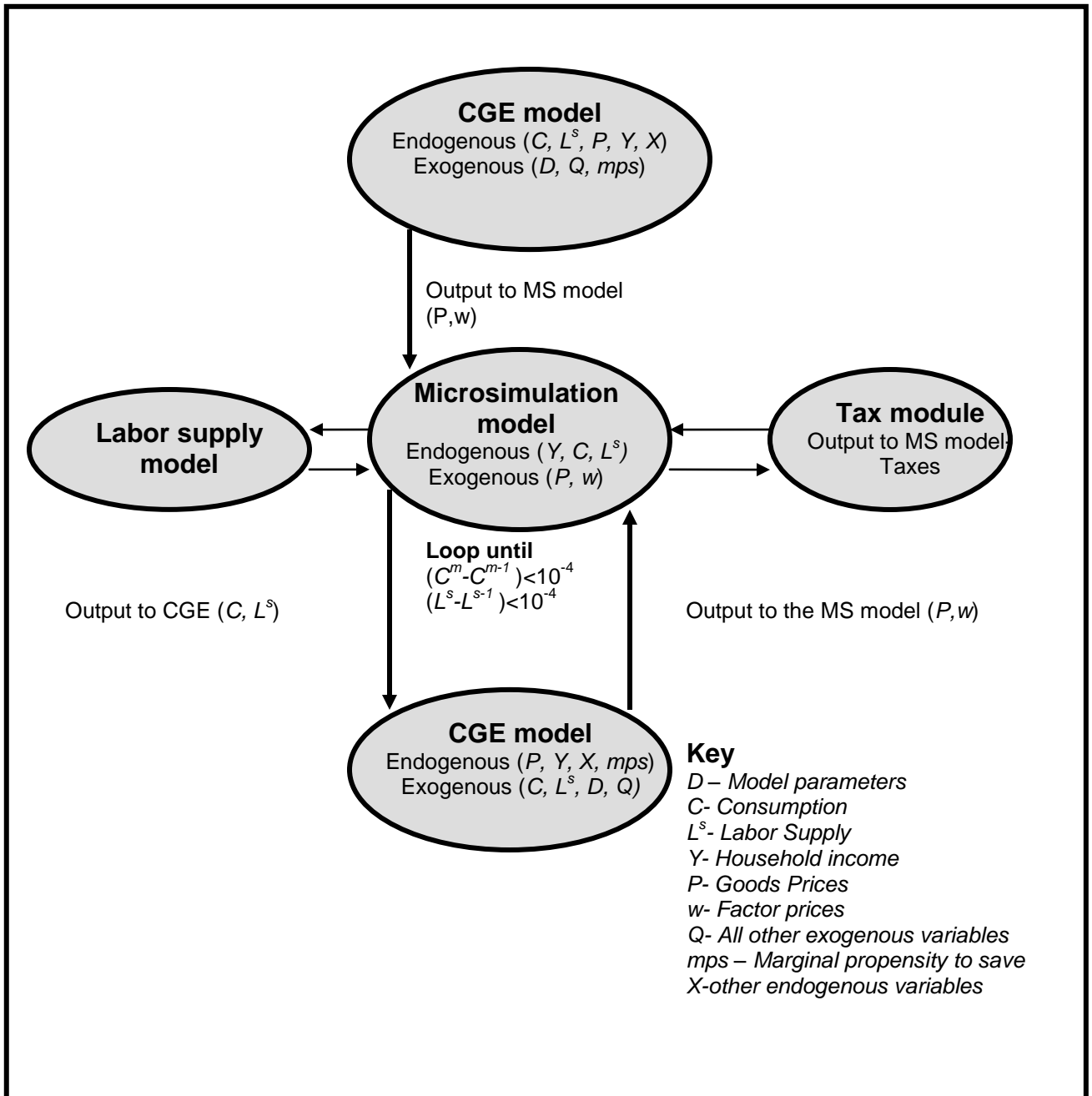
$$E_h = YD_h - S_h. \quad (4.24)$$

From the MS model three equations will be estimated: the log earnings equation, the selection equation and the LES equation. Estimation details for these equations will be given in Chapter 5.

4.4 CGE-Microsimulation model

The present work relies on a bi-directional (top-down, bottom-up) model similar in many respect to that of Savard (2003) and Bourguignon and Savard (2008). In this part of the model CGE version 2 (as explained in Section 4.2.2) will be used. The model differs from that of Savard (2003) in that we included a detailed tax module. Figure 4.3 gives a summary of the model.

Figure 4.3: Linked CGE-Microsimulation model



Source: Savard, 2003 with some modifications.

The CGE model solves for prices which equilibrate the model (change in commodity prices ΔP^m and change in factor prices Δw^m). Price changes were fed into the MS model to get new aggregated and weighted consumption and labor

supply vectors. After the first run, price changes were fed into the MS model as follows:

$$YRD_h^m = \frac{1}{CPI_h^m} [(YL_h^m + YK_h^m + TR_h + GT_h) - taxes_h^m], \quad (4.25)$$

$$P_q^m C_{hq} = P_q^m \lambda_{h^*q} + \beta_{h^*q} (E_h^m - \sum_j P_j^m \lambda_{h^*j}), \quad (4.26)$$

All variables are defined as before, superscript m on all variables denotes variable at iteration m . In addition vectors P^m and w^m at iteration m and are calculated as follows:

$$P_q^m = 1 + \Delta P_{qCGE}^m, \quad (4.27)$$

$$w^m = 1 + \Delta W_{CGE}^m. \quad (4.28)$$

The MS model generates commodity demand and labor supply vectors which are weighted by inverse probability weights²⁷ and aggregated and then transferred as inputs to the CGE model, where they will be exogenous. For example aggregated consumption at iteration m is calculated as follows:

$$Agg.Cons^m = \sum_h W_h C_{hq}^m H_h, \quad (4.29)$$

where W_h represents weights, C_{hq} is consumption and H_h is total number of households per group. The CGE model then determines a temporary equilibrium which is consistent with the predetermined level of consumption and labor supply variables. New price changes $(\Delta P_q^{m+1}, \Delta w^{m+1})$ will again be calculated in the CGE

²⁷ The probabilities are survey participation probabilities.

model, which will be fed back to the MS model. The iteration continues until the difference between the two consecutive iterations are close to zero. In the first run of the CGE model both consumption and labor supply are endogenous and in the second CGE model these variables are made exogenous. This was mainly done in the CGE model in order to reproduce behavior which we have in the MS model (since both consumption and labor supply are endogenous in the MS model) in order to facilitate convergence. After the first run the hypotheses of the CGE model were changed to make it fully determined. Firstly, the consumption demand equations were removed in the CGE model, and replaced by the following equation:

$$E_H = \sum_q P_q C_{hq} , \quad (4.30)$$

where total expenditure (E_H) is defined as the sum of the product of prices and quantities of all commodities. Secondly, the leisure demand equation was removed from the CGE model and labor supply was made exogenous in the CGE model. Following Savard (2003), marginal propensity to save was endogenized in order to ensure balance of the household budget.

The linked model can take into account full agent heterogeneity and consider feedback effects that arise from endogenizing prices in the CGE model. The two models should be regarded as complements. The CGE model, unlike the MS model, does not fully account for heterogeneity of household behavior and it assumes that intra-group variance is zero. On the other hand the MS model is a partial equilibrium model, which does not account for general equilibrium effects. The main role of the MS module in a linked framework is to provide a detailed computation of net incomes at the household level through a detailed description of the tax-benefit system of the economy, and to estimate individual behavioral responses to policy change.

CHAPTER 5

IMPUTATION, ESTIMATION AND CALIBRATION OF PARAMETERS

This chapter deals with the estimation, imputation and calibration of model parameters. The first section introduces the data sources. The second section gives imputation of taxes and social assistance. The third section shows how the discrete labor supply parameters have been derived, while the last section gives the estimation and calibration of the linear expenditure system.

5.1 Data Sources

5.1.1 Microsimulation dataset

For purposes of the model estimation and simulation we used a merged South African Income and Expenditure Household Survey (IES) and Labor Force Survey (LFS) for the year 2000. The two datasets were prepared at the same time, with the same respondents interviewed, so the two could be merged. The IES was used as the primary data set, since it contains detailed information on household income and expenditures required for tax and benefit calculations. The LFS provides detailed employment information for individual members at working age and also the relationships of household members. The LFS was used as the main source of demographic and employment data. The year 2000 was used as the base year for two main reasons. Firstly, the social accounting matrix (SAM) is also for that particular year; this is important since we intend to merge the two models (the CGE and microsimulation models). Secondly, it is mainly in this particular year where the two surveys were conducted at the same time, which makes it possible to merge the two surveys and get a detailed dataset needed for the tax and benefit model.

In order to adjust and correct for data inconsistencies, we closely followed work which was done by the ‘Provide’ project (see Pauw, 2005). Raw data came in ‘The American Standard Code for Information Interchange’ (ASC11) fixed width text files. Different dictionaries were created and used to read data into STATA, and various do-files were used to extract, correct, merge and impute missing data (see Pauw (2005) for a detailed explanation of how it was carried out). After all necessary adjustments, data was then mapped into different income and expenditure groups according to what we have in the social accounting matrix.

5.1.2 CGE data set

We used a South African Social Accounting Matrix that was developed by Thurlow and van Seventer (2002) under the auspices of the International Food Policy Research Institute (IFPRI) in order to capture the base year structure of the South African economy. The original SAM consists of 43 sectors, 14 household types, government sector, enterprise and the rest of the world. In this study, an aggregated version of this SAM that includes five sectors, four factors of production and 64 household groups is used. Table 5.1 gives the schematic of the social accounting matrix used.

Table 5.1: Schematic structure of the social accounting matrix (SAM) for South Africa

	Activities (1)	Commodities (2)	Factors (3)	Household (HH) (4)	Enterprise (Ent) (5)	Government (Govt) (6)	Sav- Inv (7)	ROW (8)	Total
Activities (1)		Marketed output							Activity income
Commodities (2)	Intermediat e demand	Transaction costs		Household consumption		Government consumption	Inv	Exports	Total demand
Factors (3)	Value added							Factor inc	Factor inc
Households (HH) (4)			Factor inc to HH	Inter-household transfer	Surplus to HH dividends	Gov transfers to HH		Transfer to HH	HH income
Enterprise (Ent)(5)			Factor inc to Ent			Transfer to enterprise		Transfer to enterprise	Ent income
Government (Govt) (6)	Activity taxes	Commodity taxes	Factor inc to Govt	Personal income tax	corporate tax			ROW Transfer to Govt	Govt income
Savings- Investment (7)				Household savings	Enterprise savings	Government savings		Foreign savings	Savings
Rest of the world (8)		Imports	Factor income to ROW		Surplus to ROW	Transfer to ROW			Foreign outflows
Total	Activity	Supply expenditure	Factor expenditure	Household expenditure	Enterprise exp	Government expenditure	Inv	Foreign inflow	

Source: Lofgren, 2002.

Note: "Sav" is savings, "Inv" is investment, inc is income and "ROW" is rest of the world.

The disaggregated social accounting matrix includes five sectors (activities) and five commodities, grouped as follows:

- Agriculture—which consists of agriculture, mining and textiles as follows: agriculture, fishing, forestry, gold, coal, other mining, textiles, apparel, leather and footwear, referred to as *agri*.
- Food—comprising food, beverages and tobacco, referred to as *food*.
- Manufacturing—comprising manufacturing, petroleum and vehicle as follows: paper products, printing, rubber, plastic, glass, non-metal mineral products, iron, non-ferrous metals, machinery, electric machinery, communication equipment, scientific equipment, other industries, wood, metal products, furniture, petroleum, vehicles and transport equipment referred to as *manf*.
- Capital Goods—comprising electricity, water, construction, basic chemicals and other chemicals referred to as *capg*.
- Services—comprising wholesale, trade, hotels and accommodation, transport services, communication, finance and insurance, business services, medical and other services, other producers and government services, referred to as *serv*.

The social accounting matrix identifies four factors of production: highly skilled labor (*Labhi*), skilled labor (*Labmed*), unskilled labor (*Lablo*) and capital. Table 5.2 gives detailed categories of labor according to different occupations.

Table 5.2: Description of labor categories

Labor category	Occupation categories
Highly skilled	Professional, legislators, senior officials, technical, managerial and administrative occupations
Skilled	Clerical, sales, transport, skilled agricultural and fishery workers, service workers, craft and production workers
Unskilled	Elementary, domestic workers and all other unspecified occupations

Source: *Own table*

All labor categories are assumed mobile across sectors and wages are crucial for income distribution. Unlike in the IFPRI SAM, where households are identified according to income level (an endogenous variable in the model), in this thesis households are classified taking into account exogenous characteristic of the representative groups. This was done mainly because households could be mobile between income groups. Hence in this thesis we have disaggregated households according to social characteristics such as race, location, gender, education and income level of household head, as shown on Table 5.3.

Table 5.3: Disaggregation of households

Representative group (Rhg)	Race				Location		Gender		Education Level		Income Level	
	African	Whites	Asians	Colored	Urban	Rural	Male	Fe	L	H	L	H
1	✓				✓		✓			✓	✓	
2	✓				✓		✓			✓		✓
3	✓				✓		✓		✓		✓	
4	✓				✓		✓		✓			✓
5	✓				✓			✓		✓	✓	
6	✓				✓			✓		✓		✓
7	✓				✓			✓	✓		✓	
8	✓				✓			✓	✓			✓
9	✓					✓	✓			✓	✓	
10	✓					✓	✓			✓		✓
11	✓					✓	✓		✓		✓	
12	✓					✓	✓		✓			✓
13	✓					✓		✓		✓	✓	
14	✓					✓		✓	✓			✓
15	✓					✓		✓	✓		✓	
16	✓					✓		✓	✓			✓

Source: Own diagram.

Note: 1. L denotes low income households, H denotes high income households and Fe denotes female.

2. The same level of aggregation applies for the other three racial groups (whites, Asians and Coloreds) which gives a total of 64 household groups.

For example the first representative household groups will be:

Rhg1-Urban African, male headed, high educated and low income households.

Some household groups were dropped since they did not have enough households (see Table E.1 in the Appendix E for details). Disaggregating households according to racial groups was mainly driven by the South African history; during the apartheid era there were large differences in income levels of different racial groups. Educational levels were used in order to capture the skill dimension. Evidence in South Africa suggests a high correlation between education and employment status (Bhorat et al., 1999).

We have used the Income and Expenditure Survey of 2000 and the Labor Force Survey of September 2000 to form these household groups (the same data set used for the MS model). Expenditure items were grouped into the following

groups: commodities, inter-household transfer payments, income taxes, household savings, and household transfers to the rest of the world. Commodities were first grouped into 96 groups according to the Standard Industrial Classification (SIC), and later on aggregated into 5 groups (as described before). Income items were grouped into the following groups, again according to what we have in the social accounting matrix: labor income, capital income, income from government transfers, household transfer income, and household transfer income from rest of the world. To calculate the actual figures for respective household income and expenditure items, the aggregate household items from the standard social accounting matrix were used as control totals in order to ensure consistency. Finally, the RAS technique was used to balance the SAM. This technique produces a new transaction matrix that is consistent with new row and column totals by reciprocally adjusting row and column totals proportionately. This technique was found to be appropriate in this case of starting with an older SAM, since it assumes the SAM is consistent. Table 5.4a gives the numeric aggregated social accounting matrix for South Africa.

