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CGE analysis of rural economic development through agriculture policy in South Africa: a focus on poverty, inequality and gender

Abstract

South Africa is one of the top economic giants of Africa, but its levels of unemployment, poverty and inequality remain persistently high. Government continues to look for workable solutions to address the challenges. If poverty reduction is to be achieved in South Africa, then the Government needs to put in place interventions that are inclusive to ensure that the poor and females are not left behind. This is because poverty levels are higher among women than men.

This study sought to assess the economywide and distribution impacts of government intervention on the rural economy through agricultural related support, focusing on the possible differential impacts for rural and urban people and male and female workers. Results from simulating reallocation of land from commercial farming to smallholder farming and increasing overall agriculture capital indicate that generally, policies could yield positive impacts on the South African economy as measured by the increase in consumption. However, poverty persists over the simulation period and rural households benefit relatively less than their urban counterparts.

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List of abbreviations

AGRA	Alliance for a Green Revolution in Africa
CAADP	Comprehensive Africa Agriculture Development Programme
CGE	Computable General Equilibrium
CRDP	Comprehensive Rural Development Programme
DAFF	Department of Agriculture, Forestry and Fisheries
DPME	Department of Planning, Monitoring and Evaluation
DWYPD	Department of Women Youth and Persons with Disabilities
GDP	Gross Domestic Product
GoSA	Government of South Africa
LFS	Labour Force Survey
MTSF	Medium-Term Strategic Framework
NDP	National Development Plan
NIDS	National Income Dynamics Study
NPC	National Planning Commission
NTC	National Technical Certificate
SALDRU	Southern Africa Labour and Development Research Unit
SAM	Social Accounting Matrix
SDG	Sustainable Development Goals

Executive summary

South Africa is one of the top economic giants of Africa, but its levels of unemployment, poverty and inequality remain persistently high. If poverty reduction is to be achieved in South Africa, then the Government needs to put in place interventions that are inclusive to ensure that the poor and females are not left behind. This is because poverty levels are higher among women than men. Following the adoption of the National Development Plan (NDP) Vision 2030 in 2012, one of South Africa's key focus areas has been rural development. Rural development is one of the 14 outcomes of the 2014-2019 Medium-Term Strategic Framework (MTSF). The South African government has put in place various measures and policies to support the rural development outcome, including the Comprehensive Rural Development Programme (CRDP). The objectives of the CRDP include contributing to redistribution of agricultural land, improving food security, and expanding opportunities for rural women, among others.

This study sought to assess the economy-wide and distribution impacts of government intervention on the rural economy through agricultural support, focusing on the possible differential impacts for rural and urban people and male and female workers and households. It used Computable General Equilibrium (CGE) modelling to evaluate impacts of supporting agriculture through reallocating land from commercial agriculture to smallholder agriculture and through increasing agricultural capital in South Africa. The study conducted potential interventions widely believed to be key in improving welfare conditions mainly for poor rural communities of South Africa.

The first simulation involved redistributing land from commercial to smallholder agriculture. The second shock simulated an increase in capital for the agricultural sector as an endeavour to increase employment improve food security, given that farming takes place largely in rural areas. Results from both simulations indicate that overall, policies to improve the rural economy through agriculture could yield positive impacts in terms of improvements in welfare as measured by the increase in consumption. However, rural households appear to benefit relatively less than their urban counterparts. In addition, the results show persistence of poverty despite the interventions.

Some interesting results were obtained in terms of labour. The macro results show that female labour benefits or suffers comparatively better compared to male labour. Such a result could contribute to a reduction in the disparities that characterise the country across the gender divide. Both reallocation of land to smallholder farmers and increasing spending on agriculture capital appear good policies in terms of their overall impact in terms of benefiting all households and benefiting female labour.

However, male labour benefits relatively better than female labour in terms of labour supply and earnings outcomes based on the microsimulation results. There would be need therefore, for corrective government strategies to address the potential negative impacts like the apparent worsening of the gender gap in the labour market at the micro level. This will ensure that the agricultural policies being proposed by government do not address only the historical injustices in resource ownership, but also, importantly, address the challenge of gender inequality in the country.

1. Introduction

1.1 Context of the study

South Africa is one of the top economic giants of Africa, but its levels of unemployment, poverty and inequality remain persistently high. It contributes 16% to Africa's Gross Domestic Product (GDP); however, it is characterised by the persistent triple challenges, with those living in the rural areas and women being the most vulnerable. Economically, the country has been performing modestly over the years, especially when compared to other African countries. However, within its borders, such achievements are not shared equally by all. The World Bank and Department of Planning, Monitoring and Evaluation ([DPME], 2018) found that South Africa is one of the most unequal societies in the world and the country needs to prioritise policies that create jobs, reduce poverty and reduce inequality. Agriculture is believed to be key to Africa's future (Alliance for a Green Revolution in Africa [AGRA], 2018). According to Phoofolo (2018), agricultural sector growth is believed to contribute relatively more to poverty reduction than growth in other sectors of the economy, yet rural areas have not been included in the economic growth waves experienced by most African countries in the recent past. Consequently, rural communities in most African countries, South Africa included, are home for the poorest people.

Rural development has long been considered a strategy to improve the economic and social life of the rural poor through extending the benefits of development to the poorest living in the rural areas, including small scale farmers, tenants and the landless (The World Bank, 1975). Sustainable rural development can contribute to three critical goals of poverty reduction, namely a wider shared growth, household food security and sustainable natural resource management (World Bank, 2006). The rural economy not only refers to the farm but is a complex process requiring coordination among institutions and departments involved to achieve rural economic development. As pointed out by Bertolini (2019), the harmful impacts of rural poverty do not affect the rural areas alone but also affect the entire socio-economic context. If not addressed, lagging rural poverty can perpetuate the rural-urban economic divide, exacerbate inequality, promote congestion in urban areas and worsen related social problems; thus, further increasing the public budget for social policy spending. Hence, analysis of any rural development should take an economywide approach because non-agriculture activities also affect rural households as well as the rural-urban links and the relationship between agricultural and non-agricultural sectors (Du Toit, 2016; Mabugu, 2018).

The potential of rural development in South Africa, and the need to rekindle it, is widely acknowledged even within government circles (Bank & Hart, 2017). Rural development is widely acknowledged as a strategy to improve the economic and social life of rural poor (Bank & Hart, 2017). Despite its potential, agriculture does not seem to get the focus it deserves in South Africa as the country's agricultural sector is one of the least supported globally (Department of Agriculture, Forestry and Fisheries [DAFF], 2014). South Africa's public spending on agriculture as a share of total government expenditure is above that of only six other countries in Africa over the period 2005 to 2015 (AGRA, 2018). In 2019, agriculture received 1.68% of total public expenditure, which is far lower than the 10% share of public expenditure that was committed by all African Heads of States and Government under the Comprehensive Africa Agriculture Development Programme (CAADP) and reaffirmed under the Malabo Declaration. As a result, the country's rural economy is said not to be vibrant enough to provide its rural communities with adequate and sustainable remunerative employment or self-employment opportunities (Department of Agriculture, 2001). Given the low public spending on agriculture in South Africa, reallocation of land from commercial to smallholder agriculture could be one way of providing the rural poor with resources to improve their livelihoods. There are discussions of land expropriation in the country, which could see land being redistributed without compensation (BusinessTech , 2020; Mutlokwa, 2020). It is a contentious issue, with supporters arguing it is an essential measure while critics dispute that it is a threat to property rights that can choke off investment (Friedman, 2018).

Women play a crucial role in African agriculture, which is mainly characterised by low technology but high land and labour intensity. Organisation for Economic Cooperation and Development ([OECD], 2016) highlighted the importance of gender in rural development, pointing out that in many countries women are significant actors in the agriculture sector and rural development. According to Arndt et al. (2011), in many African countries, women make up 60% to 80% of the workforce in agriculture and they play a significant role in food production but have little control over the resources. Equal participation of men and women in social, economic and political life is far from being achieved as noted by the Economic Community of West African States (2017). However, basing on the proportion of women in the agriculture and non-agriculture rural economy, agricultural policies are highly likely to have positive impacts on women.

While there has been an increase in access to basic services among people in rural areas and some progress has been made in terms of reduction in rural poverty over the past 20 years, DPME (2014) argued that high levels of poverty and inequality are still a characteristic of South African rural areas. The National Planning Commission ([NPC], 2012) asserted in the National Development Plan (NDP) Vision 2030 that South Africa's rural communities should be offered better opportunities that enable them fully to participate in the socio-economic and political life of the nation. DPME (2014) stated that the focus of the South African Government during the 2014-2019 MTSF continues to be rural development, with targets and actions that include provision of more support to smallholder farmers.

Statistics South Africa (2017a) provided evidence of the need to focus on interventions that benefit women when addressing poverty. The 2015 lower-bound poverty line for males was 38.2% in comparison to 41.7% for females (Statistics South Africa, 2017a). Thus, if Sustainable Development Goals (SDG), especially SDG 1 and SDG 5 of no poverty and reducing gender inequality, respectively, are to be achieved in South Africa, then the Government needs to put in place pro-poor and gender-inclusive interventions so that the poor and females are not left behind.

1.2 Research questions and objectives

Based on the above arguments, this study sought to analyse proposed policy strategies expected to improve the rural economy. The South African economy is characterised by marked multifaceted differences between males and females. This calls for government strategies that are gender-sensitive in order to achieve the leave-no-one-behind principle of SDGs. However, the policymakers first need to know what impact existing and/or proposed policies have, a contribution this study intends to make. There is a need to assess government policies to understand how they impact on gender inequality and related socio-economic challenges faced in South Africa particularly unemployment, poverty and income inequality. The focus of this study is therefore not to analyse gender sensitive government policies. Rather, it is to assess the economy-wide and distributional impact of proposed government policies to understand whether they are likely to address or perpetuate the said challenges. This helps inform policy makers on the need to improve policies being considered for implementation to improve welfare and gender outcomes for the rural economies and communities.

Specifically, the questions intended to be addressed include:

- What is the impact of reallocating land from commercial to smallholder agriculture?
- What is the impact of supporting the rural economy by increasing agriculture capital spending?
- Does this yield differential impacts on male versus female labour and on rural versus urban households?

Based on the above stated questions, the objective of the study is to:

- analyse effects of reallocation of land to smallholder agriculture and an increase in agricultural capital, on the rural economy using a CGE and micro-simulation analysis

2. Literature review

2.1 Gender issues in South Africa

2.1.1 Legal and cultural context

The reasons why women in South Africa are poorer than men are multidimensional. According to Kehler (2001), women's realities in South Africa are still determined by race, class and gender-based access to resources and opportunities. Akala (2018) concurred, pointing out that the marginalisation suffered by black women in South Africa is threefold, as a result of sexism, cultural factors, economic circumstances race and social class. Given that the poor black women's access to education, resources and opportunities are still severely limited, it is no wonder that black, particularly rural, women are the poorest.

Thamaga-Chitja et al (2010) described the contradiction between statutory laws and customary laws which continues to perpetuate inequality and poverty among rural women. In South Africa patriarchy in land allocation still exists with inheritance laws still being patriarchal in nature. Males get bigger land sizes relative to women and it is still difficult for females to get land in the rural areas from the traditional chiefs without a male representative. There are also negative perceptions in society and amongst the women about the risks involved when women own land on their own. This has led to a preference for joint land titles as this is socially acceptable and inclusive. Akinola (2018) explained how the absence of effective land management and gender construction in land allocations deepens gender inequality and restricts women's capacity building and agricultural development. This is the reality in Africa, specifically how in South Africa, for instance, despite the constitutional guarantee of gender equality, land reform in many rural areas has not benefitted women due to customary law practices which deny women access to land.

2.1.2 Gendered, regional poverty

As a result of gender inequality in the South African society, poverty levels in the country not only vary between population groups and location, but also by gender. Black African women in rural areas, characterised by low levels of education, are the main victims of the struggle against poverty and inequality. In 2015, 41.7% of females lived below the lower bound poverty level compared to 38.2% of males as stated cited in Section 1.1.

While a male-headed household has a 28% probability of being poor, the probability of a female-headed household being poor is 48% (DWYPD, 2019). As gendered poverty is mainly founded in patriarchal society that views females as not being equals, labour market wage differentials between males and females are then an outcome of a deep cultural system. In South Africa, poverty is mainly pronounced and predominantly in the rural areas compared to urban areas, where gender plays a huge role in decision making (Cheteni et al., 2019).

2.1.3 Gender disparities in the South African labour market

The labour market in South Africa is characterised by significant gender disparities. The labour market in South Africa is more favourable to men than women (Statistics South Africa, 2018). Women are more likely to be unemployed than men. The South African labour market historically was segmented along racial, class and gender lines with white men occupying the jobs associated with high returns and good opportunities

(Casale & Posel, 2005; Kehler, 2001). Black and Coloured women are the most vulnerable groups. They are also more likely to be the primary breadwinner for a larger household than white or Asian women are. These groups also earn less as they are concentrated at the lower end of the labour market (Bosch, 2020).

Women in both the formal and informal sectors face the same problems when it comes to income inequality, the main difference being the structure of the sectors. In formal employment women are disadvantaged by several things including taking extended maternity leave or taking a break to take care of the children which is often viewed negatively as lack of commitment to the employer. Taking extended leave for childcare and maternity leave reduces the pace of women's professional development as well as reduces the rate at which they are likely to be promoted relative to their male counterparts. In South Africa women who take unpaid maternity leave can claim from the Unemployment Insurance Fund (UIF), but this money is lower than their full salary. Childcare related expenses are not tax-deductible items therefore given that women are the ones mostly responsible for childcare, such costs reduce the wealth that a woman can accumulate over her lifetime. There are also other factors that contribute to women being poorer than men, for example the fact that women are not very aggressive when it comes to salary negotiations for new opportunities relative to their male counterparts. Another factor is the use of payslips from previous jobs which disadvantages women because traditionally women earn less than men therefore using their previous jobs' payslips for their new opportunities perpetuates existing pay discrepancies (Bosch, 2020).

Even though the proportion of women in the total population of South Africa was 51% in 2017, they accounted for only 44% of the employed population (Statistics South Africa, 2017b). Women still bear the brunt of unfair discrimination practices in most sectors. After the enactment of legislation to remove unfair discrimination, substantial positive changes were witnessed with women being represented among top earners (Casale & Posel, 2005). However, in 2018 women were over-represented in low paying work (97% of domestic workers) and underrepresented in high paying work as 32% of managers were women (Bosch, 2020). Ironically, even though the statistics show an increase in women participation in the labour force, the greater percentage of women have been in work typically associated with low and insecure earnings, and few possibilities for advancement with most being employed in the informal sector and also being self-employed (Casale & Posel, 2005).

The labour market gender-based segregation and discrimination is compounded by weak regulations which result in women being confined to low paying jobs with poor working conditions that lack access to social protection (DWYPD, 2019). In addition, they are largely employed in the lower levels of organisations where most jobs have short-term employment contracts or are temporary and subject to being negatively affected by adverse economic fluctuations (DWYPD, 2019). The informal sector is characterised by jobs such as selling fruit and vegetables on the street corner, hairdressing and child-minding while small-scale farming frequently is undertaken as a subsistence or survivalist activity. The rise in informal sector self-employment, therefore, may reflect very limited opportunities to earn an income elsewhere in the economy (Kehler, 2001)

Even though women have access to formal labour markets, Statistics South Africa (2018) argues that they are more likely to be engaged in unpaid labour as compared to men. Women accounted for 55.2% of the workforce involved in non-market activities in 2018 (Statistics South Africa, 2018). According to (Chitiga, Cockburn, Decaluwé, Fofana, & Mabugu, 2010), while females are engaged primarily in few tertiary activities like textiles and private services, males are distributed throughout primary and secondary sectors. This contributes to higher unemployment rates for females than for males. Despite the disparities in the labour market, women in South Africa are estimated to contribute between 35% to 45% to GDP (Department of Women, 2015). This figure is however an underestimation given the fact that it leaves out the contribution of cooking done by women to unpaid work. According to Statistics South Africa (2001), the time use survey of 2001 found that women are the ones who are more involved in reproductive work including the work of rearing and caring for children, caring for other household members, cleaning, and fetching water and fuel. The study found that men are more likely to be engaged in productive paid work. Another finding was that even though South African men spent on average 19% of their day on productive activities compared to women who spent 23%, women are likely to be remunerated less than men (Statsistics South Africa, 2001).

2.1.4 Effect of reproductive responsibilities on women's productive work and earnings

Lack of access to resources education, credit, coupled with unequal rights in the family structure in a patriarchal society (that South Africa is a part of) contribute to poverty amongst rural women. African rural women are also burdened with multiple roles concerning productive and reproductive responsibilities and subjected to discrimination and subjugation. They also live in areas with limited access to basic services and infrastructure. Women therefore have to spend many hours a day walking long distances in order to fetch water and firewood. In addition, women are the de facto heads of households and 'breadwinners' due to the men's absence, based primarily on urban migration phenomena, as well as the deteriorating socio-economic conditions in rural areas.

Rogan and Alfers (2019) noted that women in South Africa are disadvantaged because they tend to be concentrated in forms of employment which have a high risk of low returns and no social or labour protection.

Even though women may work the same hours as men , they may be excluded from working at the times of day when there is more profit to be made such as early hours of the morning when their children and family need their attention the most. Women street traders missing out on commuters on their way to work, they are also not able to work late into the night like their male counterparts as they have to attend to their family needs at the same time. Thus, women miss out on overtime allowances for those in formal employment. The main reason for this is that most women workers do not have access to quality childcare services and women are also forced to conform to social norms of socially accepted behaviour in terms of the time they go home from work. In the informal sector such as scrap metal collection women are also faced with physical intimidation and violence from their male counterparts thus, they are not able to collect as much as their male counterparts. Casale and Posel (2005) stated that gender differences in earnings can also be attributed to the fact that in all sectors of the economy women carry the economic costs of childcare, maintaining a less than continuous attachment to the labour market, working part-time, or being viewed by employers as less committed workers.

2.1.5 Existence of a gender wage gap

There is a gender wage gap in the labour market. This is despite the fact that South Africa has very progressive labour laws, for example the Employment Equity Act that emphasises on the principle of equal pay for work of equal value, the King IV that requires employers to do a gender pay audit, adjust remuneration policy and provide implementation plans for changes and lastly the Johannesburg Stock Exchange listing requirements mandating companies to table their remuneration policy and implementation report that must include gender pay gap reporting. Given that a gender wage gap exists despite the sound laws, the problems seem to emanate from the limited monitoring and implementation of those laws (Casale & Posel, 2005).

Bosch (2020) described pay equality as measured through a gender pay gap audit that takes into account the basic pay or wages, guaranteed benefits like medical aid, retirement, life cover and leave as well as incentives and rewards, like bonuses, share options, retention bonuses, and study schemes. The gender wages exhibit 'sticky floor' effect, whereby certain groups of people are kept at the bottom of the job scale characterised by the bottom decile of earners having the highest proportion of female workers (UNU-Wider, 2019).

2.1.6 Gender disparities in the agriculture sector: The case of Western Cape Province

In the South African agricultural sector employment conditions in different provinces differ but what stands out from a research done in Western Cape by Loubser (2020) is that women are mostly only employed as casual or temporary labourers during times of harvest or other labour intensive farm work. They are also rarely granted the rights to permanent employment even if they work for prolonged periods as seasonal workers. Most of the women who work on farms are therefore not covered by social insurance schemes such as pension fund, medical benefits or maternity benefits. Women in the farms often receive lower pay in comparison with their male counterparts. Even the women who are 'permanent seasonal workers' receive no bonuses or any benefits, unlike their male counterparts in the same category of work. There are so many other factors that point to the continued existence of discrimination and inequality and inequities based on gender on the farms. The Western Cape example is not far fetched form what could be happening in other provinces. Women farm workers are only regarded an extension to their male counterparts, as 'valuable' categories of workers by themselves being employed only because their husbands work on the farms. It is difficult for single females to get jobs on farms.

2.1.7 Defining household headship

The interest in household headship was generated by the perceived differences between female headed households and male headed households. The female headed households have generally been classified under the vulnerable group and are also targeted for welfare programmes (Budlender, 2003). Rogan (2013) stated that for most household surveys in South Africa, household headship is self-reported, and no criteria is given to identify who the head is. The general guideline from Statistics South Africa is that the household head is the person who assumes responsibility of the household and this person can either be male or female (Statistics South Africa ,1997). The National Income Dynamics Study (NIDS) dataset used in this study also follows the same principle that the household head is self-defined and there is no guidance that is given in terms of whether the head of the household should be the eldest, highest earner or of a specific gender. It is used simply as a construct that determines how individuals in the household are related. According to Rogan (2013), the self-reported female headship of the household can be disaggregated into three classifications which are de jure, de facto and co-resident female-headed households. De jure would be self-reported female household heads who have no attachment with a male in the sense of being divorced, never married widowed or separated. De facto are households where the self-reported female head is married but her husband or partner does not live in that residence. The third category is the co-resident, and these are the self-reported females who are married or co-residing with their partners.

Nwosu and Ndinda (2018) mentioned that female household headship, which has been rising in South Africa, is commonly related to higher poverty incidence compared to male headship. Their study based on the NIDS data found that female household headship is positively related with total household non-employment, which in turn is also positively related with poverty.

2.2 South African government policies on rural development and gender

2.2.1 Government policy in relation to rural development and agriculture

Mabugu (2016) argued that industrialisation and modernisation are intricately connected to rural development, both historically and among rapidly growing developing countries today. Xiaoyun (2014) pointed out that China developed its economy by shifting its policy from a heavy industry based and urban based strategy to a policy promoting labour intensive and light industries in rural areas. This saw an increase of the contribution of the rural economy to national industrial growth rising from 9.9% to 43.2% from 1978 to 2006 (Xiaoyun, 2014). China did not focus only on agriculture but promoted both agricultural growth and small and medium rural enterprises (Xiaoyun, 2014).

According to DAFF (2014), South Africa has among the least supported agricultural sectors in the world. AGRA (2018) provided evidence that South Africa had the 7th least public spending on agriculture as a share of total government expenditure among all African countries (after Egypt, Congo, Angola, Equatorial Guinea, Democratic Republic of Congo and South Sudan) from 2005 to 2015. Information from Statistics South Africa (2017a) indicates that the poverty rates for rural areas (according to the upper-bound poverty line) were 87.6%, 88%, 77% and 81.3% for the years 2006, 2009, 2011 and 2015 respectively; and 52%, 46.8%, 38.8% and 40.6% for the urban areas over the same years. These substantiate why South Africa needs to prioritise rural development as outlined in the 2014-2019 MTSF and the NDP Vision 2030. In 2009 the government launched the CRDP as an effective food insecurity and poverty response strategy (Government of South Africa [GoSA], 2009). The New Growth Path (Economic Development Department, 2010) and the NDP Vision 2030 (NPC, 2012) both articulate a vision of an integrated rural economy with land reform, job creation and raising agricultural production contributing to this vision. The NDP specifically outlines the potential to generate 1 million jobs in agriculture through an effective land reform programme and growth of irrigated and land-based agriculture.

2.2.2 Government policies to address gender inequality

South Africa inherited an unequal socio-economic system from the apartheid era, characterised by gender discrimination. The black women, especially the rural ones, have been the most affected by triple oppression via race, gender and class. Since the dawn of democracy, the South African government has been progressive in upscaling of women empowerment. In the recent policy cycle, 2014 to 2019, the priorities for accelerating progress for women and girls in South Africa included improving access to education for girls, employment creation and sustainable growth and the economic empowerment of all women, especially "women owned businesses, SMMEs, women cooperatives, women vendors, hawkers and village and township enterprises; development of rural women; among others" (Department of Women Youth and Persons with Disabilities [DWYPD], 2019: 8).

According to DWYPD (2019), South Africa's efforts have encompassed ensuring non-discrimination and equality under the law, agricultural productivity and food security for women, poverty reduction as well as promoting women's enterprises and women's entrepreneurship. The country's envisaged focus in terms of gender responsive policy priorities have been allocated over the short term (2019-2024), medium term (2019-2030) and long term (2019-2044). The priorities are meant to address issues that include effective gender mainstreaming across all sectors of society, reducing gender inequality, more emphasis on women's economic emancipation and transforming unequal gender relations (DWYPD, 2019).

2.2.3 Government support for women in agriculture

Given that governments cannot directly affect such factors as fertility, cultural norms and household influences that impact the participation of women in the economy, the South African government through its various departments in agriculture, land reform and rural development has rolled out several funding schemes to capacitate farmers. Special preference has been given to women. This has been in an attempt to create a conducive environment for women's participation in the economy. The statistics show that there were more women beneficiaries for the interventions than men. Included in the interventions are DAFF Female Entrepreneur Awards, a programme that seeks to correct the skewed participation of women in the sector by acknowledging, encouraging and increasing equal participation of women, young women and women with disabilities in agriculture, forestry and fishery activities. The AgriBEE Fund is another initiative that seeks to empower women in agriculture. Its scope includes the complete agricultural value chain from production, processing, marketing to distribution, aims to promote entry and participation of previously marginalised groups in the entire value chains of agriculture, forestry and fisheries. (DWYPD, 2019).