Table 5.4a: Numeric aggregated SAM for South Africa

R'm	Act	Com	TC	Lab	Cap	Firms	HH
Act	-	1 616 976.10	-	-	-	-	-
Com	808 589.11	-	155 804.00	-	-	-	556 506.94
TC	-	155 804.00	-	-	-	-	-
Lab	424 958.54	-	-	-	-	-	-
Cap	363 293.65	-	-	-	-	-	-
Firms	-	-	-	-	335 386.08	-	-
HH	-	-	-	423 214.86	-	206 168.66	-
Gov	-	-	-	-	7 659.21	572.30	846.69
Tax	20 188.80	79 994.00	-	-	-	28 444.64	99 125.36
S-I	-	-	-	-	-	151 583.20	3 122.31
Dstk	-	-	-	-	-	-	-
Row	-	229 717.92	-	1 743.68	3 5749.22	81.70	117.18
Total	1 616 976.10	208 249 2.02	155 804.00	424 958.54	378 794.51	386 850.51	659 718.47

SAM continued...

R'm	Gov	Tax	S-I	Dstk	Row	Total
Act	-	-	-	-	-	1 616 976.10
Com	166 293.04	-	132 016.42	4 011.69	259 270.82	2 082 492.02
TC	-	-	-	-	-	155 804.00
Lab	-	-	-	-	-	424 958.54
Cap	-	-	-	-	15 554.86	378 794.51
Firms	51 464.43	-	-	-	-	386 850.51
HH	30 080.79	-	-	-	254.16	659 718.47
Gov	-	227 752.80	-	-	473.23	237 304.23
Tax	-	-	-	-	-	227 752.80
S-I	-17 311.57	-	-	-	-1 365.83	136 028.12
Dstk	-	-	4 011.69	-	-	4 011.69
Row	6 777.55	-	-	-	-	274 187.25
Total	237 304.23	227 752.80	136 028.12	4 011.69	274 187.25	

Source: Thurlow, 2005.

Note: Abbreviations used in the SAM are described in Table 5.4b below.

Table 5.4b: Description of variables used in the social accounting matrix (SAM)

Variable	Description
Act	Activities
Com	Commodities
TC	Transaction costs
Lab	Labor
Cap	Capital
Firms	Firms
HH	Representative households (aggregated)
Gov	Government
Tax	Taxes (all taxes aggregated)
S-I	Savings-investment balance
Dstk	Stock
Row	rest of the world

5.1.3 Other data inputs

A number of additional data inputs were necessary to calibrate or initialize the model. Trade elasticities data for the Armington and transformation functions and substitution elasticities between factors of production (bottom of technology) were taken from Thurlow (2002). Wage curve elasticities, were taken from Kingdom and Knight (1999). Table 5.5 gives a list of all model parameters and data sources.

Table 5.5: Model parameters

Parameter	Value	Data Source
Trade elasticity- Armington elasticity:		
c_agri	2.191	
c_food	1.535	Thurlow,2002
c_manf	2.372	
c_capg	1.014	
c_services	0.643	
Trade elasticity- Constant elasticity of transformation:		
	2.000	Thurlow,2002
Elasticity of substitution between factors:		
i_agri	0.450	
i_food	0.166	Thurlow,2002
i_manf	0.337	
i_capg	0.500	
i_services	0.500	
Output aggregation elasticity for commodity:		
	4.000	Thurlow,2002
Household consumption expenditure elasticities:		
c_agri	Low income: 0.935 High income:1.622	
c_food	Low income: 0.627 High income: 1.044	From own estimation
c_manf	Low income: 1.462 High income: 0.809	
c_capg	Low income: 1.266 High income: 1.532	
c_services	Low income: 1.909 High income: 0.788	
Elasticity of labor supply with respect to income		
	0.120	Annabi, 2003
Frisch parameters for household LES demand		
	Low income: 1.489 High income: 1.032	From own estimation
Unemployment rates:		
Labhi	0.179	
Labmed	0.219	
Lablo	0.259	
Wage curve elasticity:		
Labhi	-0.112	
Labmed	-0.115	Kingdom and Knight, 1999
Lablo	-0.117	

5.2 Imputation of tax benefit module variables

South African tax rules were applied to taxable income after making respective deductions, in order to calculate taxes. We also imputed social assistance transfers (assistance) in the model. Detailed explanation of how taxes and social assistance transfers were calculated or imputed and a comparison of imputed results and official statistics are given in Appendix A.

5.3 Estimation of model parameters

From the MS model, presented in Section 4.3 before, three equations need to be estimated. These include the wage earnings equation (Equation 4.14), the selection model equation (Equation 4.15) and the linear expenditure system (Equation 4.16). The wage earnings equation was estimated using a Heckman two-step model, in order to correct for sample selection bias, stemming from the fact that we only observe a positive wage for individuals who were working at the time of the survey. The selection equation was estimated separately using maximum likelihood techniques. Estimation of these two equations was done on a subsample comprising only those at working age that is 16 to 64 years. Estimation was done separately for two demographic groups, single individuals and married couples. Detailed estimation procedures and results for the wage earnings equation and selection model are presented in Appendix B.

In order to replicate the observed labor market statuses given in the survey for the base year period, we used a calibration method which follows that of Duncan and Weeks (1998) and Bourguignon et al. (2003). This approach exploits the fact that we have information about choices of individual households in the initial situation, which can be used to transform utility evaluations of disposable income into conditional probabilities. The procedure requires drawing error terms for each individual from the normal distribution. Only 100 error terms which retain observed labor market choices after adding them to the deterministic part were selected. Hence error terms were chosen in such a way that:

$$\sigma_{hi} + \gamma \mathcal{V}'_{hi} + \varepsilon_{hi} > 0, \quad (5.1)$$

for all those observed to be working in the survey and vice versa for those not working. These residuals are kept constant in all simulations and only the deterministic part changes. The approach gives individual probabilities of choosing between two alternatives. The main advantage of the approach is that it makes use of most information in the initial dataset, including actual choices of individuals.

We used demographic translating²⁸ in order to introduce demographic variables into the linear expenditure system. STATA's NLSUR command was used in order to estimate all five commodity equations simultaneously while accounting for the possibility of correlated errors as values of the different expenditure categories were collected from the same set of households. Estimation of the linear expenditure system was done separately for different racial groups. Appendix C presents estimation procedures and results of the linear expenditure system.

5.4 Calibration of LES parameters for the CGE model

5.4.1 CGE version 1

Version 1 of the CGE model²⁹ has an endogenous labor supply model. From before (Section 4.2.1.2) maximization of a Stone-Geary utility function yielded Equations 4.6 and 4.7. The resulting demand functions are the sum of minimal and discretionary consumption (which is in parenthesis). Discretionary or supernumerary income represents income available after satisfaction of minimal consumption. From the maximization problem one derives consumer demand and leisure demand. To get the labor supply function we employed the fact that, total available time (T) is equal to working time (LS) plus leisure time (l), that is: $T = LS + l$, which implies that $LS = T - l$ and also the fact that total income (Y) is

²⁸ According to Pollak and Wales (1981), demographic translating means allowing necessary or subsistence parameters of a demand system to depend on demographic variables. This differs from demographic scaling Barten (1964), where a demand system is modified in order to incorporate commodity specific adult equivalent scales (Pollak and Wales (1981)).

²⁹ See section 4.2 for a detailed explanation of why we are using different versions of the CGE model.

equal to labor income plus non-labor income (y). With a few manipulations we get the following consumer demand and labor supply equations³⁰:

$$C_{Hq} = \lambda_{Hq} + \frac{\beta_{Hq}}{(1-\delta)P_q} \left[Y_H - \sum_j P_j \lambda_{Hj} \right], \quad (5.2)$$

$$LS = LS^{\max} - \frac{\delta}{(1-\delta)w} \left[\sum_H Y_H - \sum_H \sum_j P_j \lambda_{Hj} \right]. \quad (5.3)$$

Where now, Y_H represents total income and $LS^{\max} = T - l^{\min}$.

We followed the calibration method proposed by Dervis et al. (1982), which consists of selecting income elasticities of demand, income elasticity of labor supply and Frisch parameters outside the model and calibrating the minimum expenditures and marginal budget shares parameter that will balance out the household's budget constraint. In the model we used income elasticity of demand and Frisch parameters from the estimated linear expenditure demand system before (see Tables E.3 and E.4 in Appendix E).

Firstly, we used income elasticities of labor supply (ε_{LS}) to solve for share of leisure (δ). Income elasticity of labor supply (LS) is calculated as follows, from the labor supply Equation 5.3 given before:

$$\varepsilon_{LS} = \frac{\partial LS}{\partial Y} \frac{Y}{LS} = - \frac{\delta}{(1-\delta)w} \frac{Y}{LS}, \quad (5.4)$$

where $Y = \sum_H Y_H$.

Solving for leisure shares δ ,

$$\frac{\delta}{1-\delta} = \frac{\varepsilon_{LS} LS w}{Y}. \quad (5.5)$$

³⁰ For detailed derivations see Annabi, 2003.

Secondly, we used income elasticities of demand (ε_{yq}) to solve for marginal budget shares (β_q). Income elasticity of demand is calculated as follows, from the LES Equation 5.2 before:

$$\varepsilon_{yq} = \frac{\partial C_{Hq}}{\partial Y_H} \frac{Y_H}{C_{Hq}} = \frac{\beta_{Hq}}{(1-\delta)P_q} \frac{Y_H}{C_{Hq}}. \quad (5.6)$$

Solving for marginal budget shares β_{Hq} ,

$$\beta_{Hq} = \varepsilon_{yq} \frac{(1-\delta)P_q C_{Hq}}{Y_H}. \quad (5.7)$$

To solve for minimum expenditure (λ_{Hq}) we used Frisch parameters, which is the negative of ratio of total expenditure to discretionary expenditure. Initially solve for λ_{Hq} from the consumption expenditure Equation 5.2 before to get:

$$\lambda_{Hq} = C_{Hq} - \frac{\beta_{Hq}}{(1-\delta)P_q} \left[Y_H - \sum_j P_j \lambda_{Hj} \right]. \quad (5.8)$$

But we know that Frisch is given as the negative of the ratio between income or expenditure and discretionary income or expenditure.

$$Frisch_H = - \frac{Y_H}{Y_H - \sum_j P_j \lambda_{Hj}}. \quad (5.9a)$$

$$\text{This implies that: } Y_H - \sum_j P_j \lambda_{Hj} = - \frac{Y_H}{Frisch_H}. \quad (5.9b)$$

Substituting Equation 5.9b, in Equation 5.8 we get:

$$\lambda_{Hq} = C_{Hq} + \frac{\beta_{Hq}}{(1-\delta)P_q} \left[\frac{Y_H}{Frisch_H} \right]. \quad (5.10)$$

5.4.2 CGE version 2

In the CGE version 2, labor supply is fixed³¹. Household consumption expenditure was modeled by a linear expenditure demand system (Equation 4.16). We again followed the calibration method proposed by Dervis et al. (1982), which consists of selecting income elasticities and Frisch parameters outside the model and calibrating the λ_{Hq} and β_{Hq} parameters that will balance out the household's budget constraint. We again used income elasticity from the estimated LES function in the MS model, for calibration purposes. Firstly, we used income elasticities of demand (ε_{yq}) to solve for marginal budget shares (β_{Hq}). Income elasticity of demand is calculated as follows, from the LES Equation 4.16 (after dividing by P_q throughout) before.

$$\varepsilon_{yq} = \frac{\partial C_{Hq}}{\partial Y_H} * \frac{Y_H}{C_{Hq}} = \frac{\beta_{Hq}}{P_q} * \frac{Y_H}{C_{Hq}}. \quad (5.11)$$

Solving for marginal budget shares β_{Hq} ,

$$\beta_{Hq} = \varepsilon_{yq} * \frac{P_q C_{Hq}}{Y_H}. \quad (5.12)$$

To solve for minimum expenditure (λ_{Hq}) we used Frisch parameters, which is the negative of the ratio of total expenditure to discretionary expenditure; initially solve for λ_{Hq} from the consumer demand Equation 4.16 before to get:

$$\lambda_{Hq} = C_{Hq} - \frac{\beta_{Hq}}{P_q} \left[Y_H - \sum_j P_j \lambda_{Hj} \right]. \quad (5.13)$$

But we know that Frisch is given as the negative of the ratio between income or expenditure and discretionary income or expenditure.

$$Frisch_H = - \frac{Y_H}{Y_H - \sum_j P_j \lambda_{Hj}}. \quad (5.14)$$

³¹ Since it was taken from the MS model.

Substituting the Frisch parameter in Equation 5.14 above and factoring out (Y_H/P_q) , we get:

$$\lambda_{Hq} = \frac{Y_H}{P_q} \left[\frac{P_q C_{Hq}}{Y_H} + \frac{\beta_{Hq}}{Frisch_H} \right]. \quad (5.15)$$

The calibration procedure explained above results in household specific minimum expenditure (λ_{Hq}) and marginal budget shares (β_{Hq}), hence the resulting consumption demand functions will not aggregate perfectly. The linear expenditure consumption demand system will only aggregate perfectly when marginal budget shares (β_{Hq}) are equal for all households (see Cogneau and Robilliard, 2007). This result is known in literature as Gorman aggregation result. Gorman (1953) considers the question ‘under what condition can individual preference be aggregated so that aggregate demand functions act as if they were derived from a single individual preference?’ He concluded that this will be possible if, and only if consumer demand functions are linear with the same slope as follows.

$$X^i = A^i(P) + B^i(P)Y^i, \quad (5.16)$$

where Y^i represent income, $A^i(P)$ represents the intercept and $B^i(P)$ is the slope.

Demand curves will only aggregate perfectly if $B^i(P)$, the slope (marginal budget shares in our case), is constant for all individuals. That is, exact linear aggregation condition requires households to have parallel linear Engel curves, which implies that households would spend the same share of their excess budget on each commodity at every point of their income distribution.

We did not make marginal budget shares equal for all households, since choosing the same marginal budget shares will not balance out the household’s budget constraint. As previously stated, we selected income elasticities and Frisch parameters outside the model and calibrated minimum expenditure and marginal

budget shares parameters which are household specific in order to balance out the households' budget constraint.