2.3 Women in agriculture

Data on land and property ownership among women is limited but rural women are acutely affected by lack of access to land and property rights. This gives the government an opportunity for making an impact through land redistribution and tenures. A few women are involved in commercial agriculture; however, the majority are involved in subsistence farming for household food consumption requirements (Hart & Aliber, 2010). Land ownership is intricately linked to food security and nutrition and gender. Female headed households have a higher vulnerability to food insecurity because of poverty, which can be exacerbated by lack of access to land ownership, means of production and income generating activities. The 2016 Vulnerable Groups Indicator showed a higher percentage share of females (13.8%) living in households that experienced hunger compared to males (10,3%) (Statistics South Africa, 2016). Because of the strong link between food security and nutrition and gender, the land issue becomes critical in ensuring a gender approach to food security.

Gender dynamics in agricultural production result in women ending up being marginalised due to lack of education which limits their ability to take advantage of new technologies, low financial literacy, low access to extension services, and the complicated balance between paid work and unpaid care work that is increased in the event of sickness in the homes. This is worsened by the already low support to agriculture in general. Agricultural technological and infrastructural interventions which are mostly high input are also not gender sensitive and most are geared towards servicing the commercial farmers (Hart & Aliber, 2010).

2.4 The link between gender and investments in agriculture

Seguino (2016) pointed out that it is difficult for women to convert their productivity into improved livelihoods, relative and absolute to men because of macro-level policies and gender job segregation. Collins (2016) argued that Africa particularly is far from reaching gender equality where agricultural investment is concerned. To this end there is growing consensus that promoting gender equality and women's empowerment is a key driver for food security, poverty reduction and rural development. Achievement of gender equality is recognised as a key catalyst for reaching food self-sufficiency in Africa and eradicating challenges such as poverty, unemployment and hunger (Byerlee et al., 2009).

It is widely acknowledged that gender inequalities in agriculture continue. The Economic Community of West African States (2017) noted that equal participation of men and women in social, economic and political life is far from being achieved. In line with this consciousness, Seguino (2016) directed attention to the positive ripple effects that emerge from financing for gender equality through targeted government spending particularly in agriculture. Seguino (2016) suggests a gender and ethnical paradigm as a chance to achieve policy objectives particularly within the context of the SDGs.

Agénor (2017) argued that, given that women's role remains a critical subject on the agenda of the development process for a number of countries, it is of importance to analytically understand and quantitatively measure how women are affected by both gender-specific and general public policies particularly in terms of employment and income, among others. According to Agénor (2017), promoting women's participation in the labor force and gender equality is both desirable from the point of view of social equity and is also good economics. Agénor (2017) pointed out that these goals can be achieved through macroeconomic interventions and relevant interventions that reduce the structural constraints that limit women from participating in the job market. Such constraints exist largely due to cultural and social norms. In South Africa structural constraints manifest in the form of low financial literacy among women, the need to balance productive work and unpaid care work, gender-based segregation and discrimination that result in women being confined to jobs with poor working conditions and lower remuneration jobs; as discussed above.

2.5 Importance of smallholder farming to agriculture

2.5.1 Contribution of small-scale farms to the agriculture sector

Lerman and Sutton (2008) conducted a comparative study to assess the efficiency differences between large commercial farms and small-scale farms in Moldova. Their findings established that small individual farms are more efficient and more productive compared to large corporate farms. Mburu, Ackello-Ogutu and Mulwa (2014) found small scale wheat farmers in the Nakuru District of Kenya to have higher technical efficiency than the large scale farmers. Muyanga and Jayne (2019) identified the existence of a u-shaped relationship between farm size and productivity in Kenya: an inverse relationship for farms up to 3 hectares, a flat relationship for farms between 3 and 5 hectares, and a strong positive relationship for farms between 5 and 70 hectares. Sheng, Ding and Huang (2019) conducted a similar study for Northern China and their results confirmed the existence of a mild u-shaped relationship between cropping area and maize yield. Their findings also indicate that the negative farm size-productivity relationship for small farms is attributed to their use of labour-intensive technology. Thus the inverse relationship between farm size and productivity for small farms could be smoothed by the use of capital intensive technology (Sheng, et al., 2019). These studies indicate the important contribution of small-scale farms to the agriculture sector.

2.5.2 Potential of smallholder agriculture in South Africa

Subsistence agriculture is argued to be the mainstay of small-scale farmers across Africa (Kang'ethe & Serima, 2014) and informal agriculture's potential contribution to job creation is believed to be a key policy issue today in South Africa (Cousins, 2018a). While informal sector agriculture is not synonymous with small-scale agriculture, Cousins (2018a) pointed out that they coincide very much in South Africa because of the evident subsistence and informal orientation of the overwhelming majority of smallholder farmers. Based on Cousins' (2018a) arguments, small-scale or smallholder agriculture in South Africa is more or less the same as informal agriculture.

Despite the fact that the agriculture sector's contribution both to jobs and to GDP in South Africa is relatively small, it is still believed to be vital to the South African economy, especially in the recent past. While agriculture's approximate 4% contribution to GDP in South Africa seems miniscule at face value, Mkhabela (2020) argued that this way of measuring its contribution to the country's economy appears to reduce its overall contribution given its strong backward and forward linkages. In addition, Mkhabela (2020) pointed out that supporting agriculture to ensure that it continues to thrive is a pragmatic macroeconomic policy strategy for South Africa. Furthermore, given the size of the South African economy the country's agriculture sector is larger than the economies of some African countries.

Statistics South Africa (2017c) pointed out that the growth rate in agriculture value added was key in lifting seasonally adjusted and annualised quarter-on-quarter GDP to 2.5% in the second quarter of 2017, after experiencing a decline in growth for two consecutive quarters. The 33.6% increase in agriculture production (the highest, followed by the electricity, gas and water sector that grew at 8.8%) drove the recovery in GDP growth. Recently, agriculture value added grew at 28% and 15% in the first quarter and second quarter of 2020, respectively.

Statistics South Africa (2013) acknowledged that agricultural statistics in South Africa falls short in terms of the information that is required for policy planning and formulation. There is lack of information on smallholder and subsistence agriculture as well as comprehensive information that covers all agricultural activities, information that would be necessary for assessing the involvement and role of women in agriculture (Statistics South Africa, 2013). Commercial agriculture produces 95% of the marketed agricultural output as pointed out by Schulze (2006), Sapa (2018) and Pienaar and Traub (2015). The

smallholder agricultural sector is said to produce the remaining 5% of agricultural production on an estimated 13% of total agricultural land while the other 87% is used by commercial agriculture (Aliber & Hart, 2009). Agricultural land occupied by smallholder farmers in South Africa is estimated to be 23-25% by Beinart and Delius (2018). Freguin-Gresh, et al. (2012) argued that the smallholder agricultural sector lacks access to resources that include infrastructure, land, water and credit facilities. Increasing resources to this sector could improve its contribution in the economy and also impact positively on the outcomes of women.
There has not been a significant change in the unequal distribution of land in South Africa from when it was institutionalised during the apartheid era, commercial farms continue to be held largely by white farmers while black communities own small farms (Obi & Ayodeji, 2020). The land reform program is argued not to have been successful in redistributing agricultural land. Obi and Ayodeji (2020) suggested that the South African government needs to prioritise farmer support to increase their productivity, emphasising on optimal land and gender equity. Moyo (2010) argued that efficient land reform and improved access to farming inputs is one of the solutions to addressing the deteriorating welfare conditions in South Africa.

2.6 Previous related studies

There are several studies that have been done using CGE modelling for South Africa due to the direct and indirect effects of different policy scenarios being studied. Since the early 1990's studies have used CGE methodology to evaluate the impacts of policy on economic outcomes in South Africa (McDonald & Punt, 2005).

2.6.1 Studies on rural development

Many of the studies on rural development that used CGE modelling largely focused only on assessing impact of agricultural policies or improvements in the agriculture sector (for example Herault and Thurlow (2009) and Chitiga, Mabugu and Fofana (2017) on South Africa, Schünemann (2017) on Malawi, Otchia (2014) on Democratic Republic of the Congo, Storm (1994) on India, Dorward, et al. (2004) on Malawi). While Arndt, Davies and Thurlow (2018) assessed the economy-wide impact of rural development related policies, they did not look at their poverty and inequality impact or their gender impact. Three studies closely related to what our study intends to do are Chitiga, et al. (2017), Arndt, et al. (2018) and Schünemann (2017). Specifically related to agricultural policy, Herault and Thurlow (2009) used a CGE and micro-simulation model to show that removing global and domestic price distortions on agriculture products will lower poverty and inequality. In the case of global price distortions, however, poverty reduction is lower in rural areas relative to urban areas as these households receive lower wages and are deeply rooted in poverty. They argue that price distortions may to some extent explain the poor performance with respect to rural development and agricultural outcomes.

Chitiga, et al. (2017) used a dual economy dynamic CGE model to assess the effects of macroeconomic policy on rural and urban households, agricultural growth, and the relationship between growth in non-agricultural and agriculture sectors. Chitiga, et al. (2017) analysed how macroeconomic performances affect agricultural growth and the wellbeing of rural households. Chitiga, et al. (2017) carried out three simulations namely an exchange rate policy (exchange rate depreciation, i.e. an average 7% per annum depreciation between 2005 and 2015), an agricultural growth policy (a 1 % annual increase in agriculture total factor productivity), and a non-agricultural growth policy (an expansionary fiscal policy in form of an increase in government spending averaging 20% of GDP). They found an expansionary fiscal policy to have negative impacts on agriculture and on rural development, with rural households experiencing a lower decrease in consumption; the depreciation of the exchange rate simulation resulted in a decline in the national economy; while an increase in agricultural productivity yielded a small positive impact on the overall economy, benefiting rural households relatively more (Chitiga, et al., 2017). More recently and considering government investments in different regions, Arndt, et al. (2018) used a dynamic CGE model with model parameters based on the 2015

South African SAM to study the impact of firstly, investments in major cities, secondly, investments in rural areas with the aim of increasing employment opportunities and thirdly, investment in secondary cities that have relatively stronger links to rural areas. Their findings indicate that increased investment in urban areas should not be at the expense of rural areas as lower agricultural production will cause higher food prices, lower real income and outmigration leading to a rise in urban poverty.

2.6.2 Studies on land reallocation

In modelling land reallocation from large scale commercial farmers to small scale holders Chitiga and Mabugu (2008), in their study on land reform in Zimbabwe, did not model the small holder agriculture by household or farming group but according to sectors. Each sector's output was to be homogeneous. Chitiga and Mabugu (2008) stated that assuming different production functions by type of farmer would have required very detailed production technology information. They modelled land as a factor of production among skilled labour, unskilled labour and capital. Chitiga and Mabugu (2008) simulated a land transfer of 40% from commercial farmers to communal farmers using a CGE model with five household groups that are divided according to their labour use, their farming structure and whether they are urban or rural based.

Mkhabela et al. (2018) modelled land reform in South Africa using a CGE model with two agricultural industries that reflect the dualistic structure of the South African agriculture sector. They aggregated the individual primary agricultural industries into one sector and then distinguished between the agricultural outputs from white and black commercial operations, guided by industry production shares. In a related study, Mukarati et al. (2020) also modelled land reform in South Africa in the form of reallocating land from large scale commercial farmers to small scale holders. Amongst other things, they disaggregated the agricultural sector into large-scale commercial and smallholder agriculture accounts. The agricultural sector capital accounts were divided using extrapolation into agricultural land and equipment. They assumed that the total quantity of productive agricultural land remains constant, and that land was either utilised by large commercial farmers or by small-holder beneficiaries. Land was redistributed to farmers who were assumed to be constrained in technology and production options. Their study includes poverty and inequality analysis of land reallocation but does not include impact on gender.

2.6.3 Conclusion

The studies above generally find that growth in the agricultural sector causes relatively higher positive effects for rural households relative to urban households. Herault (2006) emphasised the relevance of CGE-microsimulation analysis of any policy change in the South African context, given the high poverty and inequality levels, as the approach enables a detailed assessment of impact of policies on poverty and inequality, identifying the winners and losers. This study contributes to this avenue of research literature focusing on government rural development in South Africa through increasing agriculture resources in order to understand the differential impacts based not only on sectors, urban-rural classification, but also on gender and other household characteristics using CGE- micro-simulation methodology.

The literature review highlighted the challenges that limited agricultural statistics on South Africa poses on modelling agriculture-related policy issues. Given this lack of information on agriculture, particularly smallholder and subsistence agriculture, this study builds on previous research to make assumptions on modelling agriculture support in South Africa. Previous CGE studies that focused on transforming the rural economy through supporting agriculture do not address the gender divide. This study takes a gender focus given its importance in addressing poverty, inequality and food security in the context of South Africa, as discussed in the literature review above.

3. Data

The aim of this study is to examine the impact of an expansion of smallholder agriculture and an increase in agriculture mechanisation along gender and geographical location of labour and also the geographical location of households.

3.1 SAM

3.1.1 Original dataset

We rely on the 2015 Social Accounting Matrix (SAM) developed by Van Seventer, et al. (2019) and available from the International Food Policy Research Institute (IFPRI). The original SAM comprises of 104 commodities and 62 sectors, four labour categories by education level, capital, 14 household groups, a public sector, a representative firm and the rest of the world. While this is a very rich and highly disaggregated SAM which provides great flexibility for varied analysis, it does not provide a disaggregated public sector which limits analysis of government policies. In addition, it neither provides disaggregation by rural-urban divide nor by gender which are the key focus areas in this study. Furthermore, it has no information on racial groups which is closely linked to rural development as well as poverty and inequality.

3.1.2 Adjustments made to the original SAM

In addition to aggregating the sectors to a reduced number in order to have a focussed analysis, this study expanded labour through disaggregating it by skill level and gender. Further, households have been disaggregated by rural-urban region, in addition to the income levels in the original SAM. This adaptation of the SAM was done using various data sources that include the 2015 Labour Market Dynamics in South Africa, the Labour Force Survey (LFS) of the 2015 4th Quarter and the Statistics South Africa (2017d) 2015 Living Conditions Survey. Labour was disaggregated into male and female as well as by skill, proportional to the Living Conditions Survey information. It was further categorised by education levels: up to secondary education (unskilled), matric and tertiary education (both classified as skilled); giving us a total of 6 labour categories.

We aggregated the commodities to 31 and the activities to 29, before opening up the agricultural sector to make total number of activities 30. Despite the shortcoming of unavailability of data on smallholder agriculture as mentioned above, we used the available information as pointed out by Schulze (2006), Sapa (2018), Aliber and Hart (2009) and Pienaar and Traub (2015). Cousins (2018a) pointed out that the South African agricultural sector is extremely skewed in terms of size, capital and formality between large scale and small-scale farming. It is on the basis of this information that we disaggregate agriculture into large scale (or commercial) and smallholder subsectors. Given the subsistence nature of informal agriculture, it makes sense to assume that the capital for this sector is largely land. Thus, capital reallocated from commercial to smallholder agriculture is assumed to be land.

3.1.3 Other data

In addition to the SAM data, we used elasticities and parameters for the South African economy in order capture the structure of the South African economy. These include unemployment rates for the six levels of education as provided by Statistics South Africa, income elasticities of demand provided by Burger et al. (2015) and Mabugu et al. (2013), Armington elasticities Gibson (2003), the wage differential between male and female workers as given by Mosomi (2019) the frisch parameter given by De Wet (2003).

3.2 Micro data

For the microsimulation analysis, we used household survey data. This data is readily and publicly available from Statistics South Africa and from University of Cape Town's DataFirst portal. The 2014/2015 NIDS data was used for the micro-simulation model. The units of analysis in the NIDS data are individuals and households. The data includes information on individual demographics, levels of education, income earnings and labour market participation and on household characteristics, that include income levels and sources, household size, education level and gender of household head, consumption and expenditure (Southern Africa Labour and Development Research Unit [SALDRU], 2016).

4. The methodology

4.1 CGE micro-simulation modelling

This study used CGE micro-simulation analysis to assess the impacts of government interventions in the South African rural economy. The methodology is suitable for the research because it allows simulation and testing of several scenarios; past or existing ones to assess their impact on various variables of interest and intended policy interventions to provide valuable information on the best potential option(s). Interventions of this nature require the use of general equilibrium modelling that can adequately assess sectoral changes and economy-wide impacts. In addition, because another important focus of this study is to assess welfare and gender effects of government interventions in the rural economy, this study used Computable General Equilibrium (CGE) modelling in combination with micro-simulation modelling which adequately takes into account distribution effects of the interventions. CGE modelling is useful in this scenario as it is able to examine the expected effect envisioned by policymakers, the channel through which adopted and implemented interventions affect the economy and different players, and the unexpected results that ensue.

CGE models are excellent at capturing macroeconomic dynamics of an economy but are not good enough to account and analyse the impacts of the macroeconomic policies at a household or individual level as well as the effects of poverty and income distribution. The gap between economy-wide models like CGE models and the micro economic impact is covered by micro-simulation models that can be linked to the CGE models. The micro-simulation models can be top down, bottom up or a combination of both in order to allow for feedback from the microeconomic models to the macroeconomic models (Estrades, 2013).

This study used the PEP 1-t CGE model (in GAMS program) that was adapted to the structure of the South African economy by using the relevant elasticities and parameters. Because of the cumulative nature of investment, a dynamic CGE model was deemed more relevant to assess the policy initiatives. In addition, the policy initiatives are rolled out over a number of years, thus using a dynamic model adequately captures the impact over time.

4.2 CGE modelling

4.2.1 Additions to original model

4.2.1.1 Unemployment

The PEP 1-t assumes full employment in the labour market. Given the high levels of unemployment in South Africa, we adapted the model to capture this reality.

$$LDT_l = \sum_j LD_{j,l}$$

$$LS = LDT_l/(1 - UN_l)$$

$$LU_l = LS - LDT_l$$

where $LD_{j,l}$ is the demand for type l labour by the sector j, LDT_l is total demand for type l labour, LS is supply of type l labour, LU_l is the number of type l unemployed labor and UN_l is the unemployment rate.

4.2.1.2 Wage differential between male and female workers

The male wage and female wage are different to take into account the wage differential between male and female workers in South Africa.

$$W_{mal} = W_l$$
$$W_{fem} = W_l * (1 - \phi\_W_l)$$

where W_l is wage rate of type l labour, W_{mal} is the wage rate for male workers, W_{fem} is the wage rate for female workers and ϕ_W_l is the wage differential between male and female labour. The wage differential for South Africa is 25%, with female workers earning on average 25% less than what their male counterparts earn.

4.2.1.3 Modelling of smallholder agriculture

Smallholder agriculture was allocated 5% of total agricultural labour, based on the average proportion of labour in smallholder agriculture and capital was allocated 15% of total agricultural capital, given that smallholder agriculture land is estimated to range between 13%-25% (Aliber & Hart, 2009; Beinart & Delius, 2018; Valodia, 2007). Even though more land than labour was allocated to smallholder farming, the same production structure was assumed for large-scale farming and smallholder farming.

4.2.2 Business as Usual (BAU)

To quantify impacts of rural development related to agricultural support scenarios, we first constructed a business as usual (BAU) growth path scenario for South Africa over a 20-year period from 2015 to 2034 (to capture the NDP, CRDP and SDG implementation periods). The BAU scenario broadly assumed a balanced growth path based on recent past growth trends. The BAU scenario serves as the counterfactual against which government interventions on the rural economy are compared. Population is assumed to grow at 1.3%, which is South Africa's estimated average population growth rate based on the information from Statistics South Africa. The dynamic variables are assumed to grow at the same rate as the population index. These include labour supply, household consumption, the current account balance, public consumption, intermediate consumption, the minimum consumption of commodities in the LES demand equations, public and private capital expenditure and changes in inventories.

4.2.3 Simulations

Bahta and Strydom (2015) mentioned that agricultural growth can be simulated in a CGE model in two ways; directly through exogenously increasing agricultural output by sufficiently adjusting agricultural productivity or inputs and indirectly through exogenously increasing agricultural productivity or inputs to stimulate output. The two simulations carried out to assess the differential impacts across gender and geographical location are:

1. An increase in smallholder agriculture capital spending. This simulation is done through increasing capital spending for the smallholder agriculture sector. Initially capital spending is increased by 7,5% followed by 5% each in the following two consecutive years. This simulation is expected to shift capital away from commercial agriculture, which could potentially depress overall economic activity. This is because capital is fixed, thus the increase in smallholder capital comes from commercial agriculture. As capital demand for smallholder agriculture increases, labour demand

by the sector is also expected to increase given that the model assumes a Leontief production function.

2. An increase in agriculture capital investment. This simulation is done through increasing capital spending for the combined agriculture sector through 10% increase in capital spending in three consecutive years. This simulation is expected to trigger an increase in demand for labour used by the agriculture sector, and consequently an increase in output production by the sector as well as the sectors with which it has strong interlinkages.

It is important to mention that these simulations do not involve similar costs and they are compared only in terms of the direction of change but not the magnitude of the change across variables. The simulations are conducted from 2016. The costs of the first simulation are borne by commercial agriculture as the redistribution of land is assumed to be in form of expropriation without compensation. The second simulation is assumed to be financed through deficit financing.

4.2.4 Closures

The exchange rate is the numeraire. The variables that are exogenous in the model are current account balance, minimum consumption of commodity i by type household h, government current expenditure, new capital investment in the public sector, capital demand, labour supply, agriculture skilled labour, world prices of exports and imports and inventory changes.

4.3 Micro-simulation

4.3.1 Micro-simulation models

Otchia (2019) explains in detail the two main types of micro-simulation models and their subgroups. The description is in line with other earlier studies such as by Savard (2009), Hérault (2009), Estrades (2013), Wang et al. (2017) and Feltenstein et al. (2017), among others. The first type of micro-simulation model is the complete integration of the CGE and micro-simulation models into a single model. This is achieved through integrating household survey data into the CGE model. Complete integration can be achieved via two different approaches namely the Representative Household approach and the Fully Integrated approach. Under the Representative Household approach households are disaggregated into different representative household categories according to different socioeconomic groups. The Fully Integrated approach is a further development of the Representative Household approach. It replaces the Representative Household's groups inside a CGE model with all households available in the household survey. Fully Integrated models, in contrast to Representative Household models allow for intra-group variation. Their limitation is that they do not explicitly model household behaviour so they therefore cannot predict certain aspects of individual behaviour, for example that a particular individual may lose a job or get a job based on individual or household characteristics.

The second approach to linking CGE models to micro-simulation models is the layered approach whereby the two separate models are combined via interfaces. This approach consists of linking CGE models to micro-simulation in either a Top-Down, Bottom-up or an iterative top-down, bottom-up combination. The Top-Down approach develops a separate micro-simulation model, which is further combined sequentially to a CGE model. The model at the top is a CGE model with the same features as the Representative household model. At the bottom is the micro-simulation model, which captures the behaviour of all households in the survey. This approach is implemented in two steps. The first step is the CGE model that is used to simulate changes in prices, wages, and sectoral employment levels. The changes form the CGE model are then transmitted down to the micro-simulation model in order to estimate corresponding changes in income and consumption. The basis of the micro-simulation model is household-level survey data.

The micro-simulation analysis takes into account heterogeneity in individuals' or households' characteristics that include human capital endowments, sources of income, region of residency, consumer preferences and household demographic characteristics. This micro-data that comes from the national survey was explained in the data section above. The equations for each working age household member's earnings, for self-employment income for the household and for utility gained by each individual's labour market participation are deemed the most important elements of micro-simulation analysis (Davies, 2009). To ensure consistency between the SAM data used for CGE modelling and the survey micro-level data used for micro-simulation modelling we adjusted the sample weights of the survey data as pointed out by Robilliard and Robinson (2003) and Vandyck and Van Regemorter (2014), even though full consistency is not required when a sequential approach is used as argued by Tiberti, Cicowiez and Cockburn (2017).

4.3.2 Overview of the top-down approach used

This study used the behavioural top-down CGE-micro-simulation approach explained by Tiberti, et al. (2017). This approach was chosen for its strength of being able to predict individual labour market behaviour based on individual or household characteristics, in comparison to the Representative Household approach explained above. Three occupational choices available to household members are wage worker (1), self-employed (2) and not working (3). Workers are divided into two skill categories on the basis of their levels of education and skill classification as per Statistics South Africa definitions: skilled (with matric, a national technical certificate (NTC), tertiary qualification or employed as technical and professional workers) and unskilled (with up to incomplete secondary education or elementary and domestic workers). We present selected equations of the micro-simulation model as in Tiberti, et al. (2017).

Individual labour supply is estimated using a reduced form model:

$$ln\frac{P(E_i = m)}{P(E_i = 3)} = \alpha_m + \sum_{j=1}^{J} \beta_{mj} X_{ij} + \mu_{ij} = Z_{mi}$$

where E_i is the individual labour supply, Z_{mi} are individual utility functions from the two occupational choices, m, of being either a wage worker or self-employed (utility of category 3 is assumed to be zero), X_{ij} captures the individual's characteristics including level of education and age, and μ_{ij} is the residual term.

Tiberti, et al. (2017) explained that the individual probability of being in one of the three labour categories is estimated by:

i. Other than reference category: $P(E_i = m) = \frac{exp(Z_{mi})}{1+\sum_{m=1}^{m=2} exp(Z_{mi})}$

ii. Reference category: $P(E_i = 3) = \frac{1}{1+\sum_{m=1}^{m=2} exp(Z_{mi})}$

The individual wage is estimated using the Heckman method which first allows for selection into employment based on variables that affect the probability to be engaged in employment (which is the likelihood of the wage being observed) but that do not directly influence earnings. The selection equation estimated using a logit model is:

$$s_i^* = \gamma Z_i + \mu_i$$

$$s_i = \begin{cases} 1 \; if \; s_i^* > 0 \\ 0 \; if \; s_i^* \leq 0 \end{cases}$$

where Z_i are relevant selection variables (age, gender, marital status, region and level of education).
This is then followed by estimation of the wage function:

$$w_i = \begin{cases} \beta x_i + \varepsilon_i \; if \; s_i^* > 0 \\ \quad\quad . \quad if \; s_i^* \leq 0 \end{cases}$$

5. Application and results

5.1 Macro level results analysis

5.1.1 Reallocation of land to smallholder famers

CGE analysis provides numerous results because of its economy-wide nature. Only results linked to the focus of the study are presented. Results for changes in factor demand across sectors following reallocation of land from commercial to smallholder agriculture are given in Table 1 (change in capital demand) and Table 2 (change in labour demand).

Table 1: Capital demand by selected sectors (% change from BAU), Sim 1

Year	Commercial agriculture	Smallholder agriculture	Food	Petroleum & chemicals	Transport	Finance & business services	Construction
2016	-0,052	12,269	0,004	0,000	0,001	0,001	0,003
2017	-0,133	17,601	0,009	0,000	0,002	0,004	0,007
2018	-0,240	17,556	0,016	0,000	0,004	0,006	0,013
2019	-0,333	17,517	0,021	0,000	0,005	0,009	0,018
2020	-0,413	17,484	0,025	-0,001	0,006	0,011	0,022
2021	-0,481	17,455	0,028	-0,001	0,006	0,012	0,025
2022	-0,540	17,430	0,029	-0,002	0,007	0,014	0,027
2023	-0,590	17,409	0,031	-0,003	0,007	0,015	0,030
2024	-0,634	17,390	0,031	-0,003	0,007	0,016	0,031
2025	-0,671	17,375	0,031	-0,004	0,006	0,017	0,032

Source: Simulation results

Table 2: Composite labour demand by selected sectors (% change from BAU), Sim 1

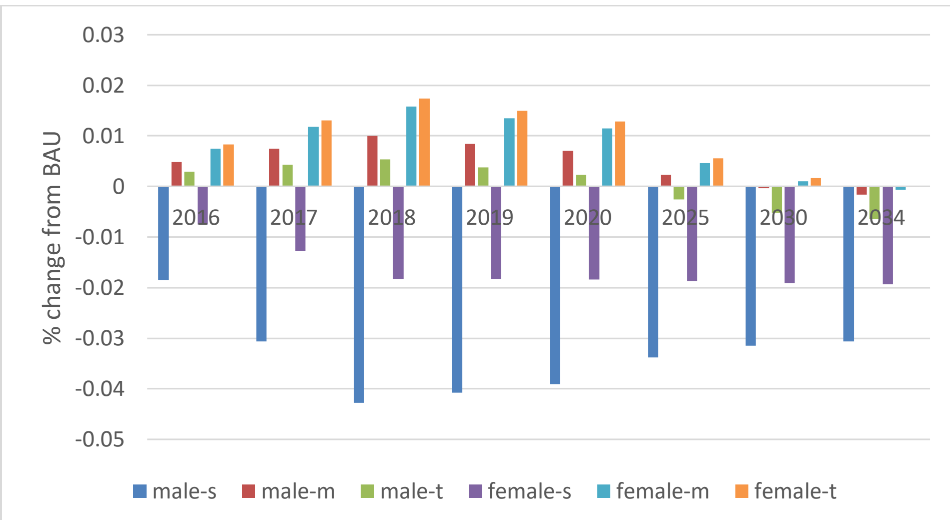
Year	Commercial agriculture	Smallholder agriculture	Food	Petroleum & chemicals	Transport	Finance & business services	Construction
2016	-1,432	11,713	0,083	-0,015	0,013	0,023	0,059
2017	-1,973	16,823	0,108	-0,022	0,015	0,032	0,083
2018	-1,823	16,885	0,088	-0,024	0,010	0,028	0,079
2019	-1,694	16,938	0,071	-0,025	0,005	0,025	0,076
2020	-1,584	16,983	0,056	-0,026	0,001	0,022	0,073
2021	-1,489	17,022	0,044	-0,027	-0,002	0,020	0,070
2022	-1,407	17,055	0,034	-0,028	-0,005	0,018	0,068
2023	-1,337	17,084	0,025	-0,029	-0,007	0,016	0,066
2024	-1,277	17,109	0,018	-0,029	-0,009	0,015	0,065
2025	-1,226	17,129	0,012	-0,030	-0,010	0,013	0,063

Source: Simulation results

As commercial agriculture land declines, its output also declines while smallholder agriculture output increases. This necessitates an increased demand for labour by the smallholder agricultural sector. Some sectors benefit from this as evidenced by their increased demand for more labour, while others are affected negatively, depending on their linkages with the two agriculture sectors.

Results for changes in labour demand across labour categories divided by gender and level of education (up to secondary-s, matric-m and tertiary-t) following reallocation of land from commercial agriculture to smallholder agriculture are given in Figure 1. The decline in commercial agriculture output production also declines results in decreased demand for labour by commercial agriculture. Even though smallholder agriculture production increases, and consequently its demand for labour, this is not enough to counter the decline in demand for labour by commercial agriculture. Given that the majority of workers in the commercial agriculture sector have lower education levels, both male and female workers with up to secondary education experience a decline in demand across the entire period of assessment. Male workers experience a higher decline or lower increase in demand because of the wage differential between male and female labour, which make female labour relatively cheaper.

Figure 1: Demand for labour (Sim 1)



Source: Simulation results

Table 3 shows how changes in Tables 1 and 2 and Figure 1 impact on the rate of unemployment across labour categories by skill level. Overall, this simulation has a positive impact on the labour market as indicated by a decline in the unemployment rate. The reason is that as capital shifts from commercial agriculture, labour in that sector becomes more relative to capital. Thus, to maintain profit maximisation, demand for labour by commercial agriculture declines so that the marginal products of labour and capital equal the wage rate and rate of return to capital, respectively. On the other hand, as more capital increases for smallholder agriculture, labour from commercial agriculture and other sectors (strongly linked with it that also experience a decline in labour demand) as well as some labour that was unemployed before the land reallocation programme are now employed by the small-scale farmers and other non-agricultural sectors whose demand for labour increases. The Table also shows workers with lower skills benefit (suffer) relatively less (worse) than those with higher skills.

Table 3: Unemployment rate: % change from BAU, Sim 1

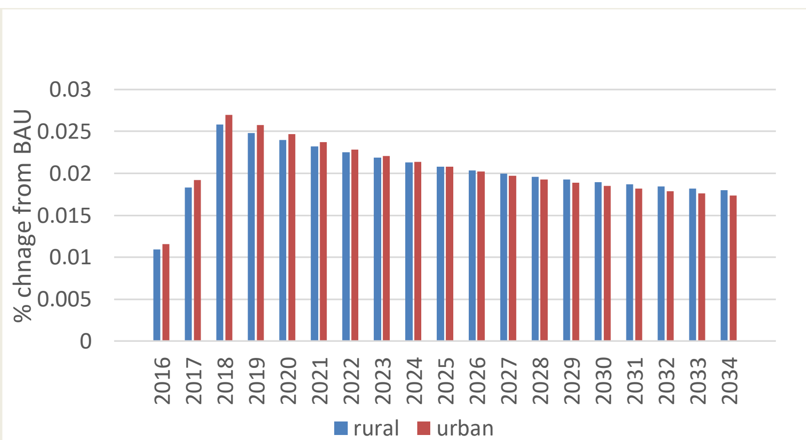
Year	Unskilled (up to secondary schools)	Skilled (matric or NTC)	Skilled (tertiary)

2016	0,003	-0,045	-0,089
2017	0,002	-0,062	-0,121
2018	-0,001	-0,056	-0,107
2019	-0,003	-0,051	-0,096
2020	-0,005	-0,047	-0,085
2021	-0,006	-0,044	-0,076
2022	-0,008	-0,040	-0,068
2023	-0,009	-0,037	-0,061
2024	-0,010	-0,035	-0,055
2025	-0,011	-0,033	-0,049

Source: SAM analysis

The reallocation of labour across sectors does yield a decline in income for poor households especially in the rural areas and an increase in income for richer household groups. Thus, in terms of household income, this policy does not provide encouraging results. Despite the decline in income, Figure 2 shows that increasing smallholder agriculture benefits all households as it has a positive impact on both rural and urban households as shown by consumption levels going up.

Figure 2: Household consumption (Sim 1)



Source: Simulation results

5.1.2 An increase in agricultural capital

In this simulation, we increased capital for agriculture by 10%. While the smallholder agriculture is key in providing sources of livelihoods for many poor people, particularly in the rural areas, the importance of commercial agriculture to the economy cannot be overlooked. This simulation intents to understand how labour and households are affected by increasing capital demand for agriculture.

Table 4 indicates that an increase in capital demand for the agriculture sector as a whole has positive impacts on the economy as capital demand across sectors increases. This also stimulates an increase in demand for labour across sectors as given Table 5. While increased capital across sectors requires more labour to work with in order to maintain equality between the value of each factor's marginal product to its price, this is not the case for commercial agriculture. However, demand for labour by commercial agriculture declines. Given the size of this sector, an increase in capital demand needs more resources which necessitates a reallocation of resources away from labour to capital. This is because the value of the marginal product for labour for commercial agriculture became less than the wage rate, necessitating a decline in demand for labour in order for the marginal product to increase.

Table 4: Capital demand by selected sectors (% change from BAU), Sim 2

Year	Commercial agriculture	Smallholder agriculture	Food	Petroleum & chemicals	Transport	Finance & business services	Construction
2016	18,754	19,548	0,096	0,024	0,036	0,029	0,012
2017	12,868	12,868	0,266	0,065	0,100	0,081	0,030
2018	11,205	12,229	0,371	0,094	0,142	0,117	0,044
2019	9,740	11,668	0,452	0,118	0,176	0,149	0,055
2020	8,451	11,178	0,514	0,139	0,204	0,177	0,065
2021	7,322	10,750	0,560	0,155	0,227	0,200	0,073
2022	6,334	10,377	0,591	0,169	0,244	0,220	0,080
2023	5,471	10,054	0,611	0,180	0,257	0,237	0,085
2024	4,720	9,773	0,622	0,189	0,267	0,250	0,089
2025	4,066	9,530	0,625	0,195	0,273	0,261	0,092

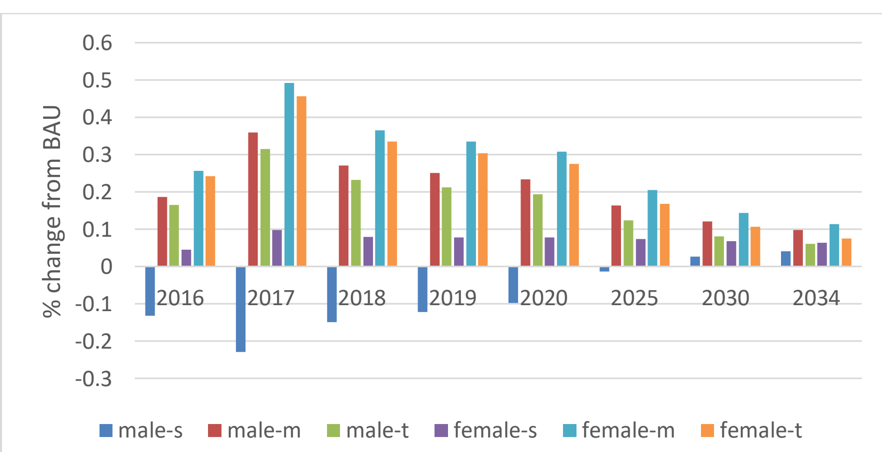
Source: Simulation results

Table 5: Composite labour demand by selected sectors (% change from BAU), Sim 2

Year	Commercial agriculture	Smallholder agriculture	Food	Petroleum & chemicals	Transport	Finance & business services	Construction
2016	-23,644	2,999	2,733	0,440	0,939	0,591	0,152
2017	-16,730	1,743	1,823	0,305	0,644	0,435	0,092
2018	-14,763	2,465	1,539	0,262	0,554	0,396	0,069
2019	-12,994	3,118	1,292	0,224	0,475	0,360	0,048
2020	-11,412	3,706	1,078	0,191	0,406	0,327	0,029
2021	-10,004	4,231	0,893	0,162	0,346	0,298	0,013
2022	-8,756	4,698	0,735	0,136	0,294	0,271	-0,001
2023	-7,656	5,113	0,600	0,115	0,249	0,246	-0,014
2024	-6,688	5,478	0,485	0,096	0,939	0,225	-0,024
2025	-5,840	5,800	0,388	0,080	0,644	0,205	-0,033

Source: Simulation results

Figure 3: Demand for labour (Sim 2)



Source: Simulation results

An increase in agricultural capital yields an overall increase in labour demand across all labour categories, except for unskilled male labour in the short run, as shown in Figure 3. Demand for unskilled male labour experiences a decline in short term. Again, given the wage differential between male and female labour, it is expected commercial agriculture reallocates resources away from labour to capital, it is male whose demand declines.

Table 6 gives changes in the rate of unemployment obtained from simulation 2. The direction of change in unemployment is the same as observed in Table 3 for Simulation 1. Like in the case for simulation 1, it shows that skilled labour experiences a higher decline in the level of unemployment than urban unskilled labour.

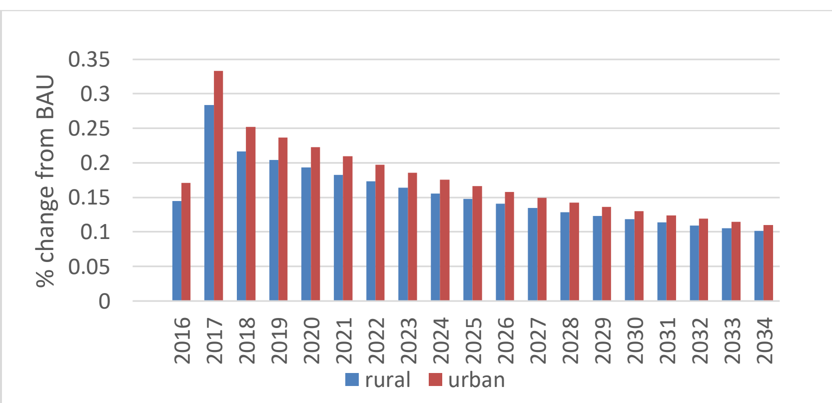
Table 6: Unemployment rate: % change from BAU, Sim 2

Year	Unskilled (up to secondary schools)	Skilled (matric or NTC)	Skilled (tertiary)
2016	0,183	-1,232	-2,620
2017	0,106	-0,919	-1,924
2018	0,071	-0,850	-1,753
2019	0,039	-0,786	-1,596
2020	0,011	-0,727	-1,453
2021	-0,014	-0,674	-1,324
2022	-0,035	-0,625	-1,207
2023	-0,054	-0,581	-1,102
2024	-0,070	-0,542	-1,007
2025	-0,083	-0,506	-0,922

Source: SAM analysis

Figure 4 shows the impact of increasing agricultural capital on household consumption. Similar to the case of simulation 1, consumption levels go up for all households. The consumption levels under simulation 2 are relatively higher than under simulation 1.

Figure 4: Household consumption (Sim 2)



Source: Simulation results

Table 7 compares the direction of change in GDP from the two simulations. It shows that for simulation 1, the rate of change in GDP rises significantly before it increases at a declining rate. However, for simulation 2, the change in GDP increases at a declining rate from when the simulation in implemented.

Table 7: Real GDP Growth: % change from BAU

Year	Sim 1	Sim 2
2016	0,028	0,428
2017	0,040	0,327
2018	0,038	0,309
2019	0,037	0,291
2020	0,036	0,275
2021	0,035	0,259
2022	0,034	0,245
2023	0,033	0,232
2024	0,032	0,220
2025	0,031	0,208

Source: Simulation results

5.2 Micro-simulation results analysis

5.2.1 Labour market results analysis

5.2.1.1 Differences across the gender and the rural-urban divide: Unskilled labour

The relative log odds of being in wage employment versus being unemployed will increase by 0.129 for urban compared to rural workers, as presented in Table 8. The relative log odds of being in self employment versus being unemployed will decrease by 0.02 for urban workers compared to rural workers. In other words, workers who stay in urban areas are more likely to be in paid employment (0.129) and less likely to be in self-employment (0.02). The relative log odds of being in wage employment versus being unemployed will decrease by 0.167 for males relative to females. The relative log odds of being in self employment versus being unemployed will increase by 0.981 for males relative to females. However, only the coefficient of gender for the self employment worker category is statistically significant.

5.2.1.2 Earnings and selection: Unskilled labour

The wage function for unskilled workers indicates that being male increases one's earnings by 36% while increasing one's level of education increases earnings by 13%. Thus, unskilled females are likely to have lower wages compared to male workers. The results also imply that while being male increases one's earnings, it has a negative effect on the likelihood of being engaged in unskilled work.

5.2.1.3 Differences between gender and across the rural-urban divide: Skilled labour

For skilled labour, whose results are given in Table 9, coefficients of all variables of interest are statistically significant. The relative log odds of being in wage employment versus being unemployed for skilled labour will increase by 0.74 for workers dwelling in urban areas relative to their rural counterparts. The relative probability of being in remunerated employment compared to being unemployed is 100% higher for urban than for rural workers. The relative log odds of being in self employment versus being unemployed will increase by 0.272 for urban workers compared to rural workers. This gives a 31% higher probability of being in self employment versus being unemployed for urban workers relative to rural workers. That is, urban workers are more likely to be in paid employment (0.74) or in self-employment (0.272) compared to rural workers.

The relative log odds of being employed will increase by 0.515 for males relative to females. The relative log odds of being engaged in self employment activities versus being unemployed will increase by 0.196 for males relative to females. This entails that the relative probability of being employed and of being self employed is respectively 67% and 22% higher for males than for females.

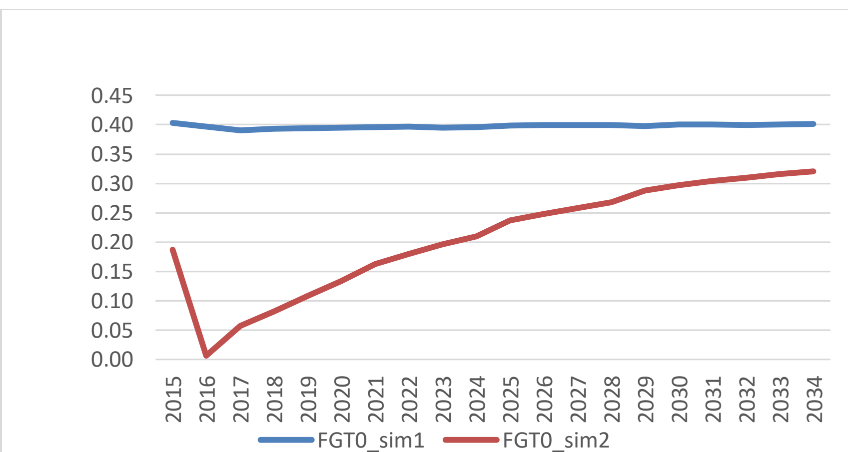
5.2.1.4 Earnings and selection: Skilled labour

Unlike in the case of unskilled workers, results for skilled workers indicate that being male both increases one's earnings and has a positive effect on the likelihood of having a skilled job. For skilled workers, wage for males are observed to be 21% higher than those of women. Being a household head, higher level of education and age also increase earnings by 8%, 3% and 28% respectively. Like the case of unskilled workers above, women are likely to have lower earnings than men. Thus women, irrespective of their levels of skills, are likely to earn lower wages compared to men. In terms of social attributes, being married has a positive effect on the likelihood of having a skilled job while an increase in the number of children in a household has a negative effect on a member's likelihood of being in skilled employment. Females who are in households with more children are thus less likely to earn higher wages or be in skilled employment.

5.2.2 Changes in poverty and inequality

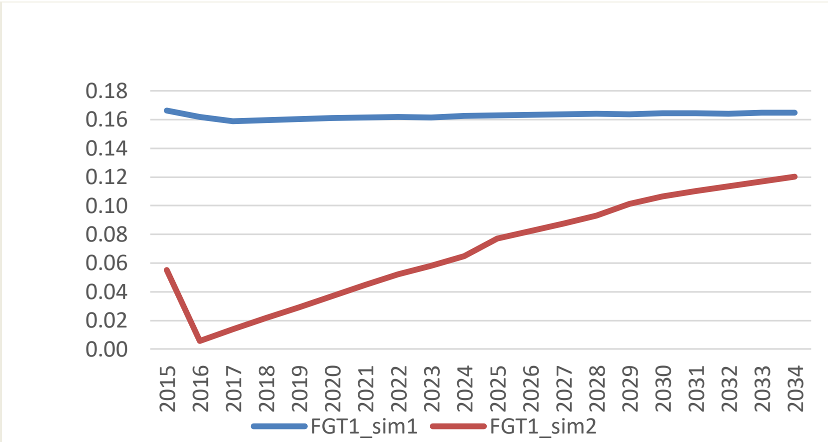
Progression of the poverty rate and poverty gap are presented in Figure 5 and Figure 6, respectively. The poverty rate does not change much under simulation 1 but declines under simulation 2 particularly in the short to medium term and rises in the long term. The simulated support of rural development through an increase in agriculture capital expenditure, specifically for smallholder agriculture, does not yield the anticipated positive impacts on poverty. This could be attributed to lower returns on capital and wages as well as a decline in household transfer income. The decline in prices was not enough to yield a positive impact on poverty reduction.

Figure 5: Poverty rate



<u>Source:</u> Authors' estimation from results

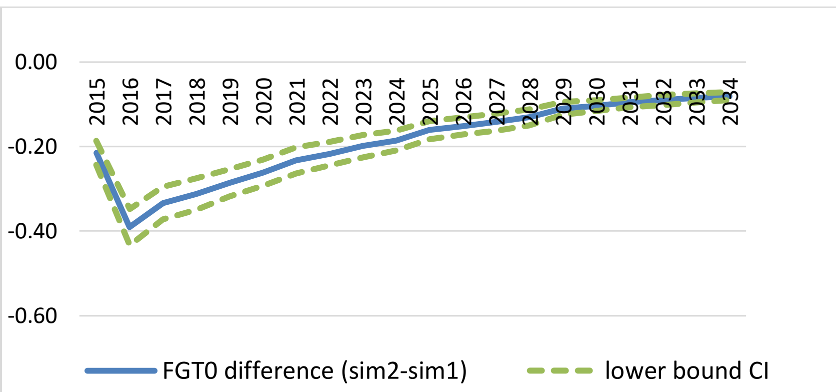
Figure 6: Poverty gap rate



Source: Authors' estimation from results

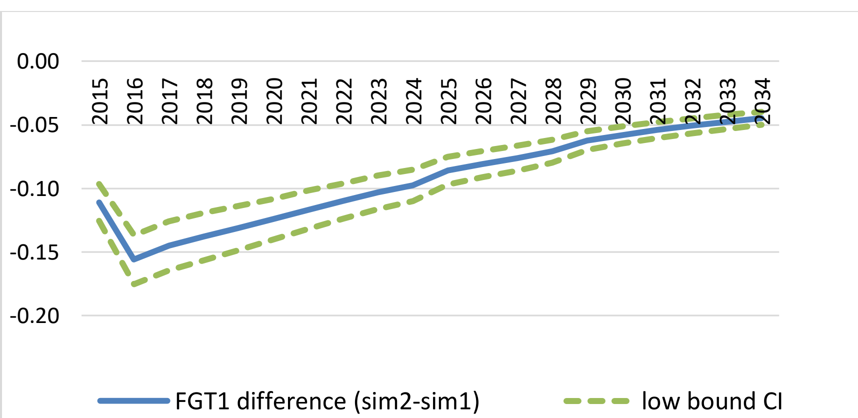
Figure 7 and Figure 8 indicate the increasing difference in poverty rate and poverty gap rate over the simulation period while Figure 9 shows the robustness of the results as indicated by the FTG0 for simulation 1 always showing higher poverty rate than that of simulation 2.