CHAPTER 6

RESEARCH ANALYSIS AND RESULTS

In the first part (Section 6.1) of this chapter the analysis will be done using only the CGE model since we want to fully explain what happens in the CGE model as we increase social assistance transfers to poor households before we link the two models (CGE and MS models). In addition we also want to incorporate more household heterogeneity in the CGE model, by considering more household groups (64 household groups) which were disaggregated according to exogenous household characteristics³². In the second part of this chapter (Section 6.2) we will then apply a linked top-down, bottom-up model and consider only two representative household groups. Lastly, in the final part of the chapter we will do a comparative analysis of the TD-BU model and the MS-only model.

6.1 CGE model

6.1.1 Policy experiments

In the analysis here, we use the CGE version 1 model which was explained in Section 4.2.1. We double social assistance transfers to low income households in our simulations (those whose income is below 40% of total gross income). In order to balance the government budget, we experiment with two different financing options.

Option 1: Direct taxes to households and firms.

Option 2: Increase in commodity taxes.

6.1.2 Simulation results

Table 6.1 gives a summary of changes in macroeconomic variables following an increase in social assistance transfers to low income households under the two afore-mentioned

³² This may be more demanding in our linked model since the iteration between the two models is done manually at this stage.

different financing options. The discussion will be done per each financing option after the table.

Table 6.1: Simulation Results

Variable	Transfers financed by:	
	Direct taxes (Option 1) (%)	Commodity Tax (Option 2) (%)
Absorption	0.028	-1.086
Private Consumption	0.044	-1.676
Private Inv	-----	-----
Government Cons	-----	-----
Exports	0.161	-0.888
Imports	0.182	-1.003
CPI	0.002	1.425
Exchange rate		
(LCU per FCU)	-0.045	0.198
Factor returns:		
Unskilled labor	0.090	-0.587
Skilled labor	-0.017	-0.900
Highly skilled labor	-0.033	-1.092
Capital	-0.005	-4.872
Unemployment:		
Unskilled labor	-0.745	5.160
Skilled labor	0.166	8.216
Highly skilled labor	0.315	10.302
Labor supply:		
Unskilled labor	-0.017	-1.144
Skilled labor	-0.005	-1.108
Highly skilled labor	-0.004	-1.086

Note: "cons" is consumption, "inv" is investment and "CPI" is consumer price index. Exchange rate is expressed in terms of local currency unit (LCU) per foreign currency unit (FCU).

Option 1

Macroeconomic results for option 1 are given in the first column of Table 6.1. For this option, direct tax to households and firms is considered as an endogenous variable and adjusted to levels required to finance social assistance transfers to low income households (those whose income is below 40% of total gross income). As a first round effect an increase in social assistance transfers causes a corresponding increase in income for low income households. This will induce an increase in demand for commodities consumed in higher proportion by low income households, for example agricultural and food products³³. Production levels of items such as agriculture and food have witnessed an increase in their supply (see Table E.2 in the Appendix E).

In addition there is a second round effect, stemming from the following reasons; firstly, increased commodity prices in the economy led to a higher consumer price index, which lowers real income of all households. Secondly, firms respond to an increase in consumer demand by increasing production of commodities which are demanded in higher proportion by low income households. Since these commodities make use of a relatively high percentage of low skilled labor, there would be an increase in employment of unskilled labor and an increase in factor returns for unskilled labor (0.090%); thereby further increasing incomes of low income households, as they derive their factor income mainly from unskilled labor. A decrease in employment of high skilled income is mainly due to a fall in the output of sectors that produce goods using highly skilled technologies (for example capital goods). This follows a decrease in consumption of these commodities by high income households who mainly demand them. Thirdly, in order to maintain a balanced budget deficit the government will increase direct taxes on domestic institutions, which decreases levels of disposable income and partially offset increases in consumption. To maintain a progressive tax structure, tax rates for high income households increase by more than that for low income households.

³³ The overall impact on private consumption depends on relative MPC, as explained on the next page.

The overall impact on private consumption depends on the relative marginal propensity to consume of low income households (those gaining income) and high income households (those losing income). If the marginal propensity to consume of those gaining income is higher than that of those losing income then, *ceteris paribus*, private consumption will increase. For option 1 there is an overall increase in private consumption of 0.044%.

In sum, those in low income groups benefit from a rise in real income. The total effect on household income is positive for all those in the low income group and negative for all those in the high income group (see Table E.5 in Appendix E). Hence low income households do benefit not only from receiving transfers but also from indirect (second round effects) induced by expenses of their original transfers.

Due to the Johansen closure (fixed investment), investment will not decrease following this increase in consumption by low income households, but instead, savings of domestic institutions should adjust to maintain a savings-investment balance. Exports also increase due to the increase in the total supply of goods and services in the economy, but since low income households spend the bulk of their income on domestically produced goods, imports would not increase much initially. This would call for a slight appreciation of nominal exchange rate (by 0.045%), resulting in an increase in imports and a decrease in exports in order to maintain the current account balance.

Option 2

Results for option 2 are given in the second column of Table 6.1. In option 2, commodity tax is used to finance the increase in social assistance transfers to low income households. To facilitate this option, the commodity tax was made endogenous in the CGE model and adjusted to the level required to finance social assistance transfers to low income households. The first round effect of an increase in social assistance transfers to low income households is a corresponding increase in their income which induces an increase in consumer demand. Second

round (indirect) effects stem mainly from the following reasons: Firstly, commodity taxes raise prices of final goods. This leads to an increase in the consumer price index. This has a negative impact on households' real income and thus on private consumption, hence private consumption decreases by 1.676%. Secondly, a decrease in consumer demand will be followed by a reduction in domestic production leading to rising unemployment. All factor returns decrease under this option, thereby causing a reduction in household incomes. All in all, the net effect on income for poor households is still positive but the increase in real income is lower as compared to that of option 1 (see Table E.5 in Appendix E).

Exports decrease mainly due to a decrease in domestic production. There is a decrease in absorption (of 1.086%), prompted mainly by a decrease in private consumption and exports.

Labor supply effects

Labor supply results are presented on Table 6.1. Overall, labor supply decreases for option 1. This actually highlights the fact that the substitution effect of an increase in tax rates dominates the income effect. Theoretically, there are two different issues to consider following an increase in government transfers, which are financed by increase in taxes. The benefit (transfer) produces a pure income effect, whereas the tax rate produces both income and substitution effect. Firstly, there is a pure income effect, stemming from the fact that an increase in government transfer leads to an increase in real income which will induce individuals to consume more leisure and work less (decrease in labor supply). Secondly, a lower after-tax wage rate generates two conflicting results on the labor supply decisions. On one hand, a decrease in the after-tax wage rate decreases the opportunity cost of leisure, inducing workers to substitute work for leisure, thereby resulting in a decrease in labor supply (substitution effect). On the other hand, a decrease in after-tax wage also decreases the worker's real income, hence he or she will also decrease consumption of normal goods including leisure (income effect), leading to an increase in labor supply, thereby partially offsetting

the pure income effect given before (stemming from an increase in non-labor income or government transfers). The sum of the income effect and substitution effect yields the net effect on labor supply.

One of the main critiques of social assistance transfers is that they can interfere with incentives to work. Both social assistance (benefits) and tax rates reduce work effort. The argument is that by offering an alternative to employment, social assistance can reduce the motivation to work which decreases labor supply and output. The tax rate effectively reduces the wage rate by which the worker is rewarded, thereby inducing people to substitute work for leisure. In addition means tested social assistance can also reduce incentives to work by requiring beneficiaries and their spouses to fall below a certain income threshold.

We have very minor reductions in labor supply for option 1, highlighting the fact that social assistance do not provide major disincentive to work. Smaller reductions in labor supply could be explained by the fact that part of the effects on working hours may be delayed (Lindbeck, 1994), or that the changes in real non labor income are smaller to generate major changes in labor supply (Imbens et al., 1999). On the other hand labor supply for option 2 (where social assistance transfers are financed by increases in commodity tax) decreases significantly, highlighting that the pure income effect resulting from an increase in social assistance transfers dominates the income effect from a reduction in after-tax wage rate. For option 2 real incomes of households decrease a lot due to more drastic decrease in factor returns and higher increases in the consumer price index, compared to the other option.

6.1.3 Poverty and inequality analysis

In general, CGE models do not take into account patterns of income distribution within a particular household group. Hence within group variation is assumed to be zero. Two approaches are available in order to specify within group distribution: either by use of probability distributions like lognormal or beta distributions; which assume that the mean of the income distribution is

endogenously determined while its variance is specified exogenously, or by using disaggregated household survey data. In this study, we generate the size distribution by feeding selected data into household survey data, and use this to generate poverty and inequality measures. In particular, we use the relative percentage changes of representative households' income from the CGE model to scale survey observations on individual household total income.

Since the general equilibrium model framework allows endogenization of relative prices, the change in the monetary poverty line during each simulation can be endogenized within the CGE model (see Decaluwé et al., 1999). In this study we use a modified version of this approach, where an exogenous poverty line is used, and after each simulation the new monetary poverty line is computed by taking into account changes in the consumer price index as follows.

$$z_s = z_0 * PI, \quad (6.1)$$

where z_s is a new poverty line and z_0 is a poverty line before simulation and PI is the new price index.

For poverty and inequality analysis, we use adjusted total income figures or equivalized income which takes into account differences in size and structure of household, as explained in Section 2.1.1. We used this equivalence scale throughout the thesis. This equivalence scale is calculated as follows:

$$E = (A + \varpi K)^\theta, \quad (6.2)$$

where E is an adult equivalence scale, A is the number of adults in the household, ϖ is a fraction representation of children (K) in adult equivalized scale and θ is a scale parameter (capturing economies of scale). Woolard and Leibbrandt (2001) suggested that ϖ is 0.5 and θ is 0.9 for South Africa.

We use the Foster Greer Thorbecke (FGT) index for poverty analysis. For details of this poverty measure see Appendix D. Table 6.2 presents poverty

measures for different financing options. The first column relates to the benchmark scenario, while the two adjacent columns relate to the two policy experiments. Within each column the FGT indices with $\alpha = 0$, $\alpha = 1$ and $\alpha = 2$ are provided. Option 1 (where transfers are financed by an increase in income tax) gives a higher reduction in poverty head count than option 2 (where transfers are financed through an increase in commodity taxes). Option 1 offers a higher reduction in poverty, mainly because it taxes those in the high income group more than those in the low income group. So the income of low income households is slightly reduced due to taxation unlike what is the case with option 2. This helps to push them (low income households) above the poverty line, following an increase in government transfers. On the other hand, option 2 offers a lower poverty reduction mainly because commodity taxes are levied on all products, which affect all household groups in the same way. So it is not only those in the high income group who bear most of the cost of financing the government transfers.

Table 6.2: FGT Poverty measure (using R322 /month as poverty line)

Variable	Original income (%)	Option 1(%)	Option 2(%)
P0	29.730	25.630	26.350
P1	12.240	9.820	10.140
P2	6.803	5.300	5.480

Note: R322/ month was a lower threshold poverty line for the year 2000 as given by Statistics South Africa.

Table 6.3 gives inequality measures for different financing options. The first column relates to the benchmark scenario, while the two next columns relate to the two policy experiments. Within each column two different inequality measures are provided. The decrease in inequality is slightly more for option 1, where direct taxes increase than for option 2, since option 1 directly attacks those in the high income group by taxing those more in order to transfer to those in the low income group. While the other option (option 2 where transfers were financed by an increase in commodity tax) does not directly reduce the income of high income households, it affects all household groups in the same way.

Table 6.3: Inequality measure

Variable	Original income (%)	Option 1(%)	Option 2(%)
Relative mean deviation	47.770	46.790	46.830
Gini coefficient	62.610	61.300	61.340

Note: See Appendix D for a detailed description of these inequality indices.

6.2 Top-down, bottom-up model

6.2.1 Policy experiment

In this second part of the chapter, we run the same policy experiment but implement a linked top-down, bottom-up model. We are still considering the two forms of financing government transfers.

Option 1: Increase in direct taxes to households.

Option 2: Increase in commodity taxes.

6.2.2 Simulation results

In the first option, we increased income taxes by the same amount as the increase in social assistance transfers to low income households. This translated to about 19.2% increase in direct taxes. The increase in income tax was done in a proportional way. To maintain a progressive tax structure, tax rates for high income households increased by more than that of low income households, as illustrated in Table 6.4. The first column gives income tax rates before simulation and the second column gives income tax rates after simulation.

Table 6.4: New tax schedule

Tax bracket	Before simulation	After Simulation
1	18	21.460
2	26	30.990
3	32	38.140
4	37	44.100
5	40	47.680
6	42	50.060

Note: Own calculations. All numbers in %.

We will not concentrate much on macroeconomic variables, since it is not the main part of the analysis. Nevertheless, a summary of most macroeconomic variables is presented in Table 6.5a. The first column relates to results for option 1 and the second column relates to results for option 2. Macroeconomic variables did not differ much with the ones given in the previous section (Section 6.1.2), so the discussion will not be done extensively here. The major difference is in marginal propensity to save. We now have major changes in marginal propensity to save for both options (see Table 6.5b). This comes from the fact that we followed Savard (2003)'s suggestion of endogenizing marginal propensity to save in order to ensure the balance of the household budget, after making consumption exogenous in the CGE model.

Comparing the two options, the main difference lies in private consumption and consumer price index (CPI). Private consumption decreases for option 2, while it increases for option 1. The consumer price index increases by a greater proportion for option 2. This mainly comes from the fact that the increase in commodity taxes raises prices of final goods, which lead to an increase in the consumer price index. This has a negative impact on households' real income and hence on private consumption.

Table 6.5a: Macroeconomic Results (using the TD-BU model)

Variable	% changes from base year	
	Option 1	Option 2
Private Consumption	0.255	-0.540
Consumer Price Index (CPI)	0.002	1.335

Table 6.5b: Changes in marginal propensity to save

Variable	Base	Option 1	Option 2
Marginal propensity to save:			
Low income	0.04	0.004	0.002
High income	0.600	0.372	0.252

Note: Figures in column 3 and 4 are given as % changes from base year.

In addition there were also minor reductions in labor supply as presented in Table 6.6.

Table 6.6: Labor supply changes

Variable	Option 1 (%)	Option 2 (%)
Labor supply	-0.240	-0.210

Note: Results are taken from the discrete labor supply module.

From Table 6.6, we find minor reductions in labor supply for both the two options. We want to check what exactly happens to labor supply as social assistance transfers are increased in the discrete labor supply model. Theoretically there are two different issues to consider following an increase in social assistance transfers which are financed by increases in direct taxes, as was explained in the general equilibrium setting in Section 6.1. Firstly, a lower after-tax wage rate generates two conflicting results on labor supply decisions. On one hand, a decrease in after-tax wage rate decreases the opportunity cost of leisure, inducing a worker to substitute work for leisure, thereby resulting in a decrease in the labor supply (substitution effect). On the other hand, a decrease in after-tax wage

also decreases the worker's real income, hence he or she will also decrease consumption of normal goods including leisure (income effect), leading to an increase in the labor supply. Further, there is a pure income effect, stemming from the fact that an increase in social assistance transfers (non-labor income) leads to an increase in real income, which will induce individuals to consume more leisure and less work (decrease in labor supply). We have a corner solution scenario, where an individual only decides to work or not to work.