Figure 7: Difference between FTG0 under sim1 and sim2



Source: Authors' estimation from results

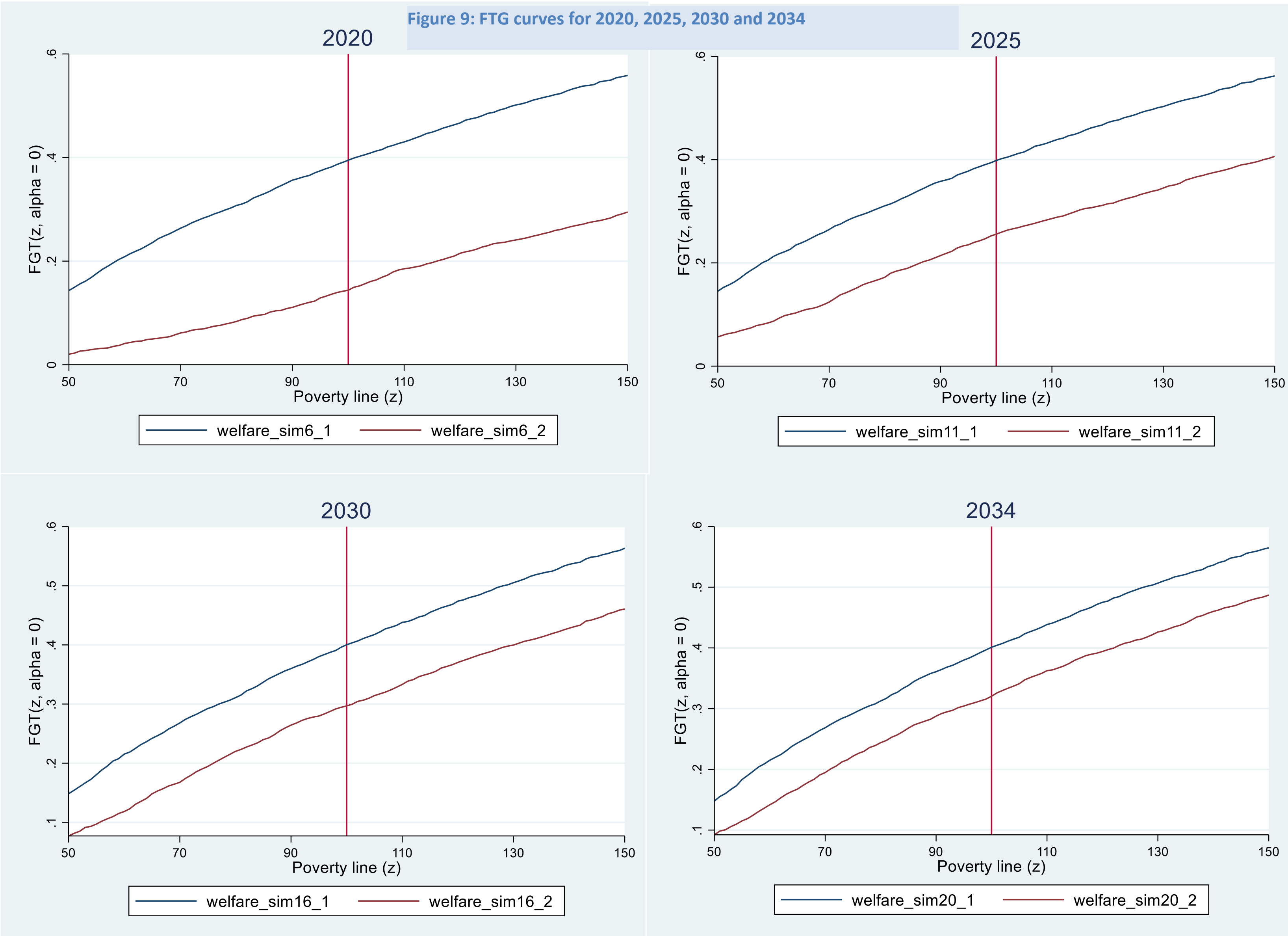
Figure 8: Difference between FTG1 under sim1 and sim2



Source: Authors' estimation from results

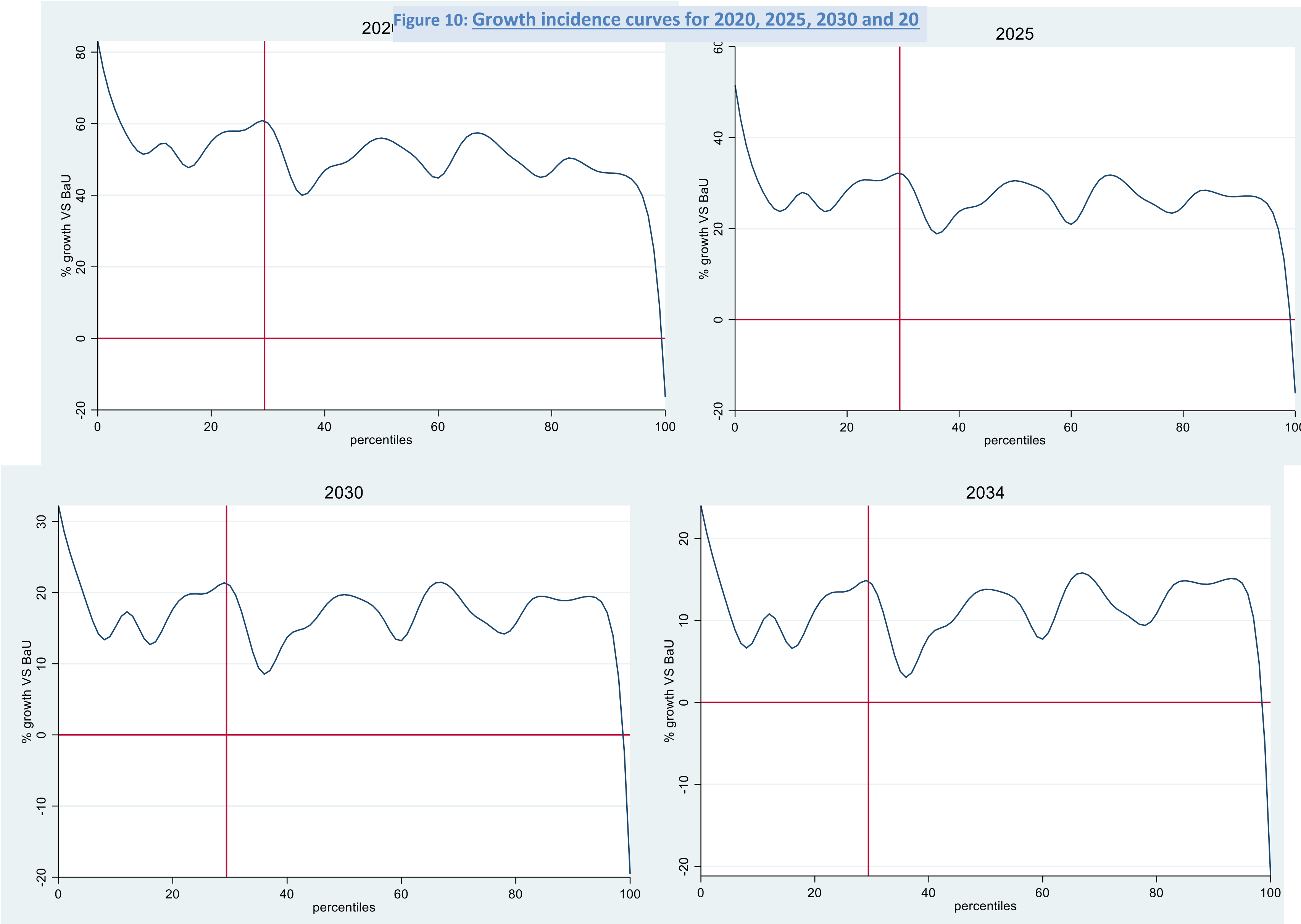
Figure 10 shows the Growth Incidence Curves, which measure the percentage change in consumption for all the percentiles in the population under simulation 2, in comparison to simulation 1. Figure 10 shows that generally households have lower income under simulation 2 that under simulation 1. The worst affected are poorest (up to 20th percentile) and the richest households, top 10%, would be negatively affected.

Figure 9: FTG curves for 2020, 2025, 2030 and 2034



Source: Authors' estimation from results

Figure 10: Growth incidence curves for 2020, 2025, 2030 and 20



Source: Authors' estimation from results

6. Conclusions and policy implications

This study analysed the economy-wide and distributional impacts of government intervention on the rural economy through agricultural, focusing on the possible differential impacts for rural and urban people and male and female workers. The study first used CGE modelling to estimate the macro impacts of reallocating land from commercial agriculture to smallholder agriculture in South Africa. Thereafter the results from the macro analysis were used to assess the consequent welfare impacts. The first simulation modelled the redistribution of land from commercial agriculture to smallholder agriculture. The second simulation increased capital for the agricultural sector, given that farming takes place largely in rural areas. Results from both simulations indicate that generally, agriculture industry support could yield positive impacts on the South African economy. The simulations could potentially contribute to improvements in welfare as measured by the increase in consumption. However, rural households appear to benefit relatively less than their urban counterparts. In addition, the results show persistence of poverty despite such interventions.

The macro results show that female labour benefits comparatively better than male labour. This result is encouraging as it suggests that increasing agriculture capital or reallocating land from commercial to smallholder agriculture could have positive effects on the gender inequality in the labour market. Unskilled labour also appears to benefit comparatively less than labour with higher levels of skills in terms of the decline in the rate of unemployment. However, based on the micro-simulation analysis, skilled male labour is likely to be in wage employment or self employment and to earn higher wages relative to female labour. For government's proposed policy of reallocating land from commercial to smallholder agriculture to have significant impacts on reducing gender inequality and poverty, there would be need for corrective strategies to address the unexpected negative impacts like the worsening of the gender gap in the labour market. These findings are in line with Cousins' (2018b) argument that while land is one of the key requirements to support small-scale farmers and other rural economy players, land alone is not enough to reduce poverty. Instead, a combination of well-structured strategies is required to promote rural development and attain the much-needed welfare improvements in rural communities. Thus, a relook at public strategies for rural development in connection with infrastructure development, pro-poor gender-sensitive strategies might be a solution to rural economic growth and development.

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Annex

Stata selected estimation results

Table 8: Labour supply: Unskilled labour

```
. * estimate multinomial logit model for occupational category (labor supply)
. xi: mlogit worker_sim0 urban i.region gender hh_head age_sim0 education n_children married
[pw=wgt09_sim0] ///
if skilled_sim0==`s', base(3)
i.region         _Iregion_1-9        (naturally coded; _Iregion_1 omitted)

Iteration 0:   log pseudolikelihood = -5177594.7
Iteration 1:   log pseudolikelihood = -4655592.1
Iteration 2:   log pseudolikelihood = -4609809.4
Iteration 3:   log pseudolikelihood = -4609354.3
Iteration 4:   log pseudolikelihood =   -4609352
```

Iteration 5: log pseudolikelihood = -4609352

Multinomial logistic regression Number of obs = 4,425
Wald chi2(30) = 282.21
Prob > chi2 = 0.0000
Log pseudolikelihood = -4609352 Pseudo R2 = 0.1098

worker_sim0	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
1						
urban	.1286408	.1211838	1.06	0.288	-.1088752	.3661567
_Iregion_2	-.7433197	.2186549	-3.40	0.001	-1.171875	-.314764
_Iregion_3	.0425009	.2282031	0.19	0.852	-.4047689	.4897708
_Iregion_4	.0612419	.2408073	0.25	0.799	-.4107318	.5332156
_Iregion_5	.0190566	.2197884	0.09	0.931	-.4117207	.4498338
_Iregion_6	.0240864	.2416388	0.10	0.921	-.4495169	.4976897
_Iregion_7	-.3137258	.2363976	-1.33	0.184	-.7770565	.149605
_Iregion_8	-.3329246	.246235	-1.35	0.176	-.8155363	.1496872
_Iregion_9	-.6783122	.2334709	-2.91	0.004	-1.135907	-.2207177
gender	-.1667513	.1222663	-1.36	0.173	-.4063888	.0728862
hh_head	.5766471	.1193662	4.83	0.000	.3426937	.8106005
age_sim0	.0372219	.0064433	5.78	0.000	.0245933	.0498504
education	.3643832	.0514684	7.08	0.000	.2635069	.4652595
n_children	-.1027553	.0332819	-3.09	0.002	-.1679867	-.0375239
married	.3156625	.1310972	2.41	0.016	.0587168	.5726083
_cons	-2.633285	.3977714	-6.62	0.000	-3.412903	-1.853667
2						
urban	-.020258	.2901542	-0.07	0.944	-.5889498	.5484338
_Iregion_2	-.5479549	.5218345	-1.05	0.294	-1.570732	.474822
_Iregion_3	-.0043546	.5426753	-0.01	0.994	-1.067979	1.059269
_Iregion_4	-1.557277	.9358565	-1.66	0.096	-3.391522	.2769682
_Iregion_5	-.8446435	.5121075	-1.65	0.099	-1.848356	.1590687
_Iregion_6	-.5002347	.6279199	-0.80	0.426	-1.730935	.7304657
_Iregion_7	-.1596445	.5211994	-0.31	0.759	-1.181177	.8618876
_Iregion_8	.4606431	.5141527	0.90	0.370	-.5470776	1.468364
_Iregion_9	.1562948	.5316099	0.29	0.769	-.8856414	1.198231
Gender	.9816252	.2532916	3.88	0.000	.4851829	1.478068
hh_head	.3520987	.2789716	1.26	0.207	-.1946756	.8988729
age_sim0	.0790327	.0131087	6.03	0.000	.0533401	.1047252
education	.7303218	.1111781	6.57	0.000	.5124166	.9482269
n_children	-.0286993	.0744988	-0.39	0.700	-.1747143	.1173157
married	.2145143	.2968366	0.72	0.470	-.3672747	.7963033
_cons	-8.92195	.8903819	-10.02	0.000	-10.66707	-7.176834
3	(base outcome)					

Table 9: Labour supply: Unskilled labour: Skilled labour

```
. * estimate multinomial logit model for occupational category (labor supply)
. xi: mlogit worker_sim0 urban i.region gender hh_head age_sim0 education n_children married
[pw=wgt09_sim0] ///
 if skilled_sim0==`s', base(3)
i.region         _Iregion_1-9       (naturally coded; _Iregion_1 omitted)

Iteration 0:   log pseudolikelihood =  -10645233
Iteration 1:   log pseudolikelihood = -9453335.9
Iteration 2:   log pseudolikelihood = -9321589.2
Iteration 3:   log pseudolikelihood = -9319847.8
Iteration 4:   log pseudolikelihood = -9319847.3

Multinomial logistic regression               Number of obs     =      6,398
                                              Wald chi2(30)     =     445.24
                                              Prob > chi2       =     0.0000
Log pseudolikelihood = -9319847.3             Pseudo R2         =     0.1245

-----------------------------------------------------------------------------
             |               Robust
 worker_sim0 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+---------------------------------------------------------------
1            |
       Urban |   .7403484   .1278633     5.79   0.000      .489741    .9909558
  _Iregion_2 |  -.1308927   .2746372    -0.48   0.634    -.6691716    .4073862
  _Iregion_3 |  -.0349161   .2714232    -0.13   0.898    -.5668958    .4970636
  _Iregion_4 |   .1028962   .2798873     0.37   0.713    -.4456729    .6514652
  _Iregion_5 |   .2565209   .2438465     1.05   0.293    -.2214094    .7344512
  _Iregion_6 |   .3393776   .3066666     1.11   0.268    -.2616778    .9404331
  _Iregion_7 |   .0676181   .2540143     0.27   0.790    -.4302407     .565477
  _Iregion_8 |  -.1009867   .2671486    -0.38   0.705    -.6245883     .422615
  _Iregion_9 |  -.2625508   .2700823    -0.97   0.331    -.7919024    .2668008
      gender |   .5145134   .1273543     4.04   0.000     .2649036    .7641231
     hh_head |   .6231952   .1387442     4.49   0.000     .3512615    .8951289
    age_sim0 |   .0542432   .0092041     5.89   0.000     .0362035    .0722829
   education |  -.1393922   .0331138    -4.21   0.000    -.2042941   -.0744903
  n_children |    -.16098   .0354426    -4.54   0.000    -.2304463   -.0915137
     married |   .5558289   .1705208     3.26   0.001     .2216142    .8900436
       _cons |  -.5882373   .3773621    -1.56   0.119    -1.327853    .1513788
-------------+---------------------------------------------------------------
2            |
       urban |   .2721701   .1635617     1.66   0.096     -.048405    .5927452
  _Iregion_2 |  -.2646572   .3164344    -0.84   0.403    -.8848573    .3555428
  _Iregion_3 |  -.6894924   .4474091    -1.54   0.123    -1.566398    .1874133
  _Iregion_4 |  -.3278244   .3420127    -0.96   0.338    -.9981571    .3425082
  _Iregion_5 |  -.6773313   .3007793    -2.25   0.024    -1.266848   -.0878147
```

_Iregion_6	-.7699399	.3834633	-2.01	0.045	-1.521514	-.0183656
_Iregion_7	-.2602022	.2970941	-0.88	0.381	-.8424961	.3220916
_Iregion_8	-.484198	.3173608	-1.53	0.127	-1.106214	.1378178
_Iregion_9	-.4937334	.3490107	-1.41	0.157	-1.177782	.190315
gender	.1964501	.1624383	1.21	0.227	-.1219231	.5148232
hh_head	.6381143	.1674608	3.81	0.000	.3098971	.9663315
age_sim0	.0882256	.0102151	8.64	0.000	.0682044	.1082468
education	-.4147284	.0436458	-9.50	0.000	-.5002726	-.3291842
n_children	-.057919	.0434059	-1.33	0.182	-.1429931	.027155
married	.419818	.2009485	2.09	0.037	.0259662	.8136698
_cons	-1.122547	.4646908	-2.42	0.016	-2.033325	-.21177
3	(base outcome)					

Model Equations of the dynamic model

1. Production

1. $VA_{j,t} = v_j XST_{j,t}$
2. $CI_{j,t} = io_j XST_{j,t}$
3. $VA_{j,t} = B_j^{VA}\left[\beta_j^{VA} LDC_{j,t}^{-\rho_j^{VA}} + \left(1-\beta_j^{VA}\right) KDC_{j,t}^{-\rho_j^{VA}}\right]^{-\frac{1}{\rho_j^{VA}}}$
4. $LDC_{j,t} = \left[\frac{\beta_j^{VA}}{1-\beta_j^{VA}} \frac{RC_j}{WC_j}\right]^{\sigma_j^{VA}} KDC_{j,t}$
5. $LDC_{j,t} = B_j^{LD}\left[\sum_l \quad \beta_{l,j}^{LD} LD_{l,j,t}^{-\rho_j^{LD}}\right]^{-\frac{1}{\rho_j^{LD}}}$
6. $LD_{l,j,t} = \left[\frac{\beta_{l,j}^{LD} WC_{j,t}}{WTI_{l,j,t}}\right]^{\sigma_j^{LD}} \left(B_j^{LD}\right)^{\sigma_j^{LD}-1} LDC_{j,t}$
7. $KDC_{j,t} = B_j^{KD}\left[\sum_k \quad \beta_{k,j}^{KD} KD_{k,j,t}^{-\rho_j^{KD}}\right]^{-\frac{1}{\rho_j^{KD}}}$
8. $KD_{k,j,t} = \left[\frac{\beta_{k,j}^{KD} RC_{j,t}}{RTI_{k,j,t}}\right]^{\sigma_j^{LD}} \left(B_j^{KD}\right)^{\sigma_j^{KD}-1} KDC_{j,t}$
9. $DI_{i,j,t} = aij_{i,j} CI_{j,t}$

2. Income and Savings

2.1. Households

10. $YH_{h,t} = YHL_{h,t} + YHK_{h,t} + YHTR_{h,t}$
11. $YHL_{h,t} = \sum_l \quad \lambda_{h,l}^{WL}\left(W_{l,t} \sum_j \quad LD_{l,j,t}\right)$
12. $YHK_{h,t} = \lambda_h^{RK}\left(\sum_j \quad R_{k,j,t} KD_{k,j,t}\right)$
13. $YHTR_{h.t} = \sum_{ag} \quad TR_{h,ag,t}$
14. $YDH_{h,t} = YH_{h,t} - TDH_{h,t} - \sum_{gv} \quad TR_{gv,h,t}$
15. $CTH_{h,t} = YDH_{h,t} - SH_{h,t} - \sum_{agng} \quad TR_{agng,h,t}$
16. $SH_{h,t} = PIXCON_t \; sh0_{h,t} + sh1_{h,t} \; YDH_{h,t}$

2.2. Firms

17. $YF_{f,t} = YFK_{f,t} + YFTR_{f,t}$
18. $YFK_{f,t} = \lambda_f^{RK}\left(\sum_j \quad R_{k,j,t} KD_{k,j,t}\right)$
19. $YFTR_{f,t} = \sum_{ag} \quad TR_{f,ag,t}$
20. $YDF_{f,t} = YF_{f,t} - TDF_{f,t}$
21. $SF_{f,t} = YDF_{f,t} - \sum_{ag} \quad TR_{ag,f,t}$

2.3. Governments

22. $YG_t = YGK_t + TDHT_t + TDFT_t + TPRODN_t + TPRCTS_t + TDHT_t$
23. $YGK_t = \lambda_{gvt,k}^{RK}\left(\sum_j \quad R_{k,j,t} KD_{k,j,t}\right)$
24. $TDHT_t = \sum_h \quad TDH_{h,t}$
25. $TDFT_t = \sum_f \quad TDF_{f,t}$
26. $TPRODN_t = TIWT_t + TIKT_t + TIPT_t$
27. $TIWT_t = \sum_i \quad TIW_{l,j,t}$
28. $TIKT_t = \sum_i \quad TIK_{k,j,t}$

29. $TIPT_t = \sum_i \quad TIP_{j,t}$
30. $TPRCTS_t = TICT_t + TIMT_t + TIXT_t$
31. $TICT_t = \sum_i \quad TIC_{i,t}$
32. $TIKT_t = \sum_i \quad TIK_{i,t}$
33. $TIPT_t = \sum_i \quad TIP_{i,t}$
34. $YGTR_t = \sum_{agng} \quad TR_{gvt,agng,t}$
35. $TDH_{h,t} = PIXCON_t^{\eta}\ ttdh0_{h,t} + ttdh1_{h,t} YH_{h,t}$
36. $TDF_{f,t} = PIXCON_t^{\eta}\ ttdf0_{h,t} + ttdf1_{h,t} YFK_{f,t}$
37. $TIW_{l,j,t} = ttiw_{l,j,t} W_{l,t} LD_{l,j,t}$
38. $TIK_{k,j,t} = ttik_{k,j,t} R_{k,j,t} KD_{k,j,t}$
39. $TIP_{j,t} = ttip_{j,t} PP_{j,t} XST_{j,t}$
40. $TIC_{i,t} = ttic_{i,t}\left[\left(PL_{i,t} + \sum_{ij} \quad PC_{ij,t} tmrg_{ij,i}\right) DD_{i,t} + \left(\{1 + ttim_{i,t}\} PWM_{i,t} e_t + \sum_{ij} \quad PC_{ij,t} tmrg_{ij,i}\right) IM_{i,t}\right]$
41. $TIM_{i,t} = ttim_{i,t}\ PWM_{i,t} e_t IM_{i,t}$
42. $TIX_{i,t} = ttix_{i,t}\left(PE_{i,t} + \sum_{ij} \quad PC_{ij,t} tmrg_{ij,i}^{X}\right) EXD_{i,t}$
43. $SG_t = YG_t - \sum_{agng} \quad TR_{agng,gvt} - G_t$

2.4. Rest of the world

44. $YROW_t = e_t \sum_i \quad PWM_{i,t} IM_{i,t} + \lambda_{row,k}^{RK}\left(\sum_j \quad R_{k,j,t} KD_{k,j,t}\right) + \sum_{agd} \quad TR_{row,agd,t}$
45. $SROW_t = YROW_t - \sum_i \quad PE_{i,t}^{FOB} EXD_{i,t} - \sum_{agd} \quad TR_{row,agd,t}$
46. $SROW_t = -CAB_t$

2.5. Transfers

47. $TR_{agng,h,t} = \lambda_{agng,h}^{TR} YDH_{h,t}$
48. $TR_{gvt,h,t} = PIXCON_t^{\eta}\ tr0_{h,t} + tr1_{h,t} YH_{h,t}$
49. $TR_{ag,f,t} = \lambda_{ag,f}^{TR} YDF_{f,t}$
50. $TR_{agng,gvt,t} = PIXCON_t^{\eta}\ TR_{ag,gvt}^{0}\ pop_t$
51. $TR_{agd,row,t} = PIXCON_t^{\eta}\ TR_{agd,row}^{0}\ pop_t$

3. Demand

52. $C_{i,h,t}\ PC_{i.t} = C_{i,h,t}^{MIN} PC_{i,t} + \gamma_{i,h}^{LES}\left(CTH_{h,t} - \sum_{ij} \quad C_{ij,h}^{MIN} PC_{ij,t}\right)$
53. $GFCF_t = IT_t - \sum_i \quad PC_{i,t} VSTK_{i,t}$
54. $PC_{i,t} INV_{i,t}^{PRI} = \gamma_i^{INVPRI}\ IT_t^{PRI}$
55. $PC_{i,t} INV_{i,t}^{PUB} = \gamma_i^{INVPUB}\ IT_t^{PUB}$
56. $INV_{i,t} = INV_{i,t}^{PRI} + INV_{i,t}^{PUB}$
57. $PC_{i,t} CG_{i,t}\ PC_i = \gamma_i^{GVT} G_t$
58. $DIT_{i,t} = \sum_j \quad DI_{i,j,t}$
59. $MRGN_{i,t} = \sum_{ij} \quad tmrg_{i,ij} DD_{ij,t} + \sum_{ij} \quad tmrg_{i,ij} IM_{ij,t} + \sum_{ij} \quad tmrg_{ij,i}^{X} EXD_{ij,t}$

4. Trade

60. $XST_{j,t} = B_j^{XT}\left[\sum_i \quad \beta_{j,i}^{XT} XS_{j,i,t}^{\rho_j^{XT}}\right]^{\frac{1}{\rho_j^{XT}}}$
61. $XS_{j,i,t} = \frac{XST_{j,t}}{\left(B_j^{XT}\right)^{1+\sigma_j^{XT}}}\left[\frac{P_{j,i,t}}{\beta_{j,i}^{XT}\ PT_{j,t}}\right]^{\sigma_j^{XT}}$
62. $XS_{j,i,t} = B_{j,i}^{X}\left[\beta_{j,i}^{X} EX_{j,i,t}^{\rho_{j,i}^{X}} + \left(1 - \beta_{j,i}^{X}\right) DS_{j,i,t}^{\rho_{j,i}^{X}}\right]^{\frac{1}{\rho_{j,i}^{X}}}$
63. $EX_{j,i,t} = \left[\frac{\left(1-\beta_{j,i}^{X}\right)}{\beta_{j,i}^{X}} \frac{PE_{i,t}}{PL_{i,t}}\right]^{\sigma_{j,i}^{X}} DS_{j,i,t}$
64. $EXD_{i,t} = EXD_i^{0}\ pop_t\ \left[\frac{e_t\ PWX_{i,t}}{PE_{i,t}^{FOB}}\right]^{\sigma_i^{XD}}$
65. $Q_{i,t} = B_i^{M}\left[\beta_i^{M} IM_{i,t}^{-\rho_i^{M}} + (1 - \beta_i^{M})\ DD_{i,t}^{-\rho_i^{M}}\right]^{\frac{-1}{\rho_i^{M}}}$
66. $IM_{i,t} = \left[\frac{\beta_i^{M}}{(1-\beta_i^{M})} \frac{PD_{i,t}}{PM_{i,t}}\right]^{\sigma_i^{M}} DD_{i,t}$

5. Prices

67. $PP_{j,t}\ XST_{j,t} = PVA_{j,t}\ VA_{j,t} + PCI_{j,t}\ CI_{j,t}$
68. $PT_{j,t} = \left(1 + ttip_{j,t}\right) PP_{j,t}$
69. $PCI_{j,t}\ CI_{j,t} = \sum_i \quad PC_{i,t}\ DI_{i,j,t}$
70. $PVA_{j,t}\ VA_{j,t} = WC_{j,t}\ LDC_{j,t} + RC_{j,t}\ KD_{j,t}$
71. $WC_{j,t}\ LDC_{j,t} = \sum_l \quad WTI_{l,j,t}\ LD_{l,j,t}$
72. $RC_{j,t}\ KD_{j,t} = \sum_l \quad RTI_{k,j,t}\ KD_{k,j,t}$
73. $WTI_{l,j,t} = W_{l,j,t}\ \left(1 + ttiw_{l,j,t}\right)$
74. $RTI_{k,j,t} = R_{k,j,t}\ \left(1 + ttik_{k,j,t}\right)$
75. $PT_{j,t}\ XST_{j,t} = \sum_i \quad P_{j,i,t}\ XS_{j,i,t}$

76. $P_{j,i,t}\ XS_{j,i,t} = PE_{i,t}\ EX_{j,i,t} + PL_{i,t}\ DS_{j,i,t}$
77. $PE_{i,t}^{FOB} = \left(PE_{i,t} + \sum_{ij} \quad PC_{ij,t} tmrg_{ij,i}^{X}\right)\left(1 + ttix_{i,t}\right)$
78. $PD_{i,t} = \left(1 + ttic_{i,t}\right)\left(PL_{i,t} + \sum_{ij} \quad PC_{ij,t} tmrg_{ij,t}\right)$
79. $PM_{i,t} = \left(1 + ttic_{i,t}\right)\left(\{1 + ttim_{i,t}\} PWM_{i,t} e_t + \sum_{ij} \quad PC_{ij,t} tmrg_{ij,i}\right)$
80. $PC_{i,t} Q_{i,t} = PM_{i,t} IM_{i,t} + PD_{i,t}\ DD_{i,t}$
81. $PIXGDP_t = \sqrt{\dfrac{\sum_j \left(PVA_{j,t} + \frac{TIP_{j,t}}{VA_{j,t}}\right) VA_j^0}{\sum_j \quad PVA_j^0 VA_j^0 + TIP_j^0} \dfrac{\sum_j \quad PVA_{j,t} VA_{j,t} + TIP_{j,t}}{\sum_j \left(PVA_j^0 + \frac{TIP_j^0}{VA_j^0}\right) VA_{j,t}}}$
82. $PIXCON_t = \dfrac{\sum_i \quad PC_{i,t} \sum_h \quad C_{i,h}^0}{\sum_{ij} \quad PC_{ij}^0 \sum_h \quad C_{ij,h}^0}$
83. $PIXINV_t^{PRI} = \prod_i \quad \left(\frac{PC_{i,t}}{PC_{ij}^0}\right)^{\gamma_i^{INVPRI}}$
84. $PIXINV_t^{PUB} = \prod_i \quad \left(\frac{PC_{i,t}}{PC_{ij}^0}\right)^{\gamma_i^{INVPUB}}$
85. $PIXGVT_t = \prod_i \quad \left(\frac{PC_{i,t}}{PC_{ij}^0}\right)^{\gamma_i^{GVT}}$

6. Equilibrium

86. $Q_{i,t} = \sum_h \quad C_{i,h,t} + CG_{i,t} + INV_{i,t} + VSTK_{i,t} + DIT_{i,t} + MRGN_{i,t}$
87. $LDT_{l,t} = \sum_j \quad LD_{l,j,t}$
88. $LS_{l,t} = LDT_{l,t} + LS_{l,t}$
89. $UN = (1 - LDT_{l,t})/LS_{l,t}$
90. $KS_{k,t} = \sum_j \quad KD_{k,j,t}$
91. $IT_t = \sum_h \quad SH_{h,t} + \sum_f \quad SF_{f,t} + SG_t + +SROW_t$
92. $IT_t^{PRI} = IT_t - IT_t^{PUB} - \sum_i \quad PC_{i,t} VSTK_{i,t}$
93. $DD_{i,t} = \sum_j \quad DS_{j,i,t}$
94. $EXD_{i,t} = \sum_j \quad EX_{j,i,t}$

7. Gross Domestic Product

95. $GDP_t^{BP} = \sum_j \quad PVA_{j,t} VA_{j,t} + TIPT_t$
96. $GDP_t^{MP} = \sum_j \quad PVA_{j,t} VA_{j,t} + TPRCTS_t$

8. Dynamic equations

97. $IT_t^{PUB} = PK_t^{PUB} \sum_{pub} \quad IND_{pub,t}$
98. $IT_t^{PRI} = PK_t^{PRI} \sum_{bus} \quad IND_{bus,t}$
99. $PK_t^{PRI} = A_t^{K\_BUS} \prod_i \quad \left[\frac{PC_{i,t}}{\gamma_i^{INVPRI}}\right]^{\gamma_i^{INVPRI}}$
100. $PK_t^{PUB} = A^{K\_PUB} \prod_i \quad \left[\frac{PC_{i,t}}{\gamma_i^{INVPUB}}\right]^{\gamma_i^{INVPUB}}$
101. $IND_{bus,t} = \varphi_{bus} \left[\frac{R_{bus,t}}{U_{bus,t}}\right]^{\sigma_{bus}^{INV}} KD_{bus,t}$
102. $IND_{k,pub,t+1} = IND_{k,pub,t+1}\ (1 + n_t)$
103. $KD_{j,t+1} = KD_{j,t}\ \left(1 - \delta_j\right) + IND_{j,t}$
104. $U_{bus,t} = PK_t^{PRI}(\delta_{bus} + IR_t)$
105. $U_{pub,t} = PK_t^{PUB}\left(\delta_{pub} + IR_t\right)$
106. $LS_{l,t+1} = LS_{l,t}\ (1 + n)$

GAMS Code

```
$TITLE    PEP standard model 1-t, version 2.0
$STITLE   Single country dynamic version, July 2013
$STITLE   Version B: Resolution using the loop command (one period at a time)
*=============================================================================*
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*  - Attribution:        You must attribute the work to:                      *
*                    Veronique Robichaud, Andre Lemelin,                      *
*                    Helene Maisonnave and Bernard Decaluwe.                  *
```

```
* 1 Set definition

** 1.1 Industries and commodities

SET

J All activities
 /
agaric, aagris, amin, afood, abevt, aknitwv, aleat, afoot, awoodpaprint, apetr, abchm, aochm, aplaglasnmm, ametals, amachequp,
amtvpotre, afurn, aomnf, autilities, acnst, atrad, aacct, altrp, aotrp, apost, afinbus, apuba, aeduc, aheal, aothser
/

J1(J) Agricultural activities
 /
agaric, aagris
/

J2(J) Informal gricultural activities
 /
aagris
/

J3(J) All sectors excluding informal agricultural activities
/
agaric, amin, afood, abevt, aknitwv, aleat, afoot, awoodpaprint, apetr, abchm, aochm, aplaglasnmm, ametals, amachequp, amtvpotre,
afurn, aomnf, autilities, acnst, atrad, aacct, altrp, aotrp, apost, afinbus, apuba, aeduc, aheal, aothser/

PUB(J) Public industries
/
apuba         Government
/

BUS(J) Private industries
/
agaric, aagris, amin, afood, abevt, aknitwv, aleat, afoot, awoodpaprint, apetr, abchm, aochm, aplaglasnmm, ametals, amachequp,
amtvpotre, afurn, aomnf, autilities, acnst, atrad, aacct, altrp, aotrp, apost, afinbus,  aeduc, aheal, aothser
/

MN(J) Manufacturing Industries
/
afood, abevt, aknitwv, aleat, afoot, awoodpaprint, apetr, abchm, aochm, aplaglasnmm, ametals, amachequp, amtvpotre, afurn, aomnf
/

I All commodities
/
cagri, clani, cmin, celcg, cwatr, cmeatfi, cvege, cfrui, cfatdair, cgraista, cafee, csuga, cofoo, cbevtob, ctextfoot, cwoodpaprint, cpetrchem,
cfert, csoapoche, cfurn, comanf, ccnst, ctradacc, ctransp, cict, cutilities, cfinbus, cpuba, ceduc, cheal, cothser
/

I1(I) All commodities except agriculture
/
clani, cmin, celcg, cwatr, cmeatfi, cvege, cfrui, cfatdair, cgraista, cafee, csuga, cofoo, cbevtob, ctextfoot, cwoodpaprint, cpetrchem, cfert,
csoapoche, cfurn, comanf, ccnst, ctradacc, ctransp, cict, cutilities, cfinbus, cpuba, ceduc, cheal, cothser

/

***vm
X(I) Exported commodities
/
```

cagri, clani, cmin, celcg, cmeatfi, cvege, cfrui, cfatdair, cgraista, cafee, csuga, cofoo, cbevtob, ctextfoot, cwoodpaprint, cpetrchem, cfert, csoapoche, cfurn, comanf, ccnst, ctradacc, ctransp, cict, cutilities, cfinbus, ceduc, cheal, cothser

/

M(I) Imported commodities
/
cagri, clani, cmin, celcg, cmeatfi, cvege, cfrui, cfatdair, cgraista, cafee, csuga, cofoo, cbevtob, ctextfoot, cwoodpaprint, cpetrchem, cfert, csoapoche, cfurn, comanf, ccnst, ctradacc, ctransp, cict, cutilities, cfinbus, ceduc, cheal, cothser
/

NM(I) Non imported commodities
/
cwatr
cpuba
/
** 1.2 Production factors
L Labor categories
/
flab-ms, flab-mm, flab-mt, flab-fs, flab-fm, flab-ft
/

ES(L) Secondary Labor categories
/
flab-ms, flab-fs
/

EM(L) Matric Labor categories
/
flab-mm, flab-fm
/

ET(L) Tertiary Labor categories
/
flab-mt, flab-ft
/

USL(L) Unskilled Labor categories
/
flab-ms, flab-fs
/
SKL(L) Skilled Labour
/
flab-mm, flab-mt, flab-fm, flab-ft
/

Mal(L) Male labour
/
flab-ms, flab-mm, flab-mt
/

Fem(L) Female labour
/
flab-fs, flab-fm, flab-ft
/

SKLM(Mal) Skilled male labour
/
flab-mm, flab-mt
/

USKM(Mal) Unskilled male labour
/
flab-ms,

USKF(Fem) Unskilled female labour

```
/
flab-fs
/

SKLF(Fem) Female Skilled labour
/
flab-fm, flab-ft
/

K All Composite Capital categories including equipment and land
/l
fcap-e
/

** 1.3 Agents

AG All agents
/
ENT, hhd-0_r, hhd-0_u, hhd-1_r, hhd-1_u, hhd-2_r, hhd-2_u, hhd-3_r, hhd-3_u, hhd-4_r, hhd-4_u, hhd-5_r, hhd-5_u, hhd-6_r, hhd-6_u,
hhd-7_r, hhd-7_u, hhd-8_r, hhd-8_u, hhd-9_r, hhd-9_u, GVT, ROW
/

GV(AG) Governmental agents
/
GVT
/

AGNG(AG) Non governmental agents
/
ENT, hhd-0_r, hhd-0_u, hhd-1_r, hhd-1_u, hhd-2_r, hhd-2_u, hhd-3_r, hhd-3_u, hhd-4_r, hhd-4_u, hhd-5_r, hhd-5_u, hhd-6_r, hhd-6_u,
hhd-7_r, hhd-7_u, hhd-8_r, hhd-8_u, hhd-9_r, hhd-9_u, ROW
/

AGD(AG) All domestic agents
/
ENT, hhd-0_r, hhd-0_u, hhd-1_r, hhd-1_u, hhd-2_r, hhd-2_u, hhd-3_r, hhd-3_u, hhd-4_r, hhd-4_u, hhd-5_r, hhd-5_u, hhd-6_r, hhd-6_u,
hhd-7_r, hhd-7_u, hhd-8_r, hhd-8_u, hhd-9_r, hhd-9_u, GVT,
/

H(AG) Households
/
hhd-0_r, hhd-0_u, hhd-1_r, hhd-1_u, hhd-2_r, hhd-2_u, hhd-3_r, hhd-3_u, hhd-4_r, hhd-4_u, hhd-5_r, hhd-5_u, hhd-6_r, hhd-6_u, hhd-7_r,
hhd-7_u, hhd-8_r, hhd-8_u, hhd-9_r, hhd-9_u
/

F(AG) Firms
/
ENT
/

** 1.4 Periods

TIME Time periods
/
1*21
/

T(TIME)

T1(time) First period;
T1(time) = yes$[ord(time) eq 1];

ALIAS (j,jj)
ALIAS (i,ij)
ALIAS (ag,agj)
ALIAS (h,hj)
ALIAS (l,lj)
```

```
ALIAS (k,kj)
ALIAS (t,tt)
;

* 2 Parameters and benchmark variables definition

** 2.1 Parameters

PARAMETERS
 aij(i,j)       Input output coefficient
 alpha          Tobin q
 A_K_PRI        Scale parameter (private investment funtion)
 A_K_PUB        Scale parameter (public investment funtion)
 B_KD(j)        Scale parameter (CES - composite capital)
 B_LD(j)        Scale parameter (CES - composite labor)
 B_M(i)         Scale parameter (CES - composite commodity)
 B_VA(j)        Scale parameter (CES - value added)
 B_X(j,i)       Scale parameter (CET - exports and local sales)
 B_XT(j)        Scale parameter (CET - total output)
 beta_KD(k,j)   Share parameter (CES - composite capital)
 beta_LD(l,j)   Share parameter (CES - composite labor)
 beta_M(i)      Share parameter (CES - composite commodity)
 beta_VA(j)     Share parameter (CES - value added)
 beta_X(j,i)    Share parameter (CET - exports and local sales)
 beta_XT(j,i)   Share parameter (CET - total output)
 delta(k,j)     Depreciation rate of capital k in industry j
 eta            Price elasticity of indexed transfers and parameters
 frisch(h)      Frisch parameter (LES function)
 gamma_GVT(i)   Share of commodity i in total current public expenditures on goods and services
 gamma_INVPRI(i) Share of commodity i in total private investment expenditures
 gamma_INVPUB(i) Share of commodity i in total public investment expenditures
 gamma_LES(i,h)  Marginal share of commodity i in household h consumption budget
 io(j)          Coefficient (Leontief - intermediate consumption)
 lambda_RK(ag,k) Share of type k capital income received by agent ag
 lambda_TR(ag,agj) Share parameter (transfer functions)
 lambda_WL(ag,l)  Share of type l labor income received by agent ad
*vm
 lambda_WLA(ag,l)  Share of informal type l labor income received by agent h
 n(time)          Population growth rate
 n1             Population growth rate for the first period
 phi(k,j)       Scale parameter (allocation of investment to industries)
 pop(time)        Population index
 rho_KD(j)      Elasticity parameter (CES - composite capital)
 rho_LD(j)      Elasticity parameter (CES - composite labor)
 rho_M(i)       Elasticity parameter (CES - composite good)
 rho_VA(j)      Elasticity parameter (CES - value added)
 rho_X(j,i)     Elasticity parameter (CET - exports and local sales)
 rho_XT(j)      Elasticity parameter (CET - total output)
 sigma_INV(k,j)  Elasticity (investment demand)
 sigma_KD(j)     Elasticity (CES - composite capital)
 sigma_LD(j)     Elasticity (CES - composite labor)
 sigma_M(i)      Elasticity (CES - composite good)
 sigma_VA(j)     Elasticity (CES - value added)
 sigma_X(j,i)    Elasticity (CET - exports and local sales)
 sigma_XT(j)     Elasticity (CET - total output)
 sigma_XD(i)     Price elasticity of the world demand for exports of product i
 sigma_Y(i,h)    Income elasticity of consumption
 tmrg(i,ij)      Rate of margin i applied to commodity ij
 tmrg_X(i,ij)    Rate of margin i applied to exported commodity x
 v(j)           Coefficient (Leontief - value added)

**VM
 phi_W(l)       Wage differntial between male and female labour
 sigma_WC(l)     Unemployment elasticity of wage
 A_WC(l)        Scale parameter (Unemployment function)
 omegao_SP(j)    Cumulative Externality effect of infrastructure in in industry manufacturing mn
 rho_SP(j)      Elasticity of public spending (Sector specific)
```

sigmao_SP(j) Sectoral productivity effect
sigmao_ED(j1) Growth in skilled agric labour supply
alpha_ED(j1) Elasticity of skilled labor supply to changes in public investment
* sigma_ED(k) Elasticity of skilled labor supply to changes in public investment

** 2.2 Variables - Benchmark
* Benchmark values of variables are parameters.
* Their acronyms are the corresponding variable names,
* followed by the letter "O".

** 2.2.1 Volume variables
CO(i,h) Consumption of commodity i by type h households
CGO(i) Public consumption of commodity i
CIO(j) Total intermediate consumption of industry j
CMINO(i,h) Minimum consumption of commodity i by type h households
CTH_REALO(h) Real consumption budget of type h households
DDO(i) Domestic demand for commodity i produced locally
DIO(i,j) Intermediate consumption of commodity i by industry j
DITO(i) Total intermediate demand of commodity i
DSO(j,i) Supply of commodity i by industry j to the domestic market
EXO(j,i) Quantity of product i exported by industry j
EXDO(i) World demand for exports of product i
G_REALO Real current government expenditures on goods and services
GDP_BP_REALO Real GDP at basic prices
GDP_MP_REALO Real GDP at market prices
GFCF_PRI_REALO Real private gross fixed capital formation
GFCF_PUB_REALO Real public gross fixed capital formation
IMO(i) Quantity of product i imported
INDO(k,j) Volume of new type k capital investment to industry j
INVO(i) Final demand of commodity i for investment purposes (GFCF)
INV_PRIO(i) Final demand of commodity i for private investment purposes
INV_PUBO(i) Final demand of commodity i for public investment purposes
KDO(k,j) Demand for type k capital by industry j
KDCO(j) Industry j demand for composite capital
KSO(k) Supply of type k capital
LDO(l,j) Demand for type l labor by industry j
**VM
LDTO(l) Total demand for type l labour
**vm
LDT2O(l) Total demand for type l informal labour
LDT3O(l) Total demand for type l formal labour
LUO(l) Number of type l unemployed labor
LDCO(j) Industry j demand for composite labor
LSO(l) Supply of type l labor
**vm
LSSKO(j1) Supply of agricultural skilled labor
LSUSLO(j1) Supply of agricultural unskilled labor
LSUO(usl) Supply of unskilled labour
LSSO(skl) Supply of skilled labour
LSTO(j1) Total supply of skilled and unskilled labour to agricultural
LSTAO(l) Total supply of labour to agricultural and non-agric sectors
MRGNO(i) Demand for commodity i as a trade or transport margin
QO(i) Quantity demanded of composite commodity i
VAO(j) Value added of industry j
VSTKO(i) Inventory change of commodity i
XSO(j,i) Industry j production of commodity i
XSTO(j) Total aggregate output of industry j

** 2.2.2 Price variables
eO Exchange rate (price of foreign currency in local currency)
IRO Interest rate
PO(j,i) Basic price of industry j's production of commodity i
PCO(i) Purchaser price of composite comodity i (including all taxes and margins)
PCIO(j) Intermediate consumption price index of industry j
PDO(i) Price of local product i sold on the domestic market (including all taxes and margins)
PEO(i) Price received for exported commodity i (excluding export taxes)
PE_FOBO(i) FOB price of exported commodity i (in local currency)

PIXCONO Consumer price index
PIXGDPO GDP deflator
PIXGVTO Public expenditures price index
PIXINV_PRIO Private investment price index
PIXINV_PUBO Public investment price index
PK_PRIO Price of new private capital
PK_PUBO Price of new public capital
PLO(i) Price of local product i (excluding all taxes on products)
PMO(i) Price of imported product i (including all taxes and tariffs)
PPO(j) Industry j unit cost including taxes directly related to the use of capital and labor but excluding other taxes on production
PTO(j) Basic price of industry j's output
PVAO(j) Price of industry j value added (including taxes on production directly related to the use of capital and labor)
PWMO(i) World price of imported product i (expressed in foreign currency)
PWXO(i) World price of exported product i (expressed in foreign currency)
RO(k,j) Rental rate of type k capital in industry j
RCO(j) Rental rate of industry j composite capital
RTIO(k,j) Rental rate paid by industry j for type k capital including capital taxes
UO(k,j) User cost of type k capital in industry j
WO(l) Wage rate of type l labor
WCO(j) Wage rate of industry j composite labor
WTIO(l,j) Wage rate paid by industry j for type l labor including payroll taxes