For those who are working already, a decrease in disposable wage will unlikely decrease labor supply, since we have set the utility of not working equal to zero or negative. For those not working there will be no decrease in labor supply since the utility is already zero. Hence in this setting there will be minimal substitution effect. Overall it depends on which income effect outweighs the other. If income effect from increase in non-labor income is greater than income effect from reduction in disposable wage rate, then labor supply will decrease and vice versa. Some authors argue that the two income effects should actually almost cancel out each other, since increases in income tax exactly match the increase in social assistance transfers (Gwartney et al., 1983); hence one of the possible explanations why changes in labor supply are minor in this case.

6.2.3 Poverty and inequality analysis

In the top-down bottom-up model, we adjusted household income by a household specific price index based on their consumption whilst maintaining the poverty line fixed in real terms. We created a fictitious household with equivalized total expenditures exactly equal to equivalized poverty lines. Then we used their new consumer price index after simulation to adjust the poverty lines. We used both relative and absolute poverty measures.

Table 6.7 presents relative and absolute poverty measures for the linked top-down, bottom-up model. The first column gives results for option 1 and the next column gives results for option 2. Doubling social assistance transfers leads to a 5.5 percentage point reduction in poverty if we use a relative poverty measure and 7 percentage point reduction if we use an absolute poverty line of R322 per

month for option 1. Social assistance was effective in pushing poor people closer to or over the poverty line. Still, even after using the TD-BU model, option 2 gives the smallest reduction in poverty.

Table 6.7: Poverty measures

Variable	Estimate (%)	
	Option 1	Option 2
Relative poverty (1/2 of median income)		
Base income	27.287	27.287
Simulation income	21.770	21.977
Absolute poverty (R322 per month poverty line)		
Base income	29.753	29.753
Simulation income	22.614	25.111

Note: Own calculations, using the poverty headcount for the analysis.

From Table 6.7, the overall percentage changes in poverty measures seem to be relatively small in magnitude. This could be partly explained by the following reasons: firstly, it could be due to the fact that we are using the poverty headcount measure and not the poverty gap. Using the poverty gap will yield slightly higher percentage changes. Secondly, the magnitude of these changes also depends on whether or not the scope of the study covered only programme participants or measured the impact on poverty nationally. For example, South Africa's social pension reduces the poverty gap for households with only older people by 96%, but this translates to a national poverty gap reduction of only 21% (Samson et al., 2004). In this study we used a national poverty measure, hence the reason why poverty reductions are smaller in magnitude. Nevertheless a 5.5 percentage point reduction shows a significant change in national poverty measure. Lastly, since we are taking into account general equilibrium effects, the prices of products bought by the poor rise, and they also bear some of the financing burden through either direct or indirect taxes, given that we are having a

budget neutral financing program, hence their real disposable incomes do not increase much.

Table 6.8 presents inequality measures for the linked top-down, bottom-up model. The first column relates to the benchmark scenario. The second column gives results for option 1 while the third column gives results for option 2. Different inequality measures have been used since there is no consensus on which measure is the best. Detailed explanations of these inequality indices are given in Appendix D. There were reductions in most inequality measures following an increase in social assistance; for example, the Gini coefficient decreased by about 3 percentage points. Comparing results for the two options, option 1 is still preferred to option 2.

Table 6.8: Inequality measures (TD-BU model)

Inequality measure	Before simulation Income (%)	After simulation income (%)	
		Option 1	Option 2
Relative mean deviation	47.714	44.980	46.206
Coefficient of variation	200.807	183.905	195.676
Gini coefficient	62.550	59.165	60.546
Theil index (GE (a), a = 1)	78.393	69.573	74.026
Mean Log Deviation (GE (a), a = 0)	77.000	66.153	69.853
Atkinson measures (eps = 1)	53.699	48.394	50.268
Sen's welfare index	6337.190	6697.557	6438.268

Note: Own calculations.

Option 1 is preferred to option 2 on welfare grounds if we use Sen's welfare measure and Atkinson's welfare index (See Table 6.8 before).

6.3 Comparison of different Models

We now want to assess the benefits of linking the two models, the CGE model and the MS model. In the first part of this section we compare different poverty, inequality and welfare measures of the results obtained from the top-down, bottom-up model with those of the MS-only model. While in the second part of

this section we assessed the importance of taking back feedback effects from the MS model to the CGE model, by closely analyzing aggregate behaviors of representative households and that of individual households in the MS model.

6.3.1 Comparison of poverty, inequality and welfare measures for different approaches

According to Bourguignon and Savard (2008), there are two forces leading to changes in poverty measures after simulations. Firstly, it is a pure distributional effect arising from changes in household incomes following changes in social assistance transfers which affects both TD-BU and MS models. Secondly, it is a change that arises from an adjustment in the structure of prices that changes relative income of households. The second effect only affects the TD-BU model, since prices are fixed in the MS model.

Table 6.9 presents a comparison of various poverty measures for different approaches. Results for the two models, MS and TD-BU models move in the same direction after simulation. All in all, the MS-only model seems to give slightly higher poverty measures for option 1 and vice versa for option 2; this result was observed regardless of which poverty measure was used (both relative and absolute poverty measures). This is mainly because the TD-BU models include price changes and under option 2 prices increase by a higher proportion making real disposable income lower and hence leading to lower poverty reduction than for the MS-only model (where prices are fixed).

In addition, the difference in poverty measures between the MS-only and TD-BU models matters most when we use an absolute poverty measure rather than a relative measure of poverty. Absolute poverty measures the absence of enough resources to secure basic commodities, while relative poverty refers to poverty as being socially defined; comparing one group of people to others. Relative poverty is closely linked to income inequality; it is defined in terms of overall distribution of income. Changes in prices are too small to generate big changes in overall distribution of income. That is why there are no big differences between the MS-only model and the TD-BU model when a

relative poverty measure is used. The fact that the difference in poverty measures between the MS-only model and the TD-BU model is most important when we use an absolute poverty measure rather than a relative measure of poverty, serves to justify the use of a linked TD-BU model especially in developing countries, given the fact that absolute poverty measures are commonly used there. Fulfillment of basic needs (absolute poverty) matters more in developing economies, than a relative poverty measure (Ravallion, 2010 and Oosthuizen, 2008).

Table 6.9: Poverty measures (comparison of different approaches)

Variable	Estimate (%) Option 1	Estimate (%) Option 2
Absolute poverty (R322 per month poverty line)³⁴		
Base income	29.753	29.753
TD-BU model	22.614	25.111
MS-only model	22.680	23.950
Relative poverty (1/2 of median income)		
Base income	27.287	27.287
TD-BU model	21.770	21.977
MS-only model	21.780	21.904

Note: R322 was a lower threshold poverty line for that year as given by Statistics South Africa.

Table 6.10 presents a comparison of inequality measures for both TD-BU model and MS-only model. The first column gives results for option 1 while the second column gives results for option 2. It can be seen that across all inequality measures the MS-only model gives the smallest reduction in inequality for option 1 and the reverse holds true for option 2. This shows the importance of taking price changes from the CGE model. Even though the magnitude of the differences is small, there is no doubt that it is important to take into consideration price changes from the CGE model, since it has resulted in further reduction or increase in all income inequality measures, depending on which financing option is used. In

³⁴ This was a lower threshold poverty line for that year as given by Statistics South Africa.

considering the magnitude of these differences we should consider the fact that the study did not only cover program participants (only those receiving the government transfers) but measured the impact of poverty and inequality for the whole nation³⁵.

Table 6.10: Inequality measures (comparison of different approaches)

Inequality measure	Option 1 (%)	Option 2 (%)
Gini coefficient:		
Before simulation	62.550	62.550
TD-BU model	59.165	60.546
MS-only model	59.173	60.500
Mean log deviation (GE (a), a = 0):		
Before simulation	77.000	77.000
TD-BU model	66.153	69.853
MS-only model	66.177	69.576

Source: Own table.

For welfare comparison we used Atkinson index and Sen's welfare measures. An explanation of these two welfare measures is given in Appendix D. Welfare results are presented in Table 6.11. The table gives Sen's welfare index and Atkinson welfare index for the TD-BU and the MS-only models.

³⁵ This partly helps to explain why the differences are smaller in magnitude.

Table 6.11: Welfare measures for the two models

Type of welfare index	Base year	Option 1		Option 2	
		TD-BU model	MS-only Model	TD-BU model	MS-only Model
Sen's welfare Index	6337.190	6697.557	6693.232	6438.268	6533.831
Atkinson Index	53.699	48.394	48.406	50.268	50.130

Source: Own table.

From Table 6.11, the TD-BU method dominates the MS-only model on welfare grounds for option 1 and the reverse holds true for option 2, if we use Sen's welfare index and Atkinson index. Now the difference between the MS model and the TD-BU model is clear and higher when using welfare indices, unlike what was the case with inequality and poverty indices.

6.3.2 Assessing the importance of feedback effect in TD-BU Model

According to Savard (2003), the main contribution of the TD-BU approach stems from the fact that behavior of the representative households in the CGE model is not a perfect aggregation of behavior of individual households in the MS model, which justifies taking back these feedback effects to the CGE model. From Table 6.5b, we observed that there were major changes in marginal propensity to save³⁶ in the TD-BU model, which can highlight the existence of feedback effects. Colombo (2010) pointed out that these changes in mps could be due to two reasons; firstly it could arise from data inconsistency between the two datasets, social accounting matrix (which is used as the main database for the CGE model) and the household survey data. Secondly it could be due to feedback effects from the MS model³⁷. In this study the first reason of data inconsistency is very minimal, since the social accounting matrix was constructed in such a way that it is fully consistent with the data observed in the survey. We weighted and aggregated all household income and expenditure items from the survey and then

³⁶ A variable which was flexed after linking the two models

³⁷ Arising, mainly from the fact that, in MS model we consider single households in CGE model we have representative households.

used these shares to build the household income and expenditure items in the SAM. Hence changes in marginal propensity to save can be attributed mainly to feedback effects.

We now consider individual components of household income and expenditure behavior to find the main cause of feedback effects. Variation in these variables will determine the magnitude of the differences between the MS model and the CGE model results. Savard (2003) pointed out that there is perfect aggregation from the income side (capital income, government income and foreign income), apart from labor supply. For example, for capital income, which aggregate perfectly we have:

$$PK * KS_H = \sum_{h \in H} PK * KS_h , \quad (6.3)$$

where PK is a price of capital, KS is an initial value of capital stock and small letter subscripts denote items at individual level while capital letter subscripts denote items at aggregated representative household level.

Table 6.12 gives a comparison of labor supply figures from the two models. The first column gives labor supply changes from the MS model and second column gives labor supply changes from the CGE model.

Table 6.12: Comparison of labor supply changes for option 1

Variable	MS model (%)	CGE model (%)
Labor supply changes:	-0.240	-0.030

Source: Own table

In general we have minor changes in labor supply, but there are differences in labor supply changes from different models. Labor supply responses are smaller in the CGE model than in the MS model. The difference could be attributed to both different ways of modeling labor supply in the two models and also to feedback effects.

From the expenditure side, Section 5.4.2 gave a detailed explanation of why linear expenditure demand curves do not aggregate perfectly. Table 6.13 gives consumption expenditure changes from the two models.

Table 6.13: Comparison of total consumption expenditure changes for option1

Variable	MS model	CGE Model
Total consumption expenditure:		
Low income household	31.865	27.225
High income household	-5.329	-2.357

Source: Own table

From Table 6.13, we have significant differences in total consumption expenditure changes for the two models, even though the changes move in the same direction. This highlights the fact that consumption expenditure changes are the main source of feedback effects. The MS model gives higher increases for low income households and higher decreases for those in high income households than the CGE model. The differences mainly come from two items; firstly it stems from differences in income tax calculations for the two models and secondly from the fact that individual household behavior in the MS model is different from ‘average’ representative household behavior in the CGE model.

Income tax changes differ in the two models because, in the MS model income tax calculations depend on the income tax bracket to which an individual household belongs, while in the CGE model income tax is calculated as a proportion of the representative household’s income. In the MS model we use differentiated tax rates while in the CGE model we use same or ‘average’ shares. So we have the following:

$$T_{Hy}Y_H \neq \sum_{h \in H}^N t_{yh}Y_h, \quad (6.4)$$

where t_{yh} is income tax rate calculated on specific individual household income, T_{Hy} is income tax rate for the aggregated representative household, Y_h is individual household income and Y_H is aggregated representative household income.

The effect of changes in income taxes in the model is captured via the labor market, by altering disposable wages and also via consumption changes, by altering disposable income. Since we are using both changes in consumption levels and labor supply as linking variables from the MS model back to the CGE model we indirectly transfer the level of disposable income which is not compatible with what was used in the CGE model. Hence it is important to take back feedback effects from the MS model to the CGE model since individual behavior in the MS model does not always correspond to the aggregate behavior used in the CGE model.

CHAPTER 7

SUMMARY AND CONCLUSION

Although social assistance transfers have grown at a faster pace in years following closely after independence in South Africa, its income inequality still remains one of the highest in the world. This thesis used a top-down, bottom-up model which combines an econometrically-estimated MS model of labor supply, a detailed tax-benefit module, and a computable general equilibrium model, in order to analyze the impact of social assistance transfers on reducing income inequality in South Africa.

The CGE model allowed us to take into account general equilibrium effects of increasing social assistance transfers to low income households, such as relative price effects, and it also let us consider implications of different financing options. Financing social assistance transfers by an increase in income tax (option 1) gives a higher increase in absorption. This increase mainly comes from a higher increase in private consumption. Option 1 also gives a higher reduction in poverty head count (of about 4%) than option 2 (where transfers are financed through an increase in commodity taxes). Option 1 offers a higher reduction in poverty and inequality measures, mainly because under this option low income households are taxed less than those in the high income group, so the income of low income households is not reduced much due to taxation like what is the case with option 2. This helps to push them (low income households) above the poverty line, following an increase in government transfers. On the other hand, option 2 offers a lower poverty reduction mainly because commodity taxes are levied on all products, which affect all household groups. It is not only those in the high income group who bear most of the cost of financing the government transfers. In addition option 2 cannot be regarded as a better option since there is a conflict of interests, decrease in absorption and inequality when transfers are financed by commodity tax. We also have minor reductions in labor supply for option 1, highlighting the fact social assistance does not provide major disincentives to work.

The TD-BU model allowed us to take into account both heterogeneity of economic agents (since it uses micro data sets) and general equilibrium effects of

increasing social assistance transfers to low income households. Overall results show that even though the doubling of social assistance transfers did not generate dramatic changes in macroeconomic variables, it caused significant reductions in both inequality and poverty measures. Doubling social assistance leads to a 5.5% reduction in poverty if we use a relative poverty measure and 7% if we use an absolute poverty line of R322 per month. The overall percentage changes in poverty measures seem to be relatively small (5.5%) in magnitude, after doubling social assistance transfers to poor households. This mainly stems from the fact that we are using the poverty headcount measure and not the poverty gap. Using the poverty gap will yield slightly higher percentage changes. In addition, the magnitude of these changes also depends on whether or not the scope of the study covered only program participants or measured the impact on poverty nationally. In this study we used a national poverty measure, hence one of the reason why poverty reductions are small in magnitude.