** 2.2.3 Nominal (value) variables
CABO Current account balance
CTHO(h) Consumption budget of type h households
GO Current government expenditures on goods and services
GDP_BPO GDP at basic prices
GDP_FDO GDP at purchasers' prices from the perspective of final demand
GDP_IBO GDP at market prices (income-based)
GDP_MPO GDP at market prices
GFCFO Gross fixed capital formation
ITO Total investment expenditures
IT_PRIO Total private investment expenditures
IT_PUBO Total public investment expenditures
RKDO(k,j) Type k capital income in industry j
SFO(f) Savings of type f businesses
SGO Government savings
SHO(h) Savings of type h households
SROWO Rest-of-the-world savings
TDFO(f) Income taxes of type f businesses
TDFTO Total government revenue from business income taxes
TDHO(h) Income taxes of type h households
TDHTO Total government revenue from household income taxes
TICO(i) Government revenue from indirect taxes on product i
TICTO Total government receipts of indirect taxes on commodities
TIKO(k,j) Government revenue from taxes on type k capital used by industry j
TIKTO Total government revenue from from taxes on capital
TIMO(i) Government revenue from import duties on product i
TIMTO Total government revenue from import duties
TIPO(j) Government revenue from taxes on industry j production (excluding taxes directly related to the use of capital and labor)
TIPTO Total government revenue from production taxes (excluding taxes directly related to the use of capital and labor)
TIWO(l,j) Government revenue from payroll taxes on type l labor in industry j
TIWTO Total government revenue from payroll taxes
TIXO(i) Government revenue from export taxes on product i
TIXTO Total government revenue from export taxes
TPRCTSO Total government revenue from taxes on products and imports
TPRODNO Total government revenue from other taxes on production
TRO(ag,agj) Transfers from agent agj to agent ag
YDFO(f) Disposable income of type f businesses
YDHO(h) Disposable income of type h households
YFO(f) Total income of type f businesses
YFKO(f) Capital income of type f businesses
YFTRO(f) Transfer income of type f businesses
YGO Total government income
YGKO Government capital income
YGTRO Government transfer income
YHO(h) Total income of type h households

```
 YHKO(h)        Capital income of type h households
 YHLO(h)        Labor income of type h households
*vm added
 YHL_WO(h)      Labor (wage) income of type h households
 YHL_AGO(h)     Labor (self employed) income of type h households
 YHTRO(h)       Transfer income of type h households
 YROWO          Rest-of-the-world income

**  2.2.4 Rates and intercepts
 sh0O(h)        Intercept (type h household savings)
 sh1O(h)        Slope (type h household savings)
 tr0O(h)        Intercept (transfers by type h households to government)
 tr1O(h)        Marginal rate of transfers by type h households to government
 ttdf0O(f)      Intercept (income taxes of type f businesses)
 ttdf1O(f)      Marginal income tax rate of type f businesses
 ttdh0O(h)      Intercept (income taxes of type h households)
 ttdh1O(h)      Marginal income tax rate of type h households
 tticO(i)       Tax rate on commodity i
 ttikO(k,j)     Tax rate on type k capital used in industry j
 ttimO(i)       Rate of taxes and duties on imports of commodity i
 ttipO(j)       Tax rate on the production of industry j
 ttiwO(l,j)     Tax rate on type l worker compensation in industry j
 ttixO(i)       Export tax rate on exported commodity i
**VM
 uno(l)         Unemployment rate
;


* 3 Data

** 3.1 Data from the SAM
*  SAM data are nominal values. However, several volume variables are
*  provisionally set equal to the corresponding nominal SAM value. Once the
*  benchmark prices have been set or calibrated, volumes will be re-calculated
*  (section 4.4).

***with commercial and smallholder agric and aggregated sectors
PARAMETER
SAM(*,*,*,*);

$CALL GDXXRW.EXE SASAM2015.xlsx  par=SAM rng=SAM-GAMS6.260!A1:EA131 Rdim=2 Cdim=2
$GDXIN SASAM2015.GDX
$LOAD SAM
$GDXIN

 CO(i,h)        = SAM('I',i,'AG',h);
 CGO(i)         = SAM('I',i,'AG','gvt');
 DSO(j,i)       = SAM('J',j,'I',i);
 DDO(i)         = SUM[j,DSO(j,i)];
 DIO(i,j)       = SAM('I',i,'J',j);
 EXO(j,i)       = SAM('J',j,'X',i);
 EXDO(i)        = SAM('X',i,'AG','ROW');
 INVO(i)        = SAM('I',i,'OTH','INV');
 VSTKO(i)       = SAM('I',i,'OTH','VSTK');
 IMO(i)         = SAM('AG','ROW','I',i);
 RKDO(k,j)      = SAM('K',k,'J',j);
 LDO(l,j)       = SAM('L',l,'J',j);
 SFO(f)         = SAM('OTH','INV','AG',f);
 SGO            = SAM('OTH','INV','AG','GVT');
 SHO(h)         = SAM('OTH','INV','AG',h);
 SROWO          = SAM('OTH','INV','AG','ROW');
 TDFO(f)        = SAM('AG','TD','AG',f);
 TDHO(h)        = SAM('AG','TD','AG',h);
 TICO(i)        = SAM('AG','TI','I',i);
 TIKO(k,j)      = SAM('AG',k,'J',j);
 TIMO(i)        = SAM('AG','TM','I',i);
 TIPO(j)        = SAM('AG','TA','J',j);
```

```
 TIXO(i)        = SAM('AG','GVT','X',i);
 TIWO(l,j)      = SAM('AG',l,'J',j);
 TRO(ag,agj)    = SAM('AG',ag,'AG',agj);
 lambda_RK(ag,k) = SAM('AG',ag,'K',k);
***vm lambda_WL(h,l)  = SAM('AG',h,'L',l);
***vm
 lambda_WL(ag,l)  = SAM('AG',ag,'L',l);
 lambda_WLA(ag,l) = SAM('AG',ag,'L',l);
 tmrg(i,ij)     = SAM('I',i,'I',ij);
 tmrg_X(i,ij)   = SAM('I',i,'X',ij);
* tmrg_X(i,ij)   = 0;
display TIPO, IMO, co, ldo, tro;

** 3.2 Other data
*  Some parameters cannot be calibrated using SAM values
** Exogenous parameters

PARAMETER
PARSAI(i,*), PARSAJ(j,*), PARSAJI(i,j), PARSAAG(*,ag), PARSAT(time,*), PARSAKJ1(k,j), PARSAKJ2(k,j);

*$CALL GDXXRW.EXE PARSA092015.xlsx squeeze = 'no' par=PARSAI rng=PARSA3!A3:C87 par=PARSAJ rng=PARSA3!F3:J52 par=PARSAJI
rng=PARSA3!AJ3:CT87 par=PARSAAG rng=PARSA3!L3:AG92 par=PARSAT rng=PARSA3!A93:B103 par=PARSAKJ1 rng=PARSA3!A108:AY110
par=PARSAKJ2 rng=PARSA3!A113:AY115
$CALL GDXXRW.EXE PARSA092015.xlsx squeeze = 'no' par=PARSAI rng=PARSA6261!A3:C34 par=PARSAJ rng=PARSA6261!F3:J33 par=PARSAJI
rng=PARSA6261!AJ3:BN34 par=PARSAAG rng=PARSA6261!L3:AG39 par=PARSAT rng=PARSA6261!A40:B60 par=PARSAKJ1
rng=PARSA6261!A64:AE65 par=PARSAKJ2 rng=PARSA6261!A68:AE69
$GDXIN PARSA092015.gdx
$LOAD PARSAJ, PARSAI, PARSAJI, PARSAAG, PARSAT, PARSAKJ1, PARSAKJ2
$GDXIN


* Population growth
 n(time)        = 0.015;
 n1             = SUM[t1,n(t1)];
 pop(t1)        = 1;
 loop{time$[ORD(time) gt 1],
 pop(time)      = pop(time-1)*[1+n(time-1)];
 };

* Interest rate
 IRO            = 0.04;

* Elasticity - Investment demand function
* sigma_INV(k,j)  = PARKJ2(k,j);
 sigma_INV(k,j)  = 2;

* Price elasticity (should be set equal to one when verifying model homogeneity)
 eta            = 1;

** CES and CET elasticities
* sigma_KD(j)    = PARSAJ(j,'sigma_KD');
* sigma_LD(j)    = PARSAJ(j,'sigma_LD');
* sigma_M(i)     = PARSAI(i,'sigma_M');
* sigma_VA(j)    = PARSAJ(j,'sigma_VA');
* sigma_X(j,i)   = PARSAJI(j,i);
 sigma_X(j,i)   = 2;
* sigma_XT(j)    = PARSAJ(j,'sigma_XT');
 sigma_KD(j)    = 0.8;
 sigma_LD(j)    = 0.8;
 sigma_M(i)     = 2;
 sigma_VA(j)    = 1.5;
 sigma_X(j,i)   = 2;
 sigma_XT(j)    = 2;

** Elasticity of international demand for exported commodity i
 sigma_XD(i)    = PARSAI(i,'sigma_XD');
```

```
** LES parameters
 frisch(h)       = PARSAAG('frisch',h);
 sigma_y(i,h)    = PARSAAG(i,h);

**VM
 sigma_WC(l)     = -0.1;
 UNO(ES)    = 0.32;
 UNO(EM)    = 0.255;
 UNO(ET)    = 0.125;
 phi_W(l)   = 0.25;

** Intercepts of transfers, direct taxes and savings
*  One can either choose to assign a value to the intercept and calibrate
*  the slopes accordingly, or the other way around. This type of modelling
*  can be useful to take into account known marginal savings or taxation rates
*  or to deal with negative average saving rates in cases where savings are
*  negative for some household groups.
*  When no further information is available, one can simply set the intercepts
*  to zero and calibrate an average rate: this is what we do here.
 sh0O(h)        = PARSAAG('sh0O',h);
 tr0O(h)        = PARSAAG('tr0O',h);
 ttdf0O(f)      = PARSAAG('ttdf0O',f);
 ttdh0O(h)      = PARSAAG('ttdh0O',h);

* Also we need to assign values to some prices
 eO            = 1;
 PEO(i)         = 1;
 PLO(i)         = 1;
 PWMO(i)        = 1;
 WO(l)          = 1;

**VM
 rho_SP(j)      = 0;
 rho_SP(mn)     = 0.4;
 alpha_ED(j1)   =0.5;

* 4 Calibration

** 4.1 Calculation of income and savings related variables and parameters

 YHKO(h)        = SUM[k,lambda_RK(h,k)];
 YHLO(h)        = SUM[l,lambda_WL(h,l)];

 YHL_AGO(h)      = SUM[l,{lambda_WL(h,l)/YHLO(h)}*SUM[lj,LDO(l,'aagris')]];
 YHL_WO(h)       = YHLO(h)-YHL_AGO(h);
display YHLO, YHL_AGO, YHL_WO;

 YHTRO(h)       = SUM[ag,TRO(h,ag)];
 YHO(h)         = YHLO(h)+YHKO(h)+YHTRO(h);
 YDHO(h)        = YHO(h)-TDHO(h)-TRO('gvt',h);
 CTHO(h)        = YDHO(h)-SHO(h)-SUM[agng,TRO(agng,h)];

 YFKO(f)        = SUM[k,lambda_RK(f,k)];
 YFTRO(f)       = SUM[ag,TRO(f,ag)];
 YFO(f)         = YFKO(f)+YFTRO(f);
 YDFO(f)        = YFO(f)-TDFO(f);

 YGKO           = SUM[k,lambda_RK('gvt',k)];
 TDHTO          = SUM[h,TDHO(h)];
 TDFTO          = SUM[f,TDFO(f)];
 TICTO          = SUM[i,TICO(i)];
 TIMTO          = SUM[i,TIMO(i)];
 TIXTO          = SUM[i,TIXO(i)];
 TIWTO          = SUM[(l,j),TIWO(l,j)];
 TIKTO          = SUM[(k,j),TIKO(k,j)];
 TIPTO          = SUM[j,TIPO(j)];
 TPRODNO        = TIKTO+TIWTO+TIPTO;
```

```
 TPRCTSO        = TICTO+TIMTO+TIXTO;
 YGTRO          = SUM[ag,TRO('gvt',ag)];
 YGO            = YGKO+TDHTO+TDFTO+TPRODNO+TPRCTSO+YGTRO;
display YFTRO, YGTRO;
* YROWO          = SUM[i,IMO(i)]+SUM[k,lambda_RK('row',k)]
*                +SUM[ag,TRO('row',ag)];
***vm added +SUM[l,lambda_WL('row',l)];
 YROWO          = SUM[i,IMO(i)]+SUM[k,lambda_RK('row',k)]
               +SUM[ag,TRO('row',ag)]
               +SUM[l,lambda_WL('row',l)];

 CABO           = -SROWO;

 ITO            = SUM[h,SHO(h)]+SUM[f,SFO(f)]+SGO+SROWO;

 lambda_RK(ag,k) = lambda_RK(ag,k)/SUM[j,RKDO(k,j)];
***vm lambda_WL(h,l)  = lambda_WL(h,l)/SUM[j,LDO(l,j)];
***vm
 lambda_WL(ag,l)  = lambda_WL(ag,l)/SUM[j,LDO(l,j)];
 lambda_TR(agng,h)
              = TRO(agng,h)/YDHO(h);
 lambda_TR(ag,f) = TRO(ag,f)/YDFO(f);

 sh1O(h)        = [SHO(h)-sh0O(h)]/YDHO(h);
 tr1O(h)        = [TRO('gvt',h)-tr0O(h)]/YHO(h);

** 4.2 Calibration of investment and government spending shares

 gamma_GVT(i)    = CGO(i)/SUM[ij,CGO(ij)];

*  As in this SAM we do not have private investment separate from public
*  investment, we will assume that the investment shares are the same.

 gamma_INVPRI(i) = INVO(i)/SUM[ij,INVO(ij)];
 gamma_INVPUB(i) = gamma_INVPRI(i);


** 4.3 Calibration of income tax rates
 ttdf1O(f)      = [TDFO(f)-ttdf0O(f)]/YFKO(f);
 ttdh1O(h)      = [TDHO(h)-ttdh0O(h)]/YHO(h);


** 4.4 Calibration of margins, prices and volumes

 PCO(i)         = [DDO(i)+IMO(i)+SUM(ij, tmrg(ij,i))+TICO(i)+TIMO(i)]
               /[DDO(i)+IMO(i)];
 tmrg(i,ij)      = tmrg(i,ij)/PCO(i);
 tmrg_X(i,ij)    = tmrg_X(i,ij)/PCO(i);

 DDO(i)         = DDO(i)/PLO(i);
 IMO(i)         = IMO(i)/(PWMO(i)*eO);

 tmrg(i,ij)      = tmrg(i,ij)/{DDO(ij)+IMO(ij)};

 tticO(i)       = TICO(i)/{(PLO(i)+SUM[ij,PCO(ij)*tmrg(ij,i)])*DDO(i)
                    +(eO*PWMO(i)+SUM[ij,PCO(ij)*tmrg(ij,i)])*IMO(i)
                    +TIMO(i)};

 PDO(i)         = {PLO(i)+SUM[ij,PCO(ij)*tmrg(ij,i)]}*(1+tticO(i));

 ttimO(i)$IMO(i) = TIMO(i)/[eO*PWMO(i)*IMO(i)];

 PMO(i)         = {(1+ttimO(i))*eO*PWMO(i)+SUM[ij,PCO(ij)*tmrg(ij,i)]}
                *(1+tticO(i));
display EXO;
 EXO(j,i)       = EXO(j,i)/PEO(i);
 tmrg_X(ij,i)$EXDO(i)
```

```
              = tmrg_X(ij,i)/SUM[j,EXO(j,i)];
 ttixO(i)$EXDO(i) = TIXO(i)/[EXDO(i)-TIXO(i)];
 PE_FOBO(i)      = (1+ttixO(i))*(PEO(i)+SUM[ij,PCO(ij)*tmrg_X(ij,i)]);
 PWXO(i)         = PE_FOBO(i)/eO;
 EXDO(i)         = EXDO(i)/(PWXO(i)*eO);
display DSO;
 DSO(j,i)        = DSO(j,i)/PLO(i);
 XSO(j,i)        = DSO(j,i)+EXO(j,i);
 PO(j,i)$XSO(j,i)= [PLO(i)*DSO(j,i)+PEO(i)*EXO(j,i)]/XSO(j,i);
 XSTO(j)         = SUM[i,XSO(j,i)];
 PTO(j)          = SUM[i$XSO(j,i),PO(j,i)*XSO(j,i)]/XSTO(j);

 QO(i)           = [PMO(i)*IMO(i)+PDO(i)*DDO(i)]/PCO(i);

 MRGNO(i)        = SUM[ij,tmrg(i,ij)*DDO(ij)]+
                 SUM[ij,tmrg(i,ij)*IMO(ij)]+
                 SUM[(j,ij),tmrg_X(i,ij)*EXO(j,ij)];
display MRGNO, EXO, DSO;

 CO(i,h)         = CO(i,h)/PCO(i);
 CGO(i)          = CGO(i)/PCO(i);
 DIO(i,j)        = DIO(i,j)/PCO(i);
 INVO(i)         = INVO(i)/PCO(i);
 VSTKO(i)        = VSTKO(i)/PCO(i);
 GFCFO           = ITO-SUM[i,PCO(i)*VSTKO(i)];

 CIO(j)          = SUM[i,DIO(i,j)];
 DITO(i)         = SUM[j,DIO(i,j)];
 GO              = SUM[i,PCO(i)*CGO(i)];

 PCIO(j)         = SUM[i,PCO(i)*DIO(i,j)]/CIO(j);

**VM
 PIXCONO         = SUM[i,PCO(i)*SUM[h,CO(i,h)]]/SUM[i,PCO(i)*SUM[h,CO(i,h)]];
 A_WC(l)         = {WO(l)/PIXCONO}/[UNO(l)**(sigma_WC(l))];

 WO(l)           = A_WC(l)*[UNO(l)**(sigma_WC(l))]*PIXCONO;
 WO(fem)         = A_WC(fem)*[UNO(fem)**(sigma_WC(fem))]*PIXCONO*(1-phi_W(fem));

 ttiwO(l,j)$LDO(l,j)
              = TIWO(l,j)/LDO(l,j);
 WTIO(l,j)       = WO(l)*(1+ttiwO(l,j));
* WTIO(fem,j)       = WTIO(fem,j)*(1-phi_W(fem,j));
Display WO, WTIO;

 ttikO(k,j)$RKDO(k,j)
              = TIKO(k,j)/RKDO(k,j);

 LDO(l,j)        = LDO(l,j)/WO(l);
 LDCO(j)         = SUM[l,LDO(l,j)];
**VM
 LDTO(l)         = SUM[j,LDO(l,j)];
 LDT2O(l)        = SUM[j2,LDO(l,j2)];
 LDT3O(l)        = SUM[j3,LDO(l,j3)];
 LSO(l)          = LDTO(l)/(1-UNO(l));
 LUO(l)          = LSO(l)-LDTO(l);
**VM
 LSO(l)          = SUM[j,LDO(l,j)]+UNO(l)*LSO(l);
* LSO(l)         = SUM[j,LDO(l,j)];
 WCO(j)$LDCO(j)  = SUM[l,WTIO(l,j)*LDO(l,j)]/LDCO(j);

** 4.5 Calibration of dynamic parameters
*-----------------------------------------------------------------------------*
*     HERE IT IS ASSUMED THAT THE ONLY INFORMATION AVAILABLE IS              *
*                  WHAT IS USUALLY FOUND IN A SAM.                    *
*                  IF YOU HAVE OTHER INFORMATION,                     *
*        SUCH AS THE AMOUNT OF PUBLIC INVESTMENT EXPENDITURES,              *
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*              OR INVESTMENT BY INDUSTRY OF DESTINATION,                 *
*            THEN YOU ARE URGED TO USE A CALIBRATION PROCEDURE           *
*               THAT TAKES THAT INFORMATION INTO ACCOUNT.                *
*                 SEE APPENDIX F IN THE MODEL DOCUMENT                   *
*------------------------------------------------------------------------------*
*  In case we do not have any information on investment by sector of desti-
*  nation or initial capital stock or the rental rate of capital, the dynamic
*  parameters must be calibrated on the basis of assumptions.
*  Here we develop a calibration procedure based on two key assumptions.
*   1- Tobin's q, RO(k,j)/UO(k,j), is the same for all types of capital and all
*     sectors, including the public sector. This translates as
*     RO(k,j) = alpha*UO(k,j) = alpha*PK_PRIO*(delta(k,j)+IRO)
*     where alpha is an unknown constant.
*   2-  The economy depicted in the SAM is following a balanced growth path,
*      that is, a path where all variables except prices grow at the constant
*      population growth rate. This implies:
*      INDO(k,j) = KDO(k,j)*(n1+delta(k,j))

*  First let's assume that the depreciation rate is known.

 delta(k,j)     = PARSAKJ1(k,j);


*  The values assigned PKPRIO and PKPUBO are arbitrary. Any proportional change
*  in PKPRIO results in an equal change in UO(k,bus) and RO(k,bus), and in an
*  inversely proportional change in KDO(k,bus) and INDO(k,bus); the same is true
*  of PKPUBO relative to UO(k,pub), RO(k,pub), KDO(k,pub) and INDO(k,pub).
*  Assigning values to PKPRIO and PKPUBO merely defines the units of measurement
*  of the capital stocks. So we set both of them equal to one:

 PK_PRIO        = 1;
 PK_PUBO        = 1;

*  Using model equations 100 and 101 below, we can calibrate the scale
*  parameters of these functions:

 A_K_PRI        = 1/PK_PRIO*{PROD[i$gamma_INVPRI(i),(PCO(i)/gamma_INVPRI(i))
             **gamma_INVPRI(i)]};
 A_K_PUB        = 1/PK_PUBO*{PROD[i$gamma_INVPUB(i),(PCO(i)/gamma_INVPUB(i))
             **gamma_INVPUB(i)]};

*  Using these depreciation rates, the price of capital, and the interest rate,
*  we can calibrate the user cost of capital

 UO(k,bus)      = PK_PRIO*(IRO+delta(k,bus));
 UO(k,pub)      = PK_PUBO*(IRO+delta(k,pub));

*  We can also calibrate alpha in our first assumption as being:

 alpha          = SUM[(k,j),RKDO(k,j)*{(n1+delta(k,j))
                 /(delta(k,j)+IRO)}
                 /(ITO-SUM[i,PCO(i)*VSTKO(i)])];

* From our first assumption, we can then calibrate RO:

 RO(k,j)        = alpha*UO(k,j);

* Then from the value in our SAM we calibrate KDO:

 KDO(k,j)       = RKDO(k,j)/RO(k,j);

* And finally our second assumption allows us to calibrate INDO:

 INDO(k,j)      = KDO(k,j)*(n1+delta(k,j));

**vm
 LSTO(j1)       = SUM(l,LDO(l,j1));
```

```
 LSSKO(j1)       = SUM(skl,LDO(skl,j1));
 LSUSLO(j1)      = LSTO(j1)-LSSKO(j1);

* LSUO(usl)       = SUM(j,LDO(usl,j));
* LSSO(skl)       = SUM(j,LDO(skl,j));
* LSUO(usl)       = SUM(usl,LDCO(j));
* LSSO(skl)       = SUM(skl,LDCO(j));
display lsto, lssko, lsuslo, lso, ldto, luo, ldco;

*  We can calibrate private and public investment.

 IT_PUBO        = SUM[(k,pub),INDO(k,pub)]*PK_PUBO;
 IT_PRIO        = ITO-IT_PUBO-SUM[i,VSTKO(i)*PCO(i)];
 INV_PUBO(i)    = gamma_INVPUB(i)*IT_PUBO/PCO(i);
 INV_PRIO(i)    = gamma_INVPRI(i)*IT_PRIO/PCO(i);

*  Finally, we can calibrate the parameter in the investment demand function

 phi(k,bus)$KDO(k,bus)
            = INDO(k,bus)/KDO(k,bus)*[UO(k,bus)/RO(k,bus)]**sigma_INV(k,bus);
**VM
 sigmao_SP(j)    =[IT_PUBO/IT_PUBO]**rho_SP(j);
 omegao_SP(j)    =prod(time,sigmao_SP(j));

 sigmao_ED(j1)    =[IT_PUBO/IT_PUBO]**alpha_ED(j1);

** 4.6 Calibration of other prices and volumes

 RTIO(k,j)       = RO(k,j)*(1+ttikO(k,j));
 KDCO(j)         = SUM[k,KDO(k,j)];
 KSO(k)          = SUM[j,KDO(k,j)];
 RCO(j)$KDCO(j)  = SUM[k,RTIO(k,j)*KDO(k,j)]/KDCO(j);

 VAO(j)          = LDCO(j)+KDCO(j);
 PVAO(j)         = [WCO(j)*LDCO(j)+RCO(j)*KDCO(j)]/VAO(j);

 ttipO(j)        = TIPO(j)/{PVAO(j)*VAO(j)+SUM[i,PCO(i)*DIO(i,j)]};
 PPO(j)          = PTO(j)/(1+ttipO(j));

* PIXGDPO is tautologically equal to 1, based on its formula
* PIXGDPO        = {SUM[j,{(PVAO(j)*VAO(j)+TIPO(j))/VAO(j)}*VAO(j)]
*                /SUM[j,{(PVAO(j)*VAO(j)+TIPO(j))/VAO(j)}*VAO(j)]
*                *SUM[j,{(PVAO(j)*VAO(j)+TIPO(j))/VAO(j)}*VAO(j)]
*                /SUM[j,{(PVAO(j)*VAO(j)+TIPO(j))/VAO(j)}*VAO(j)]}**0.5;
 PIXGDPO        = 1;

* PIXCONO is tautologically equal to 1, based on its formula
* PIXCONO        = SUM[i,PCO(i)*SUM[h,CO(i,h)]]/SUM[i,PCO(i)*SUM[h,CO(i,h)]];
 PIXCONO        = 1;

* PIXGVTO is tautologically equal to 1, based on its formula
* PIXGVTO        = PROD[i$gamma_GVT(i),(PCO(i)/PCO(i))**gamma_GVT(i)];
 PIXGVTO        = 1;

* PIXINV_PRIO is tautologically equal to 1, based on its formula
* PIXINV_PRIO    = PROD[i$gamma_INVPRI(i),(PCO(i)/PCO(i))**gamma_INVPRI(i)];
 PIXINV_PRIO    = 1;

* PIXINV_PUBO is tautologically equal to 1, based on its formula
* PIXINV_PUBO    = PROD[i$gamma_INVPUB(i),(PCO(i)/PCO(i))**gamma_INVPUB(i)];
 PIXINV_PUBO    = 1;

** 4.7 Calibration of indexed transfers and parameters

 TRO(agd,'row')  = TRO(agd,'row')/PIXCONO**eta;
 TRO(agng,'gvt') = TRO(agng,'gvt')/PIXCONO**eta;
 ttdf0O(f)       = ttdf0O(f)/PIXCONO**eta;
```

```
 ttdh0O(h)      = ttdh0O(h)/PIXCONO**eta;
 sh0O(h)        = sh0O(h)/PIXCONO**eta;
 tr0O(h)        = tr0O(h)/PIXCONO**eta;
display tro;


*  4.8 Calibration of function parameters

**  4.8.1 Leontief functions
 io(j)          = CIO(j)/XSTO(j);
 v(j)           = VAO(j)/XSTO(j);
 aij(i,j)       = DIO(i,j)/CIO(j);

**  4.8.2 Calibration of CET parameters
*   4.8.2.1 CET between commodities
 rho_XT(j)      = (1+sigma_XT(j))/sigma_XT(j);
 beta_XT(j,i)${XSO(j,i) and (SUM[ij,XSO(j,ij)] gt 0)}
              = PO(j,i)*XSO(j,i)**(1-rho_XT(j))/
                SUM[ij$XSO(j,ij),PO(j,ij)*XSO(j,ij)**(1-rho_XT(j))];
 B_XT(j)        = XSTO(j)
               /SUM[i$XSO(j,i),beta_XT(j,i)*XSO(j,i)**rho_XT(j)
               ]**(1/rho_XT(j));

**   4.8.2.2 CET between exports and local production
 rho_X(j,i)$[EXO(j,i) and DSO(j,i)]
              = (1+sigma_X(j,i))/sigma_X(j,i);
 rho_X(j,i)$[(not EXO(j,i)) or (not DSO(j,i))]
              = 1;
 beta_X(j,i)$XSO(j,i)
              = PEO(i)*EXO(j,i)**(1-rho_X(j,i))/
               [PEO(i)*EXO(j,i)**(1-rho_X(j,i))
               +PLO(i)*DSO(j,i)**(1-rho_X(j,i))];
 B_X(j,i)$XSO(j,i)
              = XSO(j,i)/
              [beta_X(j,i)*EXO(j,i)**rho_X(j,i)+
              (1-beta_X(j,i))*DSO(j,i)**rho_X(j,i)]
              **(1/rho_X(j,i));

**  4.8.3 Calibration of CES parameters
**   4.8.3.1 Composite good
 rho_M(i)$[IMO(i) and DDO(i)]
              = (1-sigma_M(i))/sigma_M(i);
 rho_M(i)$[(not IMO(i)) or (not DDO(i))]
              = -1;
 beta_M(i)$QO(i) = PMO(i)*IMO(i)**(rho_M(i)+1)/
               [PMO(i)*IMO(i)**(rho_M(i)+1)+
                PDO(i)*DDO(i)**(rho_M(i)+1)];
 B_M(i)$QO(i)    = QO(i)
                /[beta_M(i)*IMO(i)**(-rho_M(i))+
                (1-beta_M(i))*DDO(i)**(-rho_M(i))
                ]**(-1/rho_M(i));

**   4.8.3.2 Composite capital
 rho_KD(j)$KDCO(j)
              = (1-sigma_KD(j))/sigma_KD(j);
 beta_KD(k,j)$KDO(k,j)
              = RTIO(k,j)*KDO(k,j)**(rho_KD(j)+1)/
                SUM[kj,RTIO(kj,j)*KDO(kj,j)**(rho_KD(j)+1)];
 B_KD(j)$KDCO(j) = KDCO(j)
               /SUM[k$KDO(k,j),beta_KD(k,j)*KDO(k,j)**(-rho_KD(j))
               ]**(-1/rho_KD(j));

**   4.8.3.3 Composite labor
 rho_LD(j)      = (1-sigma_LD(j))/sigma_LD(j);
 beta_LD(l,j)$LDO(l,j)
              = WTIO(l,j)*LDO(l,j)**(rho_LD(j)+1)/
                SUM[lj,WTIO(lj,j)*LDO(lj,j)**(rho_LD(j)+1)];
```

```
B_LD(j)$LDCO(j) = LDCO(j)/SUM[l,beta_LD(l,j)$LDO(l,j)*LDO(l,j)**(-rho_LD(j))]
                    **(-1/rho_LD(j));

**   4.8.3.4 Value added
 rho_VA(j)$[KDCO(j) and LDCO(j)]
            = (1-sigma_VA(j))/sigma_VA(j);
 rho_VA(j)$[(not KDCO(j)) or (not LDCO(j))]
            = -1;
 beta_VA(j)      = WCO(j)*LDCO(j)**(rho_VA(j)+1)/
             [WCO(j)*LDCO(j)**(rho_VA(j)+1)+
              RCO(j)*KDCO(j)**(rho_VA(j)+1)];
 B_VA(j)        = VAO(j)
              /[beta_VA(j)*LDCO(j)**(-rho_VA(j))+
              (1-beta_VA(j))*KDCO(j)**(-rho_VA(j))
              ]**(-1/rho_VA(j));

**  4.8.4 Calibration of LES parameters
*   As the assigned values of income elasticities may not result in
*   consumption shares that add up to 1, this first step
*   adjusts the elasticities proportionally

 sigma_Y(i,h)    = sigma_Y(i,h)*CTHO(h)/SUM[ij,sigma_Y(ij,h)*PCO(ij)*CO(ij,h)];
 gamma_LES(i,h)  = PCO(i)*CO(i,h)*sigma_Y(i,h)/CTHO(h);
 CMINO(i,h)      = CO(i,h)+gamma_LES(i,h)*[CTHO(h)/
             (PCO(i)*frisch(h))];

** 4.9 Calibration of gross domestic products

 GDP_BPO        = SUM[j,PVAO(j)*VAO(j)]+TIPTO;
 GDP_MPO        = GDP_BPO+TPRCTSO;
 GDP_IBO        = SUM[(l,j),WO(l)*LDO(l,j)]+SUM[(k,j),RO(k,j)*KDO(k,j)]
              +TPRODNO+TPRCTSO;
 GDP_FDO        = SUM{i,PCO(i)*(SUM[h,CO(i,h)]+CGO(i)+INVO(i)+VSTKO(i))}
             +SUM[i,PE_FOBO(i)*EXDO(i)]-SUM[i,PWMO(i)*eO*IMO(i)];

** 4.10 Calibration of real (volume) variables computed from price indices
 CTH_REALO(h)    = CTHO(h)/PIXCONO;
 G_REALO        = GO/PIXGVTO;
 GDP_BP_REALO    = GDP_BPO/PIXGDPO;
 GDP_MP_REALO    = GDP_MPO/PIXCONO;
 GFCF_PRI_REALO  = IT_PRIO/PIXINV_PRIO;
 GFCF_PUB_REALO  = IT_PUBO/PIXINV_PUBO;

* 5 Model

** 5.1 Variable definition
VARIABLES

**  5.1.1 Volume variables
 C(i,h,time)        Consumption of commodity i by type h households
 CG(i,time)         Public final consumption of commodity i
 CI(j,time)         Total intermediate consumption of industry j
 CMIN(i,h,time)      Minimum consumption of commodity i by type h households
 CTH_REAL(h,time)    Real consumption budget of type h households
 DD(i,time)         Domestic demand for commodity i produced locally
 DI(i,j,time)       Intermediate consumption of commodity i by industry j
 DIT(i,time)        Total intermediate demand for commodity i
 DS(j,i,time)       Supply of commodity i by industry j to the domestic market
 EX(j,i,time)       Quantity of product i exported by industry j
 EXD(i,time)        World demand for exports of product i
 G_REAL(time)       Real current government expenditures on goods and services
 GDP_BP_REAL(time)   Real GDP at basic prices
 GDP_MP_REAL(time)   Real GDP at market prices
 GFCF_PRI_REAL(time) Real private gross fixed capital formation
 GFCF_PUB_REAL(time) Real public gross fixed capital formation
 IM(i,time)         Quantity of product i imported
 IND(k,j,time)      Investment in capital k for industry j
```