Despite an increase in social assistance transfers to low income households, actual distribution of income seems to only have changed slightly (3%), even though the number of poor people has decreased. This is also confirmed by earlier results by other researchers; Lehman (2010) and Armstrong (2008) also found a marginal impact of social assistance transfers on income inequality. The most probable explanation could be due to the fact that social assistance transfers are too tiny to make a big impact on inequality, despite good targeting. Social assistance transfers are too tiny relative to the income of the population's top earners. Inequality is broader than poverty, since it focuses on the entire population and not only those below the poverty line, as poverty does. Hence reductions in inequality will be much lower than reductions in poverty measures.

Secondly, this lower reduction in inequality measures could be explained by the fact that, since we are taking into account general equilibrium effects, prices of products bought by those in the low income group rise, following an increase in government transfers. In addition, they also bear some of the financing burden through either indirect taxes or commodity taxes, given that we are having a budget neutral financing program. As a result, their real disposable income does

not increase much in comparison to that of high income households. Chia et al. (1994) support the same idea by concluding that when general equilibrium effects are taken into account, given a budget neutral targeting program; it is more difficult to eliminate poverty than is suggested by traditional analysis. Option 1 is preferred to option 2 on welfare grounds using both Sen's welfare index and Atkinson index.

To assess the benefits of taking price changes from the CGE model to the MS model, we compared the results from the top-down, bottom-up model with those of the MS-only model. We found out that result for the two models move in the same direction. All in all we discovered that using MS-only model, in comparison to TD-BU model, gave a slightly less reduction in poverty measures for option 1 and vice versa for option 2. This result was observed regardless of which poverty measure was used (both relative and absolute poverty measures). This is mainly because the TD-BU models include price changes. Under option 2 prices increase by a higher proportion, making real disposable income lower and hence leading to lower poverty reduction than for the MS-only model (where prices are fixed). We can conclude that when price changes are bigger, then the difference between the MS-only model and the linked TD-BU model matters most.

Furthermore, the differences in poverty measures between the MS-only and the TD-BU models are most important when we use an absolute poverty measure rather than a relative measure of poverty. Relative poverty is closely linked to income inequality; it is defined in terms of overall distribution of income. Changes in prices are too tiny to generate big changes in overall distribution of income. That is why there are no large differences between the MS-only model and the TD-BU model when a relative poverty measure is used. The fact that the difference in poverty measures between the MS-only and the TD-BU model matters most when we use an absolute poverty measure rather than a relative measure of poverty, also justifies the use of a linked TD-BU model in developing countries, where it is argued that absolute poverty is of paramount importance.

We also found out that the MS-only model gave the smallest reduction in inequality for option 1 in comparison to the TD-BU model and the reverse holds

true for option 2 across all inequality measures. This again confirms the importance of taking price changes from the CGE model. Even though the magnitude of the differences is small, there is no doubt that it is important to take into consideration price changes from the CGE model, since it has resulted in further reduction or increase in all income inequality measures, depending on which financing option is used. Neglecting these price changes may slightly overestimate or underestimate inequality and poverty measures, depending on which financing option is used. In considering the magnitude of these differences, we should consider the fact that the study did not only cover program participants only (only those receiving social assistance transfers) but measured the impact of poverty and inequality on the whole nation.

We also found out that the TD-BU method dominates the MS-only model based on welfare grounds for option 1 and the reverse holds true for option 2. This result was found to be most important when price changes are higher.

Lastly, feedback effects from the MS model to the CGE model play a crucial role in a linked model, not only for poverty, inequality and welfare analysis but also to capture the differences between individual behavior and the behavior of aggregated representative households as reflected by differences in income tax changes and consumption expenditure changes between the two models after policy simulation.

The TD-BU model developed in this thesis produces results that could be helpful to shed light on the current debate about the impact of social assistance transfers on reducing income inequality and poverty. However, in order to achieve long term solutions to the situation of perpetual poverty and inequality, a sustainable solution for alleviating poverty should be found, like human capital development.

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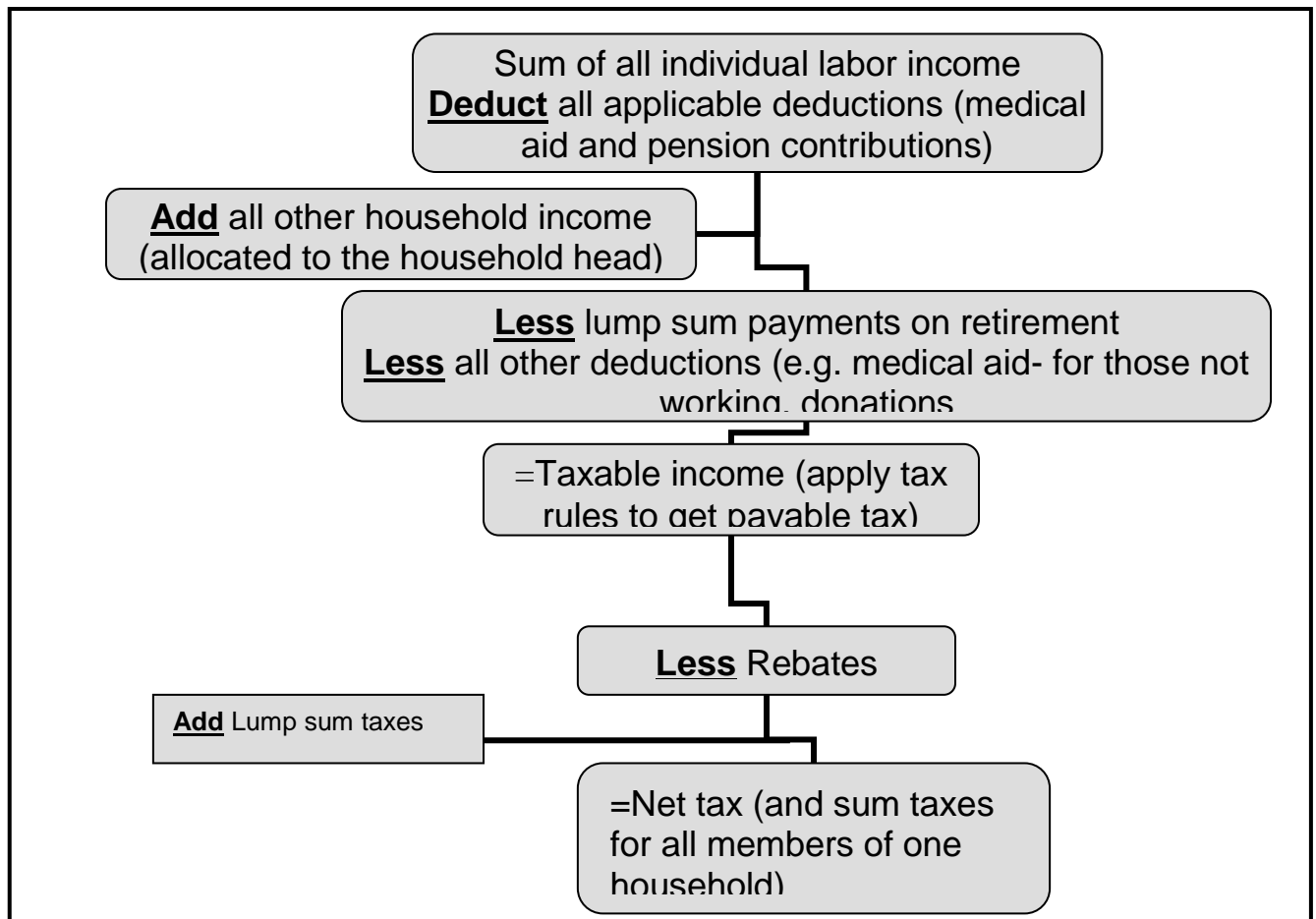
Appendix A: Tax and benefit Imputation

This appendix gives a detailed description of how taxes and social assistance were calculated or imputed in our model. In particular it discusses steps followed to calculate tax paid and social assistance.

Tax Calculation

Taxes in South Africa are calculated on an individual basis irrespective of number of children or marital status. In our database, apart from income from labor, all incomes are given at household level. Hence, it was assumed that the household head will declare and pay taxes for all income given at household level³⁸. Figure A.1 summarizes how tax paid was actually calculated.

Figure A.1: Tax calculations



Source: own diagram.

³⁸ This introduced some bias in terms of tax liability calculations.

Deductions³⁹ include among others:

- Pension contributions, which are also given at household level, but the value in the data appears to be underestimated (see Wilkinson, 2009). In South Africa, pension contributions vary according to different pension schemes. Since it is not known which particular scheme an individual belongs to, an average rate is used. Following Wilkinson (2009) we use a contribution of 5.5% of gross salary to pension's schemes.
- Deductions for medical aid contributions differ according to age. All those over 65 years could claim all their medical expenses, and for those below 65 years, the maximum amount they could claim was limited to the amount they paid in excess of R1 000 or 5% of taxable income (whichever is greater). That is, the first R1 000 or first 5% of taxable income would not qualify as a deduction. In our data set medical aid is only reported at household level, hence, following Wilkinson (2009), the amount recorded at the household level is allocated to different household members according to their labor income or just to the household head if others are not working.
- Lump sum payments on retirement: Part of Lump sum benefits are tax deductible. The maximum amount deductible for tax purposes was the greater of R120 000 or R4 500 multiplied by number of years of membership, but since we do not have information regarding number of years of membership, the first criterion is used. The excess after deducting the tax free rate of R120 000 is taxed using the average rate of tax and not the marginal tax rate in order to get lump sum taxes.
- Local dividends from all South African companies are exempt from tax at the household level, in order to avoid double taxation.
- Donations made to certain organizations, for example universities, education and churches are also tax deductible, only up to a maximum of either R500 or 2% of taxable income.

³⁹ All these deductions apply to the year 2000, which is the year the survey was conducted as explained earlier.

- Losses incurred in making a profit are also tax deductible.

The following problem was encountered when calculating taxes: The tax schedule applies to cumulated income per annum, but the database does not provide information on whether an individual worked the whole year or not, or whether gross earnings were constant throughout the year. In our calculations we assumed that the given gross earnings were constant throughout the year.

The tax is imposed at a progressive block rate with low taxable income being taxed at a lower tax rate than higher taxable income. The table below gives the detailed tax schedule for South Africa.

Table A.1: Income Tax schedule rules

Taxable income (Y) (Rand)	Rate
1 – 35 000	0.18 [Y]
35 001 – 45 000	R6 300 + 0.26 [Y-35 000]
45 001 – 60 000	R8 900 + 0.32 [Y-45 000]
60 001 – 70 000	R13 700 + 0.37 [Y-60 000]
70 001 – 200 000	R17 400 + 0.40 [Y-70 000]
200 001 and above	R69 400 + 0.42 [Y-200 000]
Rebates	
Primary rebate R3 800	
Age 65 and over in addition to primary rebate R2 900	
Tax thresholds:	
Below 65	R21 111
Age 65 and above	R37 222

Source: *South African Revenue Services.*

Table A.2 gives a comparison of imputed figures and actual figures as reported in official statistics for that particular year. The first column gives actual figures that are reported by the South African Revenue Services, the next column gives figures reported in survey data and the last column gives imputed figures.

Table A.2: Personal income tax data: In comparison with actual tax paid reported in official data

R million	Actual figures reported by SARS	Survey data	Imputed data
Average tax paid (mean)	---	3 227	8 013
Tax revenue	86 476	36 400	89 300

Source: National Treasury, South Africa (August 2004) and own calculation.

After applying the tax rules the average income tax burden (mean) increased from R3 227 before any adjustment to R8 013 after adjustment. Total tax revenue also increased significantly from R36 400 million to R89 300 million, which is slightly higher than the reported figure of R86 476 million. This is mainly due to the fact that the reported figure from the South African Revenue Services of R86 476 million excludes tax from lump sum benefits, which was around R5 219 million for this year.

Social assistance module

This section describes the imputation of social assistance transfers using our database. The following social assistance transfers were imputed; Child Support Grant, Foster Grant, Care dependence Grant, Disability Grant and Social Old Age Grant. Firstly, the definition of “household” in our survey (and in an African context at large) includes all people living under the same roof and sharing expenses (extended family). The household consists of large numbers of extended family members who are often supported by one, two or more older members. This was taken into consideration in our social assistance imputation.

Secondly, the Child Support Grant is given to caregivers of children, but the South African Income and Expenditure Survey does not contain information on biological parents or primary caregivers. We used a technique which closely follows that of Woolard (2003) in order to identify primary caregivers as follows:

- i. The oldest woman in the household aged 13 – 40 years at the time of birth of the child.

- ii. If none, then the youngest woman in the household aged 41 or over at the time of birth of the child.
- iii. If none, the oldest male in the household aged 13-40 at the time of birth of the child was used.
- iv. If none, the youngest male in household aged 41 or over at the time of birth of the child.
- v. If none, any person older than 18 in the household.

Thirdly, there is no information given in the survey in order to identify disabled children, in order to determine eligibility for the Care Dependency Grant. Instead we made use of the information given in the Labor Force Survey showing whether someone receives a Care Dependency Grant or not. In addition, no information is available in the survey to identify foster children, since the survey does not include information on biological parents of children. We made use of the information given in the Labor Force Survey showing whether someone receives a Foster Care Grant or not.

Furthermore, it is difficult to determine eligibility for Disability Assistance since there is no direct information in the survey on whether one is disabled or not. Instead, we used one of the questions in the Labor Force Survey where respondents were asked to give reasons for not working, and disability was given as a response. This was used together with what was already given in the Income and Household Survey.

Finally, for Social Old Age Pensions calculations we used a formula given in Woorldard (2003)⁴⁰ as follows:

$$\text{Single people: } D = 1.15A - 0.5B \quad (\text{A.1})$$

$$\text{Married people: } D = 1.075A - 0.5B \quad (\text{A.2})$$

Where:

A is the maximum grant payable per annum (According to rules).

B is the annual income of the applicant (single people), or half of the applicant and his or her spouse's combined annual income.

⁴⁰ The formula corresponds to how SOAP law were applied for this particular year.

D is the annual grant amount payable.

Table A.3 summarizes how the imputed figures relate to official statistics. The first column gives figures reported in survey, while column two gives actual figures that are reported by National Treasury South Africa and the last column gives imputed figures.

Table A.3: Social assistance data: In comparison with actual social assistance expenditure reported in official data

Type of grant	Survey data (before imputation) (In million rand)	Official figures (In million rand)	Imputed figures (In million rand)
Child Support Grant	862	1 411	4 563
Care Dependency Grant	---	249	188
Foster Care Grant	---	276	151
Disability Grant	1 592	3 973	3 890
Social Old Age Pensions	12 472	12 954	13 592

Source: National Treasury, South Africa (August 2004) and own calculation.