INV(i,time) Total final demand of commodity i for investment purposes (GFCF)
INV_PRI(i,time) Final demand of commodity i for private investment purposes
INV_PUB(i,time) Final demand of commodity i for public investment purposes
KD(k,j,time) Demand for type k capital by industry j
KDC(j,time) Industry j demand for composite capital
KS(k,time) Supply of type k capital
LD(l,j,time) Demand for type l labor by industry j
LDC(j,time) Industry j demand for composite labor
LS(l,time) Supply of type l labor
*vm
LSSK(j1,time) Supply of agricultural skilled labor
LSUSL(j1,time) Supply of agricultural unskilled labor
*check LSUSL2(j1,time) Supply of agricultural unskilled labor
LST(j1,time) Total supply of labour to agricultural sectors
* LSTA(l,t) Total supply of labour to agricultural sectors
MRGN(i,time) Demand for commodity i as a trade or transport margin
Q(i,time) Quantity demanded of composite commodity i
VA(j,time) Value added of industry j
VSTK(i,time) Inventory change of commodity i
XS(j,i,time) Industry j production of commodity i
XST(j,time) Total aggregate output of industry j

** 5.1.2 Price variables
e(time) Exchange rate (price of foreign currency in local currency)
IR(time) Interest rate
P(j,i,time) Basic price of industry j's production of commodity i
PC(i,time) Purchaser price of composite comodity i (including all taxes and margins)
PCI(j,time) Intermediate consumption price index of industry j
PD(i,time) Price of local product i sold on the domestic market (including all taxes and margins)
PE(i,time) Price received for exported commodity x (excluding export taxes)
PE_FOB(i,time) FOB price of exported commodity x (in local currency)
PIXCON(time) Consumer price index
PIXGDP(time) GDP deflator
PIXGVT(time) Public expenditures price index
PIXINV_PRI(time) Private investment price index
PIXINV_PUB(time) Public investment price index
PK_PRI(time) Price of new private capital
PK_PUB(time) Price of new public capital
PL(i,time) Price of local product i (excluding all taxes on products)
PM(i,time) Price of imported product i (including all taxes and tariffs)
PP(j,time) Industry j unit cost including taxes directly related to the use of capital and labor but excluding other taxes on production
PT(j,time) Basic price of industry j's output
PVA(j,time) Price of industry j value added (including taxes on production directly related to the use of capital and labor)
PWM(i,time) World price of imported product i (expressed in foreign currency)
PWX(i,time) World price of exported product i (expressed in foreign currency)
R(k,j,time) Rental rate of type k capital in industry j
RC(j,time) Rental rate of industry j composite capital
RTI(k,j,time) Rental rate paid by industry j for type k capital including capital taxes
U(k,j,time) User cost of type k capital in industry j
W(l,time) Wage rate of type l labor
WC(j,time) Wage rate of industry j composite labor
WTI(l,j,time) Wage rate paid by industry j for type l labor including payroll taxes

* 5.1.3 Nominal (value) variables
CAB(time) Current account balance
CTH(h,time) Consumption budget of type h households
G(time) Current government expenditures on goods and services
GDP_BP(time) GDP at basic prices
GDP_FD(time) GDP at purchasers' prices from the perspective of final demand
GDP_IB(time) GDP at market prices (income-based)
GDP_MP(time) GDP at market prices
GFCF(time) Gross fixed capital formation
IT(time) Total investment expenditures
IT_PRI(time) Total private investment expenditures
IT_PUB(time) Total public investment expenditures
SF(f,time) Savings of type f businesses
SG(time) Government savings

SH(h,time) Savings of type h households
SROW(time) Rest-of-the-world savings
TDF(f,time) Income taxes of type f businesses
TDFT(time) Total government revenue from business income taxes
TDH(h,time) Income taxes of type h households
TDHT(time) Total government revenue from household income taxes
TIC(i,time) Government revenue from indirect taxes on product i
TICT(time) Total government receipts of indirect taxes on commodities
TIK(k,j,time) Government revenue from taxes on type k capital used by industry j
TIKT(time) Total government revenue from from taxes on capital
TIM(i,time) Government revenue from import duties on product i
TIMT(time) Total government revenue from import duties
TIP(j,time) Government revenue from taxes on industry j production (excluding taxes directly related to the use of capital and labor)
TIPT(time) Total government revenue from production taxes (excluding taxes directly related to the use of capital and labor)
TIW(l,j,time) Government revenue from payroll taxes on type l labor in industry j
TIWT(time) Total government revenue from payroll taxes
TIX(i,time) Government revenue from export taxes on product i
TIXT(time) Total government revenue from export taxes
TPRCTS(time) Total government revenue from taxes on products and imports
TPRODN(time) Total government revenue from other taxes on production
TR(ag,agj,time) Transfers from agent agj to agent ag
YDF(f,time) Disposable income of type f businesses
YDH(h,time) Disposable income of type h households
YF(f,time) Total income of type f businesses
YFK(f,time) Capital income of type f businesses
YFTR(f,time) Transfer income of type f businesses
YG(time) Total government income
YGK(time) Government capital income
YGTR(time) Government transfer income
YH(h,time) Total income of type h households
YHK(h,time) Capital income of type h households
YHL(h,time) Labor income of type h households
YHL_W(h,time) Labor (wage) income of type h households
YHL_AG(h,time) Labor (farming) income of type h households
YHTR(h,time) Transfer income of type h households
YROW(time) Rest-of-the-world income

** 5.1.4 Rates and intercepts
sh0(h,time) Intercept (type h household savings)
sh1(h,time) Slope (type h household savings)
tr0(h,time) Intercept (transfers by type h households to governmentime)
tr1(h,time) Marginal rate of transfers by type h households to government
ttdf0(f,time) Intercept (income taxes of type f businesses)
ttdf1(f,time) Marginal income tax rate of type f businesses
ttdh0(h,time) Intercept (income taxes of type h households)
ttdh1(h,time) Marginal income tax rate of type h households
ttic(i,time) Tax rate on commodity i
ttik(k,j,time) Tax rate on type k capital used in industry j
ttim(i,time) Rate of taxes and duties on imports of commodity m
ttip(j,time) Tax rate on the production of industry j
ttiw(l,j,time) Tax rate on type l worker compensation in industry j
ttix(i,time) Export tax rate on exported commodity x
**VM
UN(l,time) Unemployment rate for formal labour
LDT(l,time) Total demand for type l labour
*vm
LDT2(l,time) Total demand for type l informal labour
LDT3(l,time) Total demand for type l formal labour
LU(l,time) Number of type l unemployed labor
sigma_SP(j,time) Externality effect of infrastructure in in industry manufacturing mn
sigma_ED(j1,time) Growth in skilled agric labour supply
* omega_SP(j,time) Cumulative Sectoral productivity effect
TFP(time) Total factor productivity
** 5.1.5 Other variables
LEON(time) Excess supply on the last market
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** 5.2 Equation definition

EQUATIONS

 EQ1(j,time)       Value added demand in industry j (Leontief)
 EQ2(j,time)       Total intermediate consumption demand in industry j (Leontief)
 EQ3(j,time)       CES between of composite labor and capital
*vm
* EQ3b1(j,time)     Cumulative Sectoral productivity effect
 EQ4(j,time)       Relative demand for composite labor and capital by industry j(CES)
 EQ5(j,time)       CES between labor categories
 EQ6(l,j,time)     Demand for type l labor by industry j (CES)
**VM
**vm EQ6a(l,time)      Unemployment rate for type l labour(LES)
 EQ6a(mal,time)      Unemployment rate for type l labour(LES)
 EQ6b(fem,time)      Unemployment rate for type l labour(LES)
 EQ7(j,time)       CES between capital categories
 EQ8(k,j,time)     Demand for type k capital by industry j (CES)
 EQ9(i,j,time)     Intermediate consumption of commodity i by industry j (Leontief)
 EQ10(h,time)      Total income of type h households
 EQ11(h,time)      Labor income of type h households
 EQ11a(h,time)     Labor (wage) income of type h households
 EQ11b(h,time)     Labor (self employed) income of type h households
 EQ12(h,time)      Capital income of type h households
 EQ13(h,time)      Transfer income of type h households
 EQ14(h,time)      Disposable income of type h households
 EQ15(h,time)      Consumption budget of type h households
 EQ16(h,time)      Savings of type h households
 EQ17(f,time)      Total income of type f businesses
 EQ18(f,time)      Capital income of type f businesses
 EQ19(f,time)      Transfer income of type f businesses
 EQ20(f,time)      Disposable income of type f businesses
 EQ21(f,time)      Savings of type f businesses
 EQ22(time)        Total government income
 EQ23(time)        Government capital income
 EQ24(time)        Total government revenue from household income taxes
 EQ25(time)        Total government revenue from business income taxes
 EQ26(time)        Total government revenue from other taxes on production
 EQ27(time)        Total government receipts of indirect taxes on wages
 EQ28(time)        Total government receipts of indirect taxes on capital
 EQ29(time)        Total government revenue from production taxes
 EQ30(time)        Total government revenue from taxes on products and imports
 EQ31(time)        Total government receipts of indirect taxes on commodities
 EQ32(time)        Total government revenue from import duties
 EQ33(time)        Total government revenue from export taxes
 EQ34(time)        Government transfer income
 EQ35(h,time)      Income taxes of type h households
 EQ36(f,time)      Income taxes of type f businesses
 EQ37(l,j,time)    Government revenue from payroll taxes on type l labor in industry j
 EQ38(k,j,time)    Government revenue from taxes on type k capital used by industry j
 EQ39(j,time)      Government revenue from taxes on industry j production
 EQ40(i,time)      Government revenue from indirect taxes on product i
 EQ41(i,time)      Government revenue from import duties on product i
 EQ42(i,time)      Government revenue from export taxes on product i
 EQ43(time)        Government savings
 EQ44(time)        Rest-of-the-world income
 EQ45(time)        Rest-of-the-world savings
 EQ46(time)        Equivalence between current account balance and ROW savings
 EQ47(agng,h,time)  Transfers from household h to agent agng
 EQ48(h,time)      Transfers from household h to government
 EQ49(ag,f,time)   Transfers from type f businesses to agent ag
 EQ50(ag,time)   Public transfers
 EQ51(agd,time)    Transfers from abroad
 EQ52(i,h,time)    Consumption of commodity i by type h households
 EQ53(time)        Gross fixed capital formation
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EQ54(i,time) Final demand of commodity i for private investment purposes
EQ55(i,time) Final demand of commodity i for public investment purposes
EQ56(i,time) Total final demand of commodity i for investment purposes
EQ57(i,time) Public final consumption of commodity i
EQ58(i,time) Total intermediate demand for commodity i
EQ59(i,time) Demand for commodity i as a trade or transport margin
EQ60(j,time) CET between different commodities produced by industry j
EQ61(j,i,time) Industry j production of commodity i (CET)
EQ62(j,i,time) CET between exports and local commodity
EQ63(j,i,time) Relative supply of exports and local commodity (CET)
EQ64(i,time) World demand for exports of product i
EQ65(i,time) CES between imports and local production
EQ66(i,time) Demand for imports (CES)
EQ67(j,time) Industry j unit cost
EQ68(j,time) Basic price of industry j's production of commodity i
EQ69(j,time) Intermediate consumption price index of industry j
EQ70(j,time) Price of industry j value added
* EQ71(j,time) Wage rate of industry j composite labor
EQ72(l,j,time) Wage rate paid by industry j for type l labor including payroll taxes
* EQ73(j,time) Rental rate of industry j composite capital
EQ74(k,j,time) Rental rate paid by industry j for type k capital including capital taxes
* EQ75(j,i,time) Total producer price
EQ75a(j,i,time) Total producer price is equal to P if there is only one product
EQ76(j,i,time) Basic price of industry j's production of commodity i
EQ77(i,time) Price received for exported commodity x (excluding export taxes)
EQ78(i,time) Price of local product i sold on the domestic market (including all taxes and margins)
EQ79(i,time) Price of imported product i (including all taxes and tariffs)
EQ80(i,time) Purchaser price of composite comodity i
EQ81(time) GDP deflator (Fischer index)
EQ82(time) Consumer price index (Laspeyres)
EQ83(time) Private investment price index
EQ84(time) Public investment price index
EQ85(time) Public expenditures price index
EQ86(i1,time) Domestic absorbtion
EQ87(l,time) Labor supply equals labor demand
**VM
EQ87a(l,time) Number of type l labor unemployed
EQ87a1(l,time) Number of type l labor unemployed
EQ87b(l,time) Number of type l labor unemployed
EQ87c(l,time) Type l labor unemployment rate
EQ88(k,time) Capital supply equals capital demand
EQ89(time) Total investment equals total savings
EQ90(time) Private investment equals total investment less public investment
EQ91(i,time) Supply of domestic production equals demand
EQ92(i,time) International demand for exports equals supply
EQ93(time) GDP at basic prices
EQ94(time) GDP at market prices
EQ95(time) GDP at market prices (income-based)
EQ96(time) GDP at purchasers' prices from the perspective of final demand
EQ97(h,time) Real consumption budget of type h households
EQ98(time) Real current government expenditures on goods and services
EQ99(time) Real GDP at basic prices
EQ100(time) Real GDP at market prices
EQ101(time) Real private gross fixed capital formation
EQ102(time) Real public gross fixed capital formation
* EQ103(k,j,time) Capital growth
EQ104(time) Total public investment
EQ105(time) Equilibrium on the private investment market
EQ106(time) Aggregate private price of capital
EQ107(time) Aggregate public price of capital
EQ108(k,bus,time) Investment demand by private industry
**vm
EQ108a(j1,time) Supply of agric labour
EQ108b(j1,time) Supply of unskilled agric labour
* EQ108c(j1,time) Growth of skilled agric labour supply
EQ108d(j1,time) Equilibrium on the agric labour supply market
EQ109a(k,bus,time) User cost of capital (private sectors)

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 EQ109b(k,pub,time) User cost of capital (public sectors)

 WALRAS(time)      Walras law verification
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*  5.3 Equations

*   5.3.1 Production

 EQ1(j,t)..     VA(j,t) =e= v(j)*XST(j,t);

 EQ2(j,t)..     CI(j,t) =e= io(j)*XST(j,t);

 EQ3(j,t)..     VA(j,t) =e= TFP(t)*B_VA(j)*{
                  [beta_VA(j)*LDC(j,t)**(-rho_VA(j))]$LDCO(j)
                 +[(1-beta_VA(j))*KDC(j,t)**(-rho_VA(j))]$KDCO(j)
                           }**(-1/rho_VA(j));
*vm
* EQ3b1(j,t).. omega_SP(j,t) =e= prod(tt$(ord(tt) le ord(t)),sigma_SP(j,t));

 EQ4(j,t)$[LDCO(j) and KDCO(j)]..
            LDC(j,t) =e= {[beta_VA(j)/(1-beta_VA(j))]*[RC(j,t)/WC(j,t)]}
                     **sigma_VA(j)*KDC(j,t);

 EQ5(j,t)$LDCO(j)..
            LDC(j,t) =e= B_LD(j)*SUM[l$LDO(l,j),beta_LD(l,j)*LD(l,j,t)
                     **(-rho_LD(j))]**(-1/rho_LD(j));

 EQ6(l,j,t)$LDO(l,j)..
            LD(l,j,t) =e= [beta_LD(l,j)*WC(j,t)/WTI(l,j,t)]**sigma_LD(j)
                     *B_LD(j)**(sigma_LD(j)-1)*LDC(j,t);
**VM
**vm EQ6a(l,t)..    W(l,t)/PIXCON(t)  =e= A_WC(l)*[UN(l,t)**(sigma_WC(l))];
 EQ6a(mal,t)..    W(mal,t)/PIXCON(t)  =e= A_WC(mal)*[UN(mal,t)**(sigma_WC(mal))];
 EQ6b(fem,t)..    W(fem,t)/PIXCON(t)  =e= A_WC(fem)*(1-phi_W(fem))*[UN(fem,t)**(sigma_WC(fem))];

 EQ7(j,t)$KDCO(j)..
            KDC(j,t) =e= B_KD(j)*SUM[k$KDO(k,j),beta_KD(k,j)*KD(k,j,t)
                    **(-rho_KD(j))]**(-1/rho_KD(j));

 EQ8(k,j,t)$KDO(k,j)..
            KD(k,j,t) =e= [beta_KD(k,j)*RC(j,t)/RTI(k,j,t)]**sigma_KD(j)
                     *B_KD(j)**(sigma_KD(j)-1)*KDC(j,t);

 EQ9(i,j,t)..    DI(i,j,t) =e= aij(i,j)*CI(j,t);