Note: Figure for Child Support Grant (survey data) reflects the total for all three types of children assistance.

In general the imputed figures are in line with the reported official figures for that year, apart from Child Support Assistance. This is mainly due to the fact that for this particular year (2000) the take-up rate for child assistance was very low. Some eligible children and households do not apply or receive assistance, either because they are unaware of their entitlement or lack the documentation, time and resources necessary to access the social support system, or due to social and psychological factors for example stigma. According to Samson et al. (2004) the take-up rate was very low for this particular year.

In order to rectify this problem and ensure that the imputed take-up rate is closer to official statistics we modeled the take-up rate for this grant. The model view take-up as fully determined by decisions of eligible applicants, given that all eligible applicants are guaranteed social assistance. A stepwise logistic regression was run to examine the

probability of taking up the benefit which one is entitled to. A variable was only retained if it improves the fit of the model. A binary logistic choice model was used.

$$y_i^* = \beta x_i + u, \quad (\text{A.3})$$

where β is a set of coefficients and u is a random disturbance term. Whether an individual takes up or not his benefit is indicated by the observable variable y_i , where

$$y_i = \begin{cases} 0 & \text{if } y_i^* \leq 0 \\ 1 & \text{if } y_i^* > 0 \end{cases} \quad (\text{A.4})$$

The probability that an individual takes up his or her benefit conditional on the values of x_i is given by,

$$\begin{aligned} Pr(y_i = 1 | x_i) &= Pr(y_i^* > 0 | x_i) \\ &= \frac{\exp(\beta x_i)}{1 + \exp(\beta x_i)}. \end{aligned} \quad (\text{A.5})$$

Selection of possible explanatory variables was guided by the fact that caregivers will only claim the social assistance if the benefits of claiming surpass the monetary, time and psychological costs of claiming the benefit. Following other previous studies⁴¹, the following explanatory variables were included: race dummy (*Dumrace*), Education dummy (*Education dummy*), gender dummy (*Gender*), age and age squared of caregiver, location dummy (*Location dummy*), employment status of caregiver (*Working status*), a dummy variable showing presence or not of dependent children in the household (*Children dummy*), another dummy variable showing presence or not of transport within 15 minutes walking distance (*Transport*), marital status of caregiver (*Marital status*), a dummy variable showing whether or not the household receives other social assistance (*other assistance*), (household income minus social assistance) divided by 1000 (*Income*), a dummy variable showing whether or not the household own their main source of dwelling (*Type of dwelling*) and province dummy variable (*Dumprov*).

⁴¹ See Hernanz et al. (2004), Blundel et al.(1988), Bruckmeier et al. (2011), Duclos (1995) and Barnes and Noble(2006)

Table A.4: Description of variables used in benefit take-up equation

Variable	Description
<i>Dumrace</i>	dummy variable for different races: Black=1 (reference), Colored=2, Asian=3, White=4.
<i>Education</i>	dummy variable for education: primary and lower secondary school=0, upper secondary and tertiary =1.
<i>Gender dummy</i>	dummy variable for gender: male= 0, female=1
<i>Location dummy</i>	location dummy variable: urban=0, rural=1
<i>Working status</i>	variable showing employment status of caregiver: working=1, unemployed=0
<i>Children dummy</i>	variable highlighting the presence or not of dependent children in the Household (children below 10 years) : No=0, Yes=1
<i>Marital status</i>	a dummy variable showing marital status of caregiver: married= 0, single=1
<i>Transport</i>	a dummy variable showing presence or not of transport within 15 minutes walking distance: Yes=1, No=0
<i>Other assistance</i>	a dummy variable showing whether or not the household receives other social assistance: Yes= 1, No =0
<i>Type of dwelling</i>	a dummy variable showing whether or not the household own their main source of dwelling: Yes= 1, No =0
<i>Dumprov</i>	province dummy variable:

Education dummy variable can have both positive and negative impact on take-up rate. On one hand ignorance of the system or complex claim procedures can present a barrier to claiming the social assistance. On the other hand more educated people may feel more stigmatized thereby reducing their probability to take-up. Children dummy was included since presence of more dependent children adds to the needs of household and likely to increase the probability of take-up. Marital status variable was included, because the presence of another adult in the household may result in the household being able to cope without claiming social assistance. Single caregivers are likely to claim than married couples. Age is associated with attitudes of greater independence and reluctance to accept ‘charity’ and might be expected to have a negative relation on take-up.

Unemployed caregivers may anticipate getting a job shortly hence they don't claim, whereas income of those employed is stable and predictable, so they claim. Accessibility to good transport system makes it easy for caregivers to go and claim social assistance. Home ownership may indicate financial independence and signal high psychological costs associated with taking up the social assistance.

Estimation was done at caregiver or adult level, since it is the adult in a family who decide to take-up or not the benefit. Table A.5 gives estimation results from the logit model.

Table A.5: Estimates for Child Support grant take-up model

Variable	Wald chi2 (25) Nagelkerke Pseudo R ²	918.38, 0.160	Prob> chi2 0
			Coefficient (Standard errors)
<i>Dumrace2</i>			0.704*** (0.120)
<i>Dumrace3</i>			0.835*** (0.287)
<i>Dumrace4</i>			0.153 (0.262)
<i>Education dummy</i>			-0.077 (0.087)
<i>Gender</i>			1.122*** (0.218)
<i>Age</i>			0.073* (0.017)
<i>Age squared</i>			-0.000*** (0.000)
<i>Location dummy</i>			-0.305*** (0.083)
<i>Working status</i>			-0.299** (0.089)
<i>Marital status</i>			0.926*** (0.083)
<i>Transport</i>			0.194 (0.143)
<i>Source of light</i>			0.210** (0.082)
<i>Other assistance</i>			0.028 (0.212)
<i>Income</i>			-0.071** (0.282)
<i>Type of dwelling</i>			0.119 (0.086)
<i>Children dummy</i>			1.004*** (0.105)
<i>Entitlement value</i>			0.117*** (0.014)
<i>Dumprov2</i>			-0.538** (0.156)
<i>Dumprov3</i>			0.279* (0.150)
<i>Dumprov4</i>			-0.844*** 0.193
<i>Dumprov5</i>			-0.656*** (0.162)
<i>Dumprov6</i>			-0.148 (0.163)
<i>Dumprov7</i>			-0.206 (0.150)
<i>Dumprov8</i>			0.174 (0.161)
<i>Dumprov9</i>			-0.361* (0.168)
<i>Constant</i>			-7.490

Note: *** Significant at 1%, ** significant at 5%, * significant at 10%.

Being White, Asian and Colored relative to being Black, being female, age, being single, availability of transport within 15 minutes walking distance, presence of other dependent children in the household and the value of entitlement all increase the probability of taking up the benefit which one is entitled to. While higher education, being employed and other household income all decrease the probability of taking up the benefit.

Probabilities were proportionately adjusted until the required take-up rate was achieved. Table A.6 summarizes the adjusted Child Support Grant.

Table A.6: Child Support Grant figures after adjustment

Type of grant	Survey data (before imputation) (In million rand)	Official figures (In million rand)	Imputed and adjusted figures (In million rand)
Child Support Grant	862	1 411	1440

Source: Provincial Budgets and Expenditures Review: 2000/01 – 2007/08 and own calculation.

Appendix B: Discrete labor supply model

The Appendix summarizes the procedure taken to estimate parameters for the wage earnings equation and selection model.

Wage earnings equation

The wage earnings equation (see Equation 4.14 before) was estimated using a Heckman two-step model. A reduced type of wage equation was used⁴², where the log of wage earnings (LW) of individual i of household h was assumed to depend on a vector of observable individual characteristics (X_{hi}) and unobservable factors (u_{hi}). The individual characteristics include the following variables: race (*Dumrace*), education (*Education*), age, age squared, gender (*Gender dummy*) and location (*Location dummy*).

Table B.1: Description of wage earnings equation variables

Variable	Description
<i>Dumrace</i>	dummy variable for different races: Black=1 (reference), Colored=2, Asian=3, White=4.
<i>Education</i>	dummy variable for education: Primary and lower secondary school=0, Upper Secondary and Tertiary =1.
<i>Gender dummy</i>	dummy variable for gender: Male= 0, Female=1
<i>Location dummy</i>	location dummy variable: Urban=0, Rural=1
<i>Chn6</i>	variable highlighting the presence or not of children under 6 years in the Household: No=0, Yes=1

Age and age squared were included in order to act as proxy for experience. Age squared captures potential non-linearity of age and wage earnings. The education dummy variable was included in order to control for human capital differences following the original Mincerian wage equation. The race dummy variable was included since characteristics that affect wage earnings could differ systematically across racial groups. The Heckman's two step model was used in order to correct for sample selection bias. In estimating the wage earnings

⁴² This was done due to lack of reliable data on actual number of working hours, which are needed to estimate a structural equation.

equation, there is a selection bias which stems from the fact that we only observe a positive wage for individuals who were working at the time of the survey. This causes a concentration of observation at zero values, and ordinary least squares (OLS) estimator will be biased since the Gauss-Markov assumption of zero correlation between independent variables and error terms will be violated. Heckman's two step procedures consists of estimating two equations; the first step determines the decision of an individual whether to participate or not in the labor market following a probit model, where the inverse mills ratio is obtained and later used in the outcome equation.

A dummy variable showing presence or not of children under six years (chn6) was included in the selection part of the Heckman model in order to act as an exclusion restriction variable.⁴³ This is in line with what has been used in literature (see Kumor, 2010, Hausman, 1980 and Heim, 2007), where it is argued that this variable has a strong effect on labor force participation, but does not have direct impact on wage earnings. An exclusion restriction is included in order to facilitate model identification, since it makes the inverse mills ratio and vector of explanatory variables (X) in the outcome equation less correlated, thereby reducing multicollinearity among predictors and correlation between error terms. If no exclusion restriction is included, then identification will be based solely on the non-linearity of the inverse mills ratio (IMR). But identification based on nonlinearity of IMR can be very weak, since it has been shown that IMR can be linear for a good range of explanatory variables (Puhani, 2000).

The estimation of wage equation was done on a subsample comprising only those at working age that is 16 to 64 years. Estimation was done separately for two demographic groups, single individuals and married couples, explicitly accounting for heterogeneity of behavioral responses across demographic groups. Table B.2 presents estimation results from Heckman model.

⁴³ Exclusion restriction is a variable that affects selection model and not the outcome equation

Table B.2: Wage earnings equation estimates

Earnings equation	Single Individuals	Married couples
Variable	Coefficient (Standard error)	Coefficient (Standard error)
Outcome equation- Log of wage:		
<i>Dumrace2</i>	0.275*** (0.042)	0.162*** (0.030)
<i>Dumrace3</i>	0.570*** (0.074)	0.488*** (0.044)
<i>Dumrace4</i>	1.039** (0.056)	0.927** (0.032)
<i>Education</i>	0.775*** (0.021)	0.847*** (0.025)
<i>Age</i>	0.080*** (0.017)	-0.221*** (0.011)
<i>Gender dummy</i>	-0.268** (0.021)	0.072** (0.059)
<i>Age squared</i>	-0.001*** (0.000)	-0.001*** (0.000)
<i>Location dummy</i>	-0.391** (0.023)	-0.413** (0.019)
<i>Constant</i>	7.734*** (0.406)	8.204*** (0.256)
Selection equation- Work:		
<i>Dumrace2</i>	0.567*** (0.024)	0.375** (0.026)
<i>Dumrace3</i>	0.247*** (0.060)	0.006 (0.050)
<i>Dumrace4</i>	0.598** (0.040)	0.271*** (0.033)
<i>Education</i>	0.170*** (0.017)	0.311*** (0.022)
<i>Age</i>	0.243*** (0.004)	-0.959** (0.024)
<i>Gender dummy</i>	-0.074** (0.016)	0.153** (0.006)
<i>Age squared</i>	-0.003*** (0.000)	-0.002*** (0.000)
<i>Location dummy</i>	-0.131** (0.016)	-0.097** (0.019)
<i>Chn6</i>	-0.306*** (0.016)	-0.143 (0.060)
<i>gender_chn6</i>	--	-0.038 (0.036)
<i>Constant</i>	-4.818*** (0.064)	-1.956*** (0.119)
<i>Mills Lambda</i>	-0.222** (0.094)	-0.648*** (0.113)
<i>Rho</i>	-0.220	-0.625
<i>Sigma</i>	1.011	1.037
<i>Wald chi2</i>	2963.88	5750.00
<i>Prob>chi2</i>	0.000	0.000
<i>Number of observation</i>	37340	24628

*** Significant at 1%, ** significant at 5%, * significant at 10%.

Note: Results of the selection part of the Heckman model are not discussed in detail here, since the selection part was estimated separately using a probit model below. This was done in order to explicitly take into account the effect of disposable predicted wage (calculated from the Heckman model and subtracting respective taxes) and government income, which are our two main variables causing labor supply changes after each simulation.

Being Colored (*Dumrace2*), being Asian (*Dumrace3*) and being White (*Dumrace4*) have a positive effect on earnings, relative to being Black. Being female relative to male (*Gender dummy*) and being in the rural area relative to urban area (*Location dummy*) both have a negative effect on earnings. Age has a positive effect on earnings, while age squared has a negative effect, indicating the fact that wage earnings increase with age but at a decreasing rate. The coefficient of the inverse mills ratio, lambda is negative and significant justifying the presence of sample selection.

Selection model

The selection model is a binomial probit model, consisting of both an observable part and an unobservable part (see Equation 4.15 before). Vector (V_{hi}) which represents the observable part of the binomial probit model consists of the following variables; race, education, age, age squared, gender, location dummy, government social transfer income, a dummy variable showing presence or not of children under six years (*chn6*) and disposable predicted earnings. A description of new variables is given in Table B.3.

Table B.3: Description of selection model variables

Variable	Description
<i>Disposable predict wage</i>	Real predicted disposable wages earnings which were estimated using Heckman’s two step model, divided by 1000. It was calculated after subtracting taxes obtained from tax module.
<i>Government income</i>	Gives social assistance transfers to low income households divided by 1000.

Each individual at working age had to choose between two alternatives, being a wage worker or being inactive, hence, Z_{hi} is a dummy variable taking value 1 if an individual is a wage worker and 0 otherwise.

The selection model was estimated separately using maximum likelihood. The estimation was done on a subsample comprising only those at working age that is 16 to 64 years. Estimation was done separately for two demographic groups, single individuals and married couples. Table B.4 presents estimation results for the selection model.

Table B.4: Selection model Estimates

Selection model	Single individuals Coefficient (standard errors)	Married couples Coefficient (standard errors)
Work		
<i>dumrace2</i>	0.523*** (0.028)	0.367*** (0.027)
<i>dumrace3</i>	0.121* (0.073)	-0.063 (0.055)
<i>dumrace4</i>	0.301** (0.094)	0.066 (0.077)
<i>Education</i>	0.036 (0.042)	0.199*** (0.044)
<i>Gender dummy</i>	-0.028 (0.020)	-0.963** (0.026)
<i>Age</i>	0.231*** (0.005)	0.141*** (0.006)
<i>Age squared</i>	-0.003*** (0.000)	-0.002*** (0.000)
<i>Location dummy</i>	-0.074** (0.023)	-0.051** (0.024)
<i>Chn6</i>	-0.306*** (0.016)	-0.131** (0.060)
<i>Government income</i>	-0.004 (0.003)	-0.026*** (0.004)
<i>Gender * chn6</i>	-----	-0.042 (0.036)
<i>Disposable predicted wage</i>	0.015** (0.005)	0.007*** (0.002)
<i>Constant</i>	-4.750*** (0.064)	-1.809*** (0.120)
<i>Number of observation</i>	37340	24628
<i>Wald chi2</i>	7658.95	4434.55
<i>Prob> chi2</i>	0.000	0.000

Note: *** Significant at 1%, ** significant at 5%, * significant at 10%.

The effects of explanatory variables on the dependent variable are not linear; hence interpretation of coefficients is not as direct as in ordinary least squares (OLS) estimation, where coefficients give slope of change in dependent

variable as explanatory variable changes. Now signs of coefficients tell us whether the probability of being employed increases or decreases as explanatory variables are changed. Gender dummy (being a female relative to male), location dummy (rural relative to urban), government income and the presence of children less than six years in the household (chn6), negatively influence the probability of being employed. While all race dummy variables, spouse's education and disposable predicted wage have a positive effect on the probability of being employed. The probability of being employed increases with age but at a decreasing rate, that is probability of being employed increases with age initially and then decreases at a higher age, as indicated by a positive sign on age and a negative sign on age squared.

Appendix C: Linear expenditure system

The Appendix summarizes the procedure taken to estimate parameters for the linear expenditure system given in section 4.3.1 (Equation 4.16). We used demographic translating in order to introduce demographic variables into the linear expenditure system. According to Pollak and Wales (1981), translating can be understood as allowing necessary or subsistence parameters of a demand system to depend on the demographic variables. We assumed that subsistence levels (λ 's) depend linearly on some set of demographic variables and that the remaining parameters are independent of demographic variables. Subsistence levels were made an explicit function of the socio-demographic characteristics as follows:

$$\lambda_{hq} = a_{0,q} + a_{1,q}A + a_{2,q}K + a_{3,q}loc + \alpha_{4,q}edu , \quad (C.1)$$

where A is the number of adults in the household minus 1, K is the number of children in the household (10 years and below), loc is a location dummy variable (0= urban, 1= rural) and edu is education dummy for household head (0=low education, 1= high education).

For estimation purposes, we used a stochastic form of the linear expenditure system obtained by adding a disturbance term, ε_{hq} to the share form of the demand equation. The share form was used in order to reduce heteroscedasticity. The share form was obtained by dividing through Equation 4.16 by total expenditure, i.e.

$$\frac{P_q C_{hq}}{E_h} = \frac{P_q \lambda_{h^*q}}{E_h} + \beta_{h^*q} \left(1 - \frac{\sum_j P_j \lambda_{h^*j}}{E_h}\right) + \varepsilon_{hq} . \quad (C.2a)$$

In addition, in order to replicate expenditures given in the survey, we also made use of the following assumption:

$$\sum_j P_j \tilde{\lambda}_{h^*j} = \sum_j P_j \hat{\lambda}_{h^*j} , \quad (C.3)$$

where $\tilde{\lambda}_{h^*j}$ denotes an adjusted minimum expenditure and $\hat{\lambda}_{h^*j}$ denotes the estimated minimum expenditure.

Our demand equation is then defined as

$$\frac{P_q C_{hq}}{E_h} = \frac{P_q \tilde{\lambda}_{h^*q}}{E_h} + \hat{\beta}_{h^*q} \left(1 - \frac{\sum_j P_j \tilde{\lambda}_{h^*j}}{E_h}\right), \quad (\text{C.2b})$$

where $\tilde{\lambda}_{h^*q}$ is obtained by inserting the estimate $\hat{\beta}_{h^*q}$ from (C.2a) and everything else from survey data, and using (C.3) to close the remaining degree of freedom.

Since expenditure shares and non-stochastic terms in our Equation C.2a, add up to one for each household, the covariance matrix is singular (due to the fact that sum of expenditure should be equal to income), so we dropped one equation. Barten (1969) showed that for marginal budget shares, β , it does not matter which equation is dropped since results are similar. The parameter of the dropped equation was then recovered from the adding-up restriction. Finally, to handle zero expenditure, commodities were aggregated to five groups as explained in Section 5.1.1.

In the case of q commodities, there will be 6 times q minus 1 ($6q-1$) parameters to be estimated (that is q a_0 's, q a_1 's, q a_2 's, q a_3 's, q a_4 's and $q-1$ marginal budget shares (β 's). From $q-1$ independent equations, a total of $6q-2$ independent coefficients can be estimated, yet the system contains $6q-1$ parameters. This implies that the system is under-identified. All these $6q-1$ parameters can be estimated from a two or more periods' household survey. According to Pollak and Wales (1992), if one of the minimum expenditures is known before estimation, then survey data for one period can be used to estimate the remaining $q-1$ minimum expenditure and marginal budget shares. For estimation purposes, minimum expenditure for services is assumed to be zero.

The linear expenditure system is linear in income but nonlinear in parameters (Judge et al., 1988), so an iterative approach was used. We used STATA's NLSUR command for estimation. NLSUR asymptotically approximates maximum likelihood (www.stata.com). NLSUR was used in order to estimate all equations simultaneously while accounting for the possibility of correlated errors

as values of the different expenditure categories were collected from the same set of households.

The Income and Expenditure Household Survey, which was used for demand estimation, does not have information on household quantities consumed. This implies that there will be no corresponding unit value of commodities. For simplicity reasons we assumed that all households in the survey face the same prices and also that prices are equal to unity for the base period. Estimation was done separately for different races. Detailed estimation results are given in Table C.1.

Table C.1 : LES equation estimates

Variable	Coefficient (Standard errors)			
	Blacks	Coloureds	Asians	Whites
Minimum expenditure:				
Agriculture:				
<i>Constant</i>	111.597*** (16.942)	50.964 (44.143)	546.036** (151.864)	38.738 (144.361)
<i>No. of Adults</i>	160.442*** (6.517)	167.183*** (19.337)	313.500*** (57.935)	104.497*** (43.276)
<i>No. of children</i>	136.804*** (8.909)	152.7306*** (28.723)	-48.330 (92.622)	41.480 (77.573)
<i>Location dummy</i>	286.070*** (17.299)	554.098*** (53.682)	559.064** (222.253)	380.454*** (83.810)
<i>Education dummy</i>	-70.726*** (17.624)	-146.854* (54.868)	-573.690*** (149.077)	-0.513 (145.263)
Food:				
<i>Constant</i>	636.415*** (30.804)	751.809*** (112.480)	2360.698*** (405.550)	1001.778*** (305.107)
<i>No. of Adults</i>	273.260*** (11.849)	458.938*** (49.272)	892.649*** (154.714)	568.916*** (91.464)
<i>No. of children</i>	228.095*** (16.198)	518.230*** (73.188)	276.0516 (247.345)	540.680 (163.952)
<i>Location dummy</i>	353.687*** (31.453)	1775.333*** (53.786)	2202.724*** (593.520)	-55.856 (177.135)
<i>Education dummy</i>	-237.637*** (32.044)	-581.167*** (139.809)	-2117.400*** (398.106)	-609.476 (307.014)
Manufacturing:				
<i>Constant</i>	61.410*** (14.627)	-85.722* (48.898)	-478.456** (296.863)	-621.965* (348.532)
<i>No. of Adults</i>	45.962*** (5.626)	48.536** (21.420)	66.662 (113.251)	-42.055 (104.482)
<i>No. of children</i>	43.515*** (7.694)	52.625 (31.817)	-163.389 (181.057)	8.313 (187.286)
<i>Location dummy</i>	55.987*** (14.935)	186.949*** (59.465)	826.717* (434.458)	420.274* (202.345)
<i>Education dummy</i>	-1.933 (15.216)	-111.810** (60.779)	93.334 (291.414)	522.312 (350.710)
Capital goods:				
<i>Constant</i>	225.124*** (11.230)	304.450*** (40.959)	752.778 (273.408)	559.161*** (218.850)
<i>No. of Adults</i>	109.522*** (4.320)	209.224*** (17.942)	542.831*** (104.303)	322.473*** (65.606)
<i>No. of children</i>	57.033*** (5.905)	90.588 (26.651)	-263.152 (166.752)	-81.054** (117.601)
<i>Location dummy</i>	-68.373*** (11.466)	-65.862 (49.809)	324.668 (400.132)	107.748 (127.057)
<i>Education dummy</i>	31.788** (11.682)	-10.752 (50.910)	-517.412 (268.39)	-372.074 (220.218)
Marginal budget shares:				
Agriculture	0.161*** (0.001)	0.118*** (0.002)	0.081*** (0.003)	0.066*** (0.001)
Food	0.315*** (0.001)	0.326*** (0.004)	0.223*** (0.007)	0.172*** (0.003)
Manufacturing	0.121*** (0.01)	0.117*** (0.003)	0.151*** (0.006)	0.165*** (0.003)
Capital goods	0.103*** (0.001)	0.108*** (0.002)	0.120*** (0.006)	0.109*** (0.002)

Notes: 1. *** significant at 1%, ** significant at 5%, * significant at 10%.

2. "Agriculture" includes agriculture, mining and textiles, "Manufacturing" includes manufacturing, petroleum and vehicles and "Capital goods" include capital goods and chemical.

Most parameters are significant at 5% level of significance, except for some demographic variables which are not significant even at 5% level. For example, the number of children is not significant for Asians. A negative sign on minimum quantities coefficient denotes a non-essential good that is only consumed if income exceeds a certain amount. Marginal effects of supernumerary income (income available after all essential quantities have been met) are all significant at 5% level.

According to Pollak and Wales (1978), we cannot infer a change in consumption of good q , (C_q) from a change in demographic variable, since changes in demographic variables affect all the minimum expenditures (λ_q) simultaneously. For example, we cannot infer a change in quantity consumed of food from an increase in number of adults, which causes an increase in minimum expenditure for food. Instead, a change in demographic variables causes a reallocation of expenditure among the consumption categories, since total expenditure remains fixed. Any increase in consumption of some goods should be balanced by decrease in the consumption of other goods.

Appendix D: Poverty and inequality indices

The Appendix explains various indices used for poverty and inequality analysis.

Poverty

For poverty analysis we used the Foster Greer Thorbecke index.

$$P_{\alpha} = \frac{1}{N} \sum_{j=1}^J \left[\frac{z - y_j}{z} \right]^{\alpha}, \quad (\text{D.1})$$

where P_{α} is the poverty measure, j is a subgroup of individuals with income below the poverty line (z), N is the number of individuals in the sample, and y_j is income of the j^{th} individual. The parameter α reflects poverty aversion and it can take three possible values:

- ***The poverty headcount*** ($\alpha = 0$)

It measures the proportion of the population whose income or consumption is below the poverty line. The index does not give a measure of the extent of poverty; for example it does not provide information on how far households are from the poverty line.

- ***The average normalized poverty gap / poverty depth*** ($\alpha = 1$)

It measures how far households are away from the poverty line. Its main weakness is that it may not capture difference in severity of poverty; that is, how large is the inequality among the poor.

- ***Severity of poverty/ average squared normalized poverty gap*** ($\alpha = 2$)

Measures both how far households are from the poverty line and also how large is the inequality among the poor.

Inequality

The following indices were used for income inequality analysis.

- **Relative mean deviation (RMD)**

It gives the ratio of the sum of the absolute value of distance between each income in the distribution and the mean income to total income. The formula is given below.

$$\text{Mean difference (MD): } MD = \frac{1}{n(n-1)} \sum |y_i - y_j|, \quad (D.2)$$

$$RMD = MD / \text{Arithmetic mean of } y, \quad (D.3)$$

where y_i is income of individual i .

The main disadvantage of this measure is that it is not sensitive to transfers between people on the same side of the mean income; hence it violates the transfer axiom, which states that a transfer from poorer to a richer person must result in an increase in inequality (*ceteris paribus*).

- **Coefficient of variation**

It is a normalized measure of dispersion. It is defined as the ratio of the standard deviation over the mean.

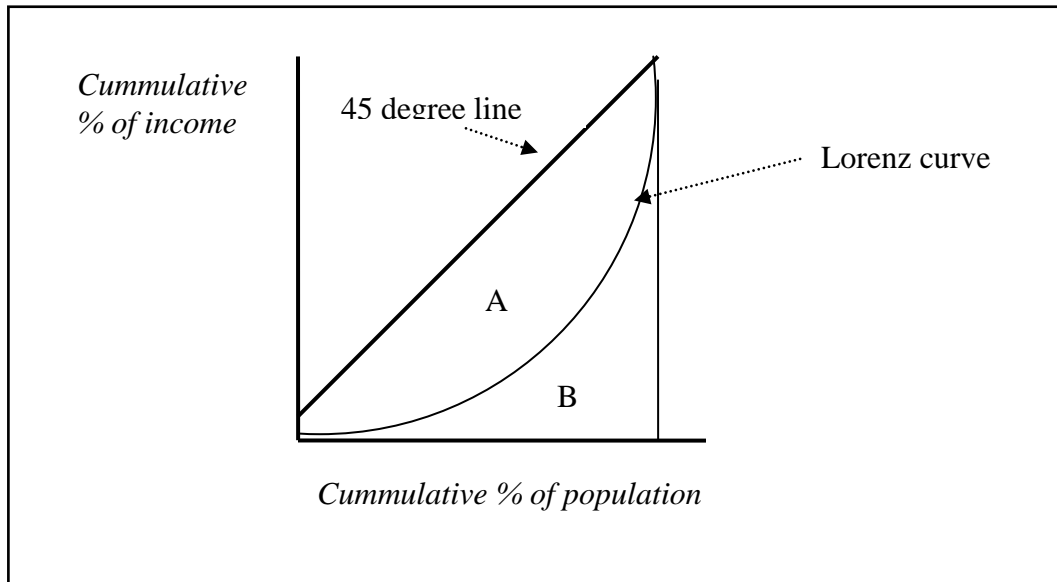
$$\text{Coefficient of variation} = \text{Standard deviation} / \text{Mean} \quad (D.4)$$

The index attaches equal weight to transfers anywhere in the distribution.

- **Gini coefficient**

The index was proposed by Gini in 1912, and it is one of the most widely used measures of inequality. The index varies from zero (indicating absolute equality) to one (indicating absolute inequality). The Gini coefficient can be calculated from the Lorenz curve as illustrated on the next diagram.

Figure D.1: Lorenz curve diagram



Note: Gini coefficient = Area between Lorenz curve and line of perfect equality (A) / Total area below line of equality (A+B).

The main disadvantage of the Gini coefficient is that it attaches more weight to transfers at the middle of the distribution than in the tails of the distribution (Atkinson, 1970). In addition the measure is not readily decomposable.

- **Theil index**

It is a member of the generalized entropy methods. Unlike the previous indices it is not derived from the Lorenz curve. The index measures an entropic "distance" the population is away from the "ideal" mean (state of everyone having the same income). The formula for the generalized entropy measure is given as:

$$GE(\alpha) = \frac{1}{\alpha(\alpha-1)} \left[\frac{1}{N} \sum_{i=1}^N \left(\frac{y_i}{\mu} \right)^\alpha - 1 \right], \quad (D.5)$$

$\alpha = 1$ gives the Theil index (Equation D.6):

$$T_{(\alpha=1)} = \frac{1}{N} \sum_{i=1}^N \frac{y_i}{\mu} \ln \left(\frac{y_i}{\mu} \right), \quad (D.6)$$

$\alpha = 0$ gives the Mean Log deviation (Equation D.7).

$$T_{(\alpha=0)} = \frac{1}{N} \sum_{i=1}^N \ln \left(\frac{\mu}{y_i} \right) . \quad (\text{D.7})$$

Where y_i , is the income of the i^{th} individual or subgroup, μ is the mean income of the individual or subgroups, and N is the population. Parameter α indicates individuals' different perceptions to inequality. A lower value of α indicates a higher degree of inequality aversion. This index indicates the extent to which inequality in the population as a whole is attributable to inequality within each population group, or between population groups. Its main advantage is that it can be decomposed across different subgroups. But it has the following disadvantages; firstly, it is an arbitrary measure of inequality. Secondly, it is insensitive to inequality among high income earners but very sensitive to inequality among relatively low income earners.

- **Atkinson index (AI)**

It is a welfare based measure of inequality. Its main feature is that it can gauge movements in different segments of income distribution. The index is equal to zero when incomes are equally distributed and moves towards unity as inequality increases. The main formula for calculating this index is given below.

$$AI = 1 - \frac{1}{\mu} \left(\frac{1}{N} \sum_{i=1}^N y_i^{(1-e)} \right)^{1/(1-e)} , \quad (\text{D.8})$$

where y_i denotes the income of person i in a population of N people with mean μ . e is the inequality aversion parameter, which reflects strength of society's preference for inequality. When e is greater than zero, there is social preference for equality. The Atkinson index becomes more sensitive to changes at the lower

end of the income distribution as e approaches unity. An e equal to zero implies neutrality to inequality.

According to Atkinson (1970) the index AI can be interpreted as expressing the cost of inequality in terms of a proportionate amount of income that could be subtracted from the mean without affecting social welfare level as follows,

$$AI = 1 - \frac{y_{EDE}}{\mu}, \quad (D.8a)$$

where y_{EDE} represents equally distributed equivalent income, which can be defined as the level of income which, if equally distributed, would give the same level of social welfare as the present distribution. The more equal the income distribution, the lower will be the value of Atkinson index and the closer will be y_{EDE} to μ .

Solving for y_{EDE} from Equation D.8a gives:

$$y_{EDE} = \mu(1 - AI) = W, \quad (D.8b)$$

which gives the same measure of welfare (W) as the Sen's welfare index (Equation D.9).

- **Sen's welfare index**

Sen extended Atkinson's index to a more general case where welfare is non-additive. The formula for calculating this index is given below.

$$W = \mu(1 - G), \quad (D.9)$$

where W measures welfare, μ is mean income and G is Gini coefficient. Welfare is increasing in mean, but decreasing in inequality. The measure captures the idea of trade-off between efficiency and inequality that is we are willing to trade more mean for a more equal distribution and vice versa.

Appendix E: General Appendix

Table E.1 : Total households per group

Household group	Frequency	Household group	Frequency
1	1 407	50	37
2	1 213	51	26
3	1 022	52	1 300
4	2 645	53	4
5	1 555	54	12
6	553	55	10
7	960	56	371
8	1 124	57	2
9	2 656	58	6
10	1 115	59	6
11	818	60	250
12	893	64	25
13	3 037	Total	25 835
14	340		
15	881		
16	347		
17	203		
18	226		
19	134		
20	661		
21	218		
22	159		
23	94		
24	241		
25	281		
26	174		
27	62		
28	98		
29	66		
30	36		
31	21		
32	27		
33	9		
34	48		
35	23		
36	328		
37	14		
38	32		
39	8		
40	40		
42	2		
44	11		
49	4		

Source: Own Table.

Table E.2: Production levels

	Option 1 (%)	Option 2 (%)
Agriculture	0.7	0.6
Food	1.2	0.5
Manufacturing	-0.2	-2.3
Capital goods	---	-1.1
Services	-0.1	-1.1
Total	---	-1.1

Source: *Own Table.*

Table E.3: Income elasticity of demand for 64 household groups

Rhg	c_agri	c_food	c_manf	c_capg	c_serv
1	1.087	0.631	1.388	1.183	1.679
2	1.362	0.812	0.993	1.212	1.045
3	1.130	0.634	1.393	1.199	1.594
4	1.609	1.129	0.727	1.749	0.758
5	1.030	0.656	1.454	1.036	1.658
6	1.211	0.749	1.149	1.378	1.125
7	1.136	0.651	1.699	1.056	1.460
8	1.535	1.090	1.027	1.527	0.712
9	0.832	0.608	1.418	1.621	2.144
10	1.081	0.784	0.880	1.963	1.157
11	0.895	0.623	1.360	1.441	1.942
12	1.232	0.975	0.724	1.701	0.942
13	0.822	0.593	1.556	1.502	2.365
14	1.020	0.753	0.893	1.428	1.387
15	0.874	0.625	1.272	1.316	2.168
16	1.204	0.984	0.734	1.691	0.937
17	0.985	0.645	1.521	1.242	1.572
18	1.070	0.744	1.035	1.511	1.241
19	0.965	0.626	1.850	0.847	1.993
20	1.505	1.115	0.810	1.662	0.788
21	0.993	0.589	1.942	0.994	2.091
22	0.965	0.681	1.234	1.374	1.469
23	0.981	0.578	2.416	1.066	2.000
24	1.201	0.953	1.356	1.355	0.841
25	0.897	0.523	2.084	1.853	2.532
26	0.887	0.643	1.328	1.987	1.523
27	0.956	0.526	1.639	1.691	2.733
28	1.073	0.695	0.961	2.076	1.338
29	0.827	0.582	1.800	1.465	2.098
30	0.721	0.620	1.224	1.728	2.169
31	0.784	0.531	3.292	1.397	2.709
32	0.889	0.670	1.502	1.573	1.412
33	0.980	0.465	6.105	0.749	1.683
34	0.900	0.637	1.338	1.234	1.213
35	0.782	0.487	3.575	0.989	1.542
36	1.226	0.835	0.952	1.683	0.972
37	0.628	0.459	2.418	0.982	2.112
38	0.780	0.526	1.716	1.315	1.448
39	3.233	0.497	1.378	1.018	1.423
40	1.032	0.738	1.362	1.335	1.015
42	1.023	0.368	1.446	1.237	3.720
44	1.300	0.638	1.246	0.797	1.343
49	0.789	0.476	1.526	1.194	1.372
50	1.394	0.614	1.021	1.159	1.172
51	1.110	0.293	4.076	1.608	2.001
52	1.320	0.909	0.941	1.665	0.939
53	1.075	0.408	25.548	1.068	1.194
54	2.027	1.134	0.844	1.583	0.886
55	0.956	0.543	6.849	0.554	1.238
56	1.240	0.849	1.104	1.763	0.916
57	0.825	0.225	2.434	1.978	15.721
58	0.718	0.975	1.459	1.159	0.930
59	0.369	0.251	8.387	3.653	5.739
60	0.656	1.126	0.863	1.823	0.985
64	1.189	0.781	1.552	1.300	0.914

Source: Own calculations.

Table E.4: Frisch parameters for 64 household groups

Rhg	Frisch	Rhg	Frisch
1	1.455	44	1.078
2	1.057	49	1.062
3	1.386	50	1.014
4	1.031	51	2.980
5	1.469	52	1.012
6	1.059	53	2.347
7	1.371	54	1.005
8	1.034	55	1.832
9	1.682	56	1.013
10	1.076	57	2.015
11	1.626	58	1.023
12	1.056	59	1.726
13	1.756	60	1.009
14	1.066	64	1.023
15	1.640		
16	1.051		
17	1.701		
18	1.090		
19	1.683		
20	1.031		
21	1.770		
22	1.099		
23	1.526		
24	1.038		
25	3.138		
26	1.173		
27	2.140		
28	1.127		
29	2.830		
30	1.195		
31	1.767		
32	1.147		
33	2.797		
34	1.108		
35	2.013		
36	1.038		
37	3.304		
38	1.180		
39	2.042		
40	1.035		
42	1.748		

Source: *Own Table.*

Table E.5: Percentage changes in real income by household group

Household Group	Option1	Option2
Urban African, male headed, educated and low income household	22.188	19.614
Urban African, male headed, educated and high income households	-0.248	-3.478
Urban African, male headed, uneducated and low income households	10.545	7.765
Urban African, male headed, uneducated and high income households	-0.312	-3.716
Urban African, female headed, educated and low income households	30.112	27.796
Urban African, female headed, educated and high income households	-0.386	-3.651
Urban African, female headed, uneducated and low income households	15.124	12.239
Urban African, female headed, uneducated and high income households	-0.381	-3.643
Rural African, male headed, educated and low income households	31.263	28.859
Rural African, male headed, educated and high income households	-0.412	-3.919
Rural African, male headed, uneducated and low income households	14.159	11.323
Rural African, male headed, uneducated and high income households	-0.430	-4.083
Rural African, female headed, educated and low income households	38.988	37.079
Rural African, female headed, educated and high income households	-0.612	-4.155
Rural African, female headed, uneducated and low income households	20.833	18.593
Rural African, female headed, uneducated and high income households	-0.471	-3.936
Urban Coloreds, male headed, educated and low income household	24.397	21.797
Urban Coloreds, male headed, educated and high income households	-0.103	-2.932
Urban Coloreds, male headed, uneducated and low income households	17.247	15.008
Urban Coloreds, male headed, uneducated and high income households	-0.273	-3.595
Urban Coloreds, female headed, educated and low income households	37.146	35.238
Urban Coloreds, female headed, educated and high income households	-0.148	-2.819
Urban Coloreds, female headed, uneducated and low income households	25.936	23.570
Urban Coloreds, female headed, uneducated and high income households	-0.293	-3.403
Rural Coloreds, male headed, educated and low income households	20.305	18.145
Rural Coloreds, male headed, educated and high income households	-0.116	-3.016
Rural Coloreds, male headed, uneducated and low income households	10.328	7.740
Rural Coloreds, male headed, uneducated and high income households	-0.184	-3.282
Rural Coloreds, female headed, educated and low income households	37.161	35.466
Rural Coloreds, female headed, educated and high income households	-0.111	-2.663
Rural Coloreds, female headed, uneducated and low income households	19.073	16.652
Rural Coloreds, female headed, uneducated and high income households	-0.123	-2.896
Urban Asians, male headed, educated and low income household	40.317	38.773
Urban Asians, male headed, educated and high income households	-0.430	-3.936
Urban Asians, male headed, uneducated and low income households	22.716	19.777
Urban Asians, male headed, uneducated and high income households	-0.361	-3.849
Urban Asians, female headed, educated and low income households	30.282	28.029
Urban Asians, female headed, educated and high income households	-0.264	-3.138
Urban Asians, female headed, uneducated and low income households	31.506	28.354
Urban Asians, female headed, uneducated and high income households	-0.690	-4.562
Rural Asians, male headed, educated and high income households	0.008	-2.787
Rural Asians, male headed, uneducated and high income households	0.891	-5.510
Urban Whites, male headed, educated and low income household	9.791	-4.795
Urban Whites, male headed, educated and high income households	-0.881	-5.506
Urban Whites, male headed, uneducated and low income households	13.423	8.630
Urban Whites, male headed, uneducated and high income households	-0.537	-4.417
Urban Whites, female headed, educated and low income households	49.647	48.629
Urban Whites, female headed, educated and high income households	-1.423	-7.094
Urban Whites, female headed, uneducated and low income households	62.948	61.957
Urban Whites, female headed, uneducated and high income households	-0.615	-4.463
Rural Whites, male headed, educated and low income households	2.173	-0.438
Rural Whites, male headed, educated and high income households	-0.696	-4.691
Rural Whites, male headed, uneducated and low income households	5.544	3.046
Rural Whites, male headed, uneducated and high income households	-1.056	-7.121
Rural Whites, female headed, uneducated and high income households	-0.706	-4.850

Source: Own calculations

Affirmation

I hereby affirm that I have completed my doctoral thesis entitled, " Government social assistance, income inequality and poverty in South Africa: A computable general equilibrium- microsimulation model " entirely on my own and unassisted, and that I have specially marked all of the quotes I have used from other authors as well as those passages in my work that are extremely close to the thoughts presented by other authors, and listed the sources in accordance with the regulations I have been given.

Date

Signature

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Eidesstattliche Erklärung

Ich erkläre hiermit an Eides Statt, dass ich meine Doktorarbeit

“Government social assistance transfers, income inequality and poverty in South Africa:
A computable general equilibrium – Microsimulation model.”

Selbständig und ohne fremde Hilfe angefertigt habe und dass ich alle von anderen Autoren wörtlich übernommenen Stellen, wie auch die sich an die Gedanken anderer Autoren eng anlehenden Ausführungen meiner Arbeit, besonders gekennzeichnet und die Quellen nach den mir angegebenen Richtlinien zitiert habe.

Die Arbeit hat bisher in gleicher oder ähnlicher Form oder auszugsweise noch keiner Prüfungsbehörde vorgelegen.

Kiel, den July 2015

CURRICULUM VITAE

CHARITY GOMO

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EDUCATION:

M.Sc. in Economics degree

University of Zimbabwe:

Degree class: Pass with merit

B.Sc. honours in Economics

University of Zimbabwe Degree class:

Upper second class (2.1)

WORK EXPERIENCE:

1. National Treasury, South Africa: Senior Economist 2014- to date
2. Rhodes University, South Africa: Lecturer 2012-2014
3. University of Witwatersrand South Africa: Lecturer 2004-2007

RESEARCH SEMINARS/WORKSHOPS/SYMPOSIA/CONFERENCES

Brown bag seminar, University of Kiel- July 2009

Prof Bröcker's doctoral seminar – July 2009, Dec 2009, July 2010, Dec 2010

14th international student conference- EGE University, Izmir, Turkey, May 2011

9th Development Dialogue- ISS Hague Netherlands, June 2011