**  5.3.2 Income and savings
**   5.3.2.1 Households

 EQ10(h,t)..     YH(h,t) =e= YHL(h,t)+YHK(h,t)+YHTR(h,t);

 EQ11(h,t)..     YHL(h,t) =e= SUM{l,lambda_WL(h,l)*W(l,t)
                    *SUM[j$LDO(l,j),LD(l,j,t)]};

 EQ11a(h,t)..    YHL_AG(h,t) =e= SUM[l,{lambda_WLA(h,l)/YHL(h,t)}*W(l,t)
                        *SUM[lj$LDO(l,'aagris'),LD(l,'aagris',t)]];
*                         *SUM[infoj$LDO(info,'aagris'),LD(info,'aagris',t)]];
*                         SUM[l,{lambda_WL(h,l)/YHLO(h)}*SUM[lj,LDO(l,'aagris')]];
*                         SUM[l,{lambda_WL(h,l)/YHLO(h)}*SUM[lj,LDO(l,'aagris')]];

 EQ11b(h,t)..    YHL_W(h,t) =e= YHL(h,t)-YHL_AG(h,t);

 EQ12(h,t)..     YHK(h,t) =e= SUM{k,lambda_RK(h,k)*SUM[j$KDO(k,j),
                    R(k,j,t)*KD(k,j,t)]};

 EQ13(h,t)..     YHTR(h,t) =e= SUM[ag,TR(h,ag,t)];
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EQ14(h,t)..    YDH(h,t) =e= YH(h,t)-TDH(h,t)-TR('gvt',h,t);

EQ15(h,t)..    CTH(h,t) =e= YDH(h,t)-SH(h,t)-SUM[agng,TR(agng,h,t)];

EQ16(h,t)..    SH(h,t) =e= PIXCON(t)**eta*sh0(h,t)+sh1(h,t)*YDH(h,t);

**   5.3.2.2 Firms

EQ17(f,t)..    YF(f,t) =e= YFK(f,t)+YFTR(f,t);

EQ18(f,t)..    YFK(f,t) =e= SUM{k,lambda_RK(f,k)*SUM[j$KDO(k,j),
                   R(k,j,t)*KD(k,j,t)]};

EQ19(f,t)..    YFTR(f,t) =e= SUM[ag,TR(f,ag,t)];

EQ20(f,t)..    YDF(f,t) =e= YF(f,t)-TDF(f,t);

EQ21(f,t)..    SF(f,t) =e= YDF(f,t)-SUM[ag,TR(ag,f,t)];

**   5.3.2.3 Government

EQ22(t)..      YG(t) =e= YGK(t)+TDHT(t)+TDFT(t)+TPRODN(t)+TPRCTS(t)+YGTR(t);

EQ23(t)..      YGK(t) =e= SUM{k,lambda_RK('gvt',k)*SUM[j$KDO(k,j),
                  R(k,j,t)*KD(k,j,t)]};

EQ24(t)..      TDHT(t) =e= SUM[h,TDH(h,t)];

EQ25(t)..      TDFT(t) =e= SUM[f,TDF(f,t)];

EQ26(t)..      TPRODN(t) =e= TIWT(t)+TIKT(t)+TIPT(t);

EQ27(t)..      TIWT(t) =e= SUM[(l,j)$LDO(l,j),TIW(l,j,t)];

EQ28(t)..      TIKT(t) =e= SUM[(k,j)$KDO(k,j),TIK(k,j,t)];

EQ29(t)..      TIPT(t) =e= SUM[j,TIP(j,t)];

EQ30(t)..      TPRCTS(t) =e= TICT(t)+TIMT(t)+TIXT(t);

EQ31(t)..      TICT(t) =e= SUM[i,TIC(i,t)];

EQ32(t)..      TIMT(t) =e= SUM[i$IMO(i),TIM(i,t)];

EQ33(t)..      TIXT(t) =e= SUM[i$EXDO(i),TIX(i,t)];

* EQ34(t)..      YGTR(t) =e= SUM[agng,TR('gvt',agng,t)];
 EQ34(t)..      YGTR(t) =e= SUM[ag,TR('gvt',ag,t)];
*                     +SUM[gv,TR('gvt',gv,t)];
* EQ34(t)..      YGTR(t) =e= SUM[ag,TR('gvt',ag,t)];

EQ35(h,t)..    TDH(h,t) =e= PIXCON(t)**eta*ttdh0(h,t)+ttdh1(h,t)*YH(h,t);

EQ36(f,t)..    TDF(f,t) =e= PIXCON(t)**eta*ttdf0(f,t)+ttdf1(f,t)*YFK(f,t);

EQ37(l,j,t)$LDO(l,j)..
            TIW(l,j,t) =e= ttiw(l,j,t)*W(l,t)*LD(l,j,t);

EQ38(k,j,t)$KDO(k,j)..
            TIK(k,j,t) =e= ttik(k,j,t)*R(k,j,t)*KD(k,j,t);

EQ39(j,t)..    TIP(j,t) =e= ttip(j,t)*PP(j,t)*XST(j,t);

EQ40(i,t)..    TIC(i,t) =e= ttic(i,t)*{
                 [(PL(i,t)+SUM[ij,PC(ij,t)*tmrg(ij,i)])*DD(i,t)]$DDO(i)
                +[((1+ttim(i,t))*PWM(i,t)*e(t)
                   +SUM[ij,PC(ij,t)*tmrg(ij,i)])*IM(i,t)]$IMO(i)};
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```
EQ41(i,t)$IMO(i)..
            TIM(i,t) =e= ttim(i,t)*PWM(i,t)*e(t)*IM(i,t);

EQ42(i,t)$EXDO(i)..
            TIX(i,t) =e= ttix(i,t)*{PE(i,t)+SUM[ij,PC(ij,t)*tmrg_X(ij,i)]}
                      *EXD(i,t);

* EQ43(t)..      SG(t) =e= YG(t)-SUM[agng,TR(agng,'gvt',t)]-G(t);
EQ43(t)..      SG(t) =e= YG(t)-SUM[ag,TR(ag,'gvt',t)]-G(t);
**   5.3.2.4 Rest of the world

* EQ44(t)..      YROW(t) =e= e(t)*SUM[i$IMO(i),PWM(i,t)*IM(i,t)]
*                  +SUM{k,lambda_RK('row',k)*SUM[j$KDO(k,j),
*                   R(k,j,t)*KD(k,j,t)]}+SUM[agd,TR('row',agd,t)];
*vm
EQ44(t)..      YROW(t) =e= e(t)*SUM[i$IMO(i),PWM(i,t)*IM(i,t)]
                +SUM{k,lambda_RK('row',k)*SUM[j$KDO(k,j),R(k,j,t)*KD(k,j,t)]}
                +SUM[agd,TR('row',agd,t)]
                +SUM[l,lambda_WL('row',l)*W(l,t)*SUM(j$LDO(l,j),LD(l,j,t))];

EQ45(t)..      SROW(t) =e= YROW(t)-SUM[i$EXDO(i),PE_FOB(i,t)*EXD(i,t)]
                  -SUM[agd,TR(agd,'row',t)];

EQ46(t)..      SROW(t) =e= -CAB(t);

**   5.3.2.5 Transfers

EQ47(agng,h,t).. TR(agng,h,t) =e= lambda_TR(agng,h)*YDH(h,t);

EQ48(h,t)..     TR('gvt',h,t) =e= PIXCON(t)**eta*tr0(h,t)+tr1(h,t)*YH(h,t);

EQ49(ag,f,t)..  TR(ag,f,t) =e= lambda_TR(ag,f)*YDF(f,t);

* EQ50(agng,t)..  TR(agng,'gvt',t) =e= PIXCON(t)**eta*TRO(agng,'gvt')*pop(t);
EQ50(ag,t)..  TR(ag,'gvt',t) =e= PIXCON(t)**eta*TRO(ag,'gvt')*pop(t);

EQ51(agd,t)..   TR(agd,'row',t) =e= PIXCON(t)**eta*TRO(agd,'row')*pop(t);


**  5.3.3 Demand

EQ52(i,h,t)..   PC(i,t)*C(i,h,t) =e= PC(i,t)*CMIN(i,h,t)+gamma_LES(i,h)
                      *{CTH(h,t)-SUM[ij,PC(ij,t)*CMIN(ij,h,t)]};

EQ53(t)..      GFCF(t) =e= IT(t)-SUM[i,PC(i,t)*VSTK(i,t)];

EQ54(i,t)..     PC(i,t)*INV_PRI(i,t) =e= gamma_INVPRI(i)*IT_PRI(t);

EQ55(i,t)..     PC(i,t)*INV_PUB(i,t) =e= gamma_INVPUB(i)*IT_PUB(t);

EQ56(i,t)..     INV(i,t) =e= INV_PRI(i,t)+INV_PUB(i,t);

EQ57(i,t)..     PC(i,t)*CG(i,t) =e= gamma_GVT(i)*G(t);

EQ58(i,t)..     DIT(i,t) =e= SUM[j,DI(i,j,t)];

EQ59(i,t)..     MRGN(i,t) =e= SUM[ij$DDO(ij),tmrg(i,ij)*DD(ij,t)]
                    +SUM[ij$IMO(ij),tmrg(i,ij)*IM(ij,t)]
                    +SUM[ij$EXDO(ij),tmrg_X(i,ij)*EXD(ij,t)];

**  5.3.4 International trade

EQ60(j,t)..     XST(j,t) =e= B_XT(j)*SUM[i$XSO(j,i),beta_XT(j,i)*XS(j,i,t)
                  **rho_XT(j)]**(1/rho_XT(j));

EQ61(j,i,t)${XSO(j,i) and [XSO(j,i) ne XSTO(j)]}..
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          XS(j,i,t) =e= XST(j,t)/B_XT(j)**(1+sigma_XT(j))*
                   {P(j,i,t)/[beta_XT(j,i)*PT(j,t)]}**sigma_XT(j);

 EQ62(j,i,t)$XSO(j,i)..
          XS(j,i,t) =e= B_X(j,i)*{
                   [beta_X(j,i)*EX(j,i,t)**rho_X(j,i)]$EXO(j,i)
                  +[(1-beta_X(j,i))*DS(j,i,t)**rho_X(j,i)]$DSO(j,i)
                         }**(1/rho_X(j,i));

 EQ63(j,i,t)$[EXO(j,i) and DSO(j,i)]..
          EX(j,i,t) =e= {[(1-beta_X(j,i))/beta_X(j,i)]*[PE(i,t)/PL(i,t)]}
                **sigma_X(j,i)*DS(j,i,t);

 EQ64(i,t)$EXDO(i)..
          EXD(i,t)  =e=  EXDO(i)*pop(t)*[e(t)*PWX(i,t)/PE_fob(i,t)]
                    **sigma_XD(i);

 EQ65(i,t)..     Q(i,t) =e= B_M(i)*{
                    [beta_M(i)*IM(i,t)**(-rho_M(i))]$IMO(i)
                   +[(1-beta_M(i))*DD(i,t)**(-rho_M(i))]$DDO(i)
                       }**(-1/rho_M(i));

 EQ66(i,t)$[IMO(i) and DDO(i)]..
          IM(i,t) =e= {[beta_M(i)/(1-beta_M(i))]*[PD(i,t)/PM(i,t)]}
                **sigma_M(i)*DD(i,t);

**  5.3.5 Prices

 EQ67(j,t)..     PP(j,t)*XST(j,t) =e= PVA(j,t)*VA(j,t)+PCI(j,t)*CI(j,t);

 EQ68(j,t)..     PT(j,t) =e= (1+ttip(j,t))*PP(j,t);

 EQ69(j,t)..     PCI(j,t)*CI(j,t) =e= SUM[i,PC(i,t)*DI(i,j,t)];

 EQ70(j,t)..     PVA(j,t)*VA(j,t) =e= [WC(j,t)*LDC(j,t)]$LDCO(j)
                        +[RC(j,t)*KDC(j,t)]$KDCO(j);

* Given the way equation 6 is written, equation 71 is redundant
* EQ71(j,t)..     WC(j,t)*LDC(j,t) =e= SUM[l$LDO(l,j),WTI(l,j,t)*LD(l,j,t)];

 EQ72(l,j,t)$LDO(l,j)..
          WTI(l,j,t) =e= W(l,t)*(1+ttiw(l,j,t));

* Given the way equation 8 is written, equation 73 is redundant
* EQ73(j,t)..   RC(j,t)*KDC(j,t) =e= SUM[k$KDO(k,j),RTI(k,j,t)*KD(k,j,t)];

 EQ74(k,j,t)$KDO(k,j)..
          RTI(k,j,t) =e= R(k,j,t)*(1+ttik(k,j,t));

* Given the way equation 61 is written, equation 75 is redundant if
* a sector produces more than one commodity
* EQ75(j,t)..     PT(j,t)*XST(j,t) =e= SUM[i,P(j,i,t)*XS(j,i,t)];

 EQ75a(j,i,t)$[XSO(j,i) eq XSTO(j)]..
          P(j,i,t) =e= PT(j,t);

 EQ76(j,i,t)$XSO(j,i)..
          P(j,i,t)*XS(j,i,t) =e= [PE(i,t)*EX(j,i,t)]$EXO(j,i)
                         +[PL(i,t)*DS(j,i,t)]$DSO(j,i);

 EQ77(i,t)$EXDO(i)..
          PE_FOB(i,t) =e= (1+ttix(i,t))*
                    {PE(i,t)+SUM[ij,PC(ij,t)*tmrg_X(ij,i)]};

 EQ78(i,t)$DDO(i)..
          PD(i,t) =e= (1+ttic(i,t))*{PL(i,t)+SUM[ij,PC(ij,t)*tmrg(ij,i)]};
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EQ79(i,t)$IMO(i)..
            PM(i,t) =e= (1+ttic(i,t))*{(1+ttim(i,t))*e(t)*PWM(i,t)
                     +SUM[ij,PC(ij,t)*tmrg(ij,i)]};

EQ80(i,t)..    PC(i,t)*Q(i,t) =e= [PM(i,t)*IM(i,t)]$IMO(i)
                        +[PD(i,t)*DD(i,t)]$DDO(i);

EQ81(t)..      PIXGDP(t) =e= {SUM[j,{(PVA(j,t)*VA(j,t)+TIP(j,t))/VA(j,t)}*VAO(j)]
                    /SUM[j,{(PVAO(j)*VAO(j)+TIPO(j))/VAO(j)}*VAO(j)]
                    *SUM[j,{(PVA(j,t)*VA(j,t)+TIP(j,t))/VA(j,t)}*VA(j,t)]
                    /SUM[j,{(PVAO(j)*VAO(j)+TIPO(j))/VAO(j)}*VA(j,t)]}**0.5;

EQ82(t)..      PIXCON(t) =e= SUM[i,PC(i,t)*SUM[h,CO(i,h)]]
                    /SUM[i,PCO(i)*SUM[h,CO(i,h)]];

EQ83(t)..      PIXINV_PRI(t) =e= PROD[i$gamma_INVPRI(i),(PC(i,t)/PCO(i))
                    **gamma_INVPRI(i)];

EQ84(t)..      PIXINV_PUB(t) =e= PROD[i$gamma_INVPUB(i),(PC(i,t)/PCO(i))
                    **gamma_INVPUB(i)];

EQ85(t)..      PIXGVT(t) =e= PROD[i$gamma_GVT(i),(PC(i,t)/PCO(i))**gamma_GVT(i)];

*  5.3.6 Equilibrium

EQ86(i1,t)..   Q(i1,t) =e= SUM[h,C(i1,h,t)]+CG(i1,t)+INV(i1,t)+VSTK(i1,t)+
                  DIT(i1,t)+MRGN(i1,t);

**vm EQ87(l,t)..    LS(l,t) =e= SUM[j$LDO(l,j),LD(l,j,t)];

**VM
EQ87(l,t)..    LDT(l,t) =e= SUM[j$LDO(l,j),LD(l,j,t)];

EQ87a(l,t)..  LDT2(l,t) =e= SUM[j2$LDO(l,j2),LD(l,j2,t)];

EQ87a1(l,t).. LDT3(l,t) =e= SUM[j3$LDO(l,j3),LD(l,j3,t)];

EQ87b(l,t)..   LU(l,t) =e= LS(l,t)-LDT(l,t);

EQ87c(l,t)..   UN(l,t)  =e= 1-LDT(l,t)/LS(l,t);

EQ88(k,t)..    KS(k,t) =e= SUM[j$KDO(k,j),KD(k,j,t)];

EQ89(t)..      IT(t) =e= SUM[h,SH(h,t)]+SUM[f,SF(f,t)]+SG(t)+SROW(t);

EQ90(t)..      IT_PRI(t) =e= IT(t)-IT_PUB(t)-SUM[i,PC(i,t)*VSTK(i,t)];

EQ91(i,t)$DDO(i)..
            SUM[j$DSO(j,i),DS(j,i,t)] =e= DD(i,t);

EQ92(i,t)$EXDO(i)..
            SUM[j$EXO(j,i),EX(j,i,t)] =e= EXD(i,t);

**  5.3.7 Gross domestic product

EQ93(t)..      GDP_BP(t) =e= SUM[j,PVA(j,t)*VA(j,t)]+TIPT(t);

EQ94(t)..      GDP_MP(t) =e= GDP_BP(t)+TPRCTS(t);

EQ95(t)..      GDP_IB(t) =e= SUM[(l,j)$LDO(l,j),W(l,t)*LD(l,j,t)]
                    +SUM[(k,j)$KDO(k,j),R(k,j,t)*KD(k,j,t)]
                    +TPRODN(t)+TPRCTS(t);

EQ96(t)..      GDP_FD(t) =e= SUM[i,PC(i,t)*(SUM[h,C(i,h,t)]+CG(i,t)+INV(i,t)
                        +VSTK(i,t))]
                    +SUM[i$EXDO(i),PE_FOB(i,t)*EXD(i,t)]
                    -SUM[i$IMO(i),PWM(i,t)*e(t)*IM(i,t)];
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**  5.3.8 Real variables

 EQ97(h,t)..     CTH_REAL(h,t) =e= CTH(h,t)/PIXCON(t);

 EQ98(t)..       G_REAL(t) =e= G(t)/PIXGVT(t);

 EQ99(t)..       GDP_BP_REAL(t) =e= GDP_BP(t)/PIXGDP(t);

 EQ100(t)..      GDP_MP_REAL(t) =e= GDP_MP(t)/PIXCON(t);

 EQ101(t)..      GFCF_PRI_REAL(t) =e= IT_PRI(t)/PIXINV_PRI(t);

 EQ102(t)..      GFCF_PUB_REAL(t) =e= IT_PUB(t)/PIXINV_PUB(t);

**  5.3.9 Dynamic equations

* EQ103(k,j,t+1)$KDO(k,j)..
*               KD(k,j,t+1) =e= KD(k,j,t)*(1-delta(k,j))+IND(k,j,t);

 EQ104(t)..      IT_PUB(t) =e= PK_PUB(t)*SUM[(k,pub)$KDO(k,pub),IND(k,pub,t)];

 EQ105(t)..      IT_PRI(t) =e= PK_PRI(t)*SUM[(k,bus)$KDO(k,bus),IND(k,bus,t)];

 EQ106(t)..      PK_PRI(t) =e= 1/A_K_PRI*PROD[i$gamma_INVPRI(i),
                     (PC(i,t)/gamma_INVPRI(i))**gamma_INVPRI(i)];

 EQ107(t)..      PK_PUB(t) =e= 1/A_K_PUB*PROD[i$gamma_INVPUB(i),
                     (PC(i,t)/gamma_INVPUB(i))**gamma_INVPUB(i)];

 EQ108(k,bus,t)$KDO(k,bus)..
             IND(k,bus,t) =e= phi(k,bus)*[R(k,bus,t)/U(k,bus,t)]
                        **sigma_INV(k,bus)*KD(k,bus,t);

**vm
 EQ108a(j1,t)..  LST(j1,t)     =e= SUM(l,LD(l,j1,t));

 EQ108b(j1,t)..  LSUSL(j1,t) =e= SUM(usl,LD(usl,j1,t));

* EQ108c(j1,t)..  LSSK(j1,t)  =e= SUM(skl,LD(skl,j1,t));

*check EQ108d(j1,t)..  LSSK(j1,t)  =e= LST(j1,t)-LSUSL2(j1,t);
 EQ108d(j1,t)..  LSSK(j1,t)  =e= LST(j1,t)-LSUSL(j1,t);

* EQ108d(j1,t)..  LST(j1,t)  =e= LSSK(j1,t)+LSUSL(j1,t);

 EQ109a(k,bus,t)$KDO(k,bus)..
             U(k,bus,t) =e= PK_PRI(t)*(delta(k,bus)+ir(t));

 EQ109b(k,pub,t)$KDO(k,pub)..
             U(k,pub,t) =e= PK_PUB(t)*(delta(k,pub)+ir(t));

**  5.3.10 Other

 WALRAS(t)..     LEON(t) =e= Q('cagri',t)-SUM[h,C('cagri',h,t)]-CG('cagri',t)
                     -INV('cagri',t)-VSTK('cagri',t)-DIT('cagri',t)
                     -MRGN('cagri',t);


* 6 Resolution
OPTION NLP = conopt
MODEL PEP1T Standard PEP dynamic model version 2_1  /ALL/;
PEP1T.HOLDFIXED=1;

** 6.1 BAU
*  First the model must be solved for the BAU. This is specially important
*  if the BAU does not follow a balanced growth path in which all prices remain
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*  constant and other variables grow at the same constant rate as the popula-
*  tion. If the BAU is not a balanced growth scenario, then, except for the
*  first period, variables cannot be initialised at their exact BAU values
*  without solving the model. So GAMS computes the values of each variable
*  for each period through this first numerical resolution.

LOOP[time,
T(time) = YES;
**  6.1.1 Variable initialisation
 C.l(i,h,time)        = CO(i,h)*pop(time);
 CAB.l(time)          = CABO*pop(time);
 CG.l(i,time)         = CGO(i)*pop(time);
 CI.l(j,time)         = CIO(j)*pop(time);
 CMIN.l(i,h,time)     = CMINO(i,h)*pop(time);
 CTH.l(h,time)        = CTHO(h)*pop(time);
 CTH_REAL.l(h,time)   = CTH_REALO(h)*pop(time);
 DD.l(i,time)         = DDO(i)*pop(time);
 DI.l(i,j,time)       = DIO(i,j)*pop(time);
 DIT.l(i,time)        = DITO(i)*pop(time);
 DS.l(j,i,time)       = DSO(j,i)*pop(time);
 e.l(time)            = eO;
 EX.l(j,i,time)       = EXO(j,i)*pop(time);
 EXD.l(i,time)        = EXDO(i)*pop(time);
 G.l(time)            = GO*pop(time);
 G_REAL.l(time)       = G_REALO*pop(time);
 GDP_BP.l(time)       = GDP_BPO*pop(time);
 GDP_BP_REAL.l(time)   = GDP_BP_REALO*pop(time);
 GDP_FD.l(time)       = GDP_FDO*pop(time);
 GDP_IB.l(time)       = GDP_IBO*pop(time);
 GDP_MP.l(time)       = GDP_MPO*pop(time);
 GDP_MP_REAL.l(time)   = GDP_MP_REALO*pop(time);
 GFCF.l(time)         = GFCFO*pop(time);
 GFCF_PRI_REAL.l(time) = GFCF_PRI_REALO*pop(time);
 GFCF_PUB_REAL.l(time) = GFCF_PUB_REALO*pop(time);
 IM.l(i,time)         = IMO(i)*pop(time);
 IND.l(k,j,time)      = INDO(k,j)*pop(time);
 INV.l(i,time)        = INVO(i)*pop(time);
 INV_PRI.l(i,time)    = INV_PRIO(i)*pop(time);
 INV_PUB.l(i,time)    = INV_PUBO(i)*pop(time);
 IR.l(time)           = IRO;
 IT.l(time)           = ITO*pop(time);
 IT_PRI.l(time)       = IT_PRIO*pop(time);
 IT_PUB.l(time)       = IT_PUBO*pop(time);
 KDC.l(j,time)        = KDCO(j)*pop(time);
 KS.l(k,time)         = KSO(k)*pop(time);
 LD.l(l,j,time)       = LDO(l,j)*pop(time);
 LDC.l(j,time)        = LDCO(j)*pop(time);
**VM
 LDT.l(l,time)        = LDTO(l)*pop(time);
*vm
 LDT2.l(l,time)       = LDT2O(l)*pop(time);
 LDT3.l(l,time)       = LDT3O(l)*pop(time);
 LU.l(l,time)         = LUO(l)*pop(time);
 LS.l(l,time)         = LSO(l)*pop(time);
**vm
 LSSK.l(j1,time)      = LSSKO(j1)*pop(time);
 LSUSL.l(j1,time)     = LSUSLO(j1)*pop(time);
*check LSUSL2.l(j1,time)    = LSUSLO(j1)*pop(time);
 LST.l(j1,time)       = LSTO(j1)*pop(time);
* LSTA.l(l,t)       = LSTAO(l)*pop(t);
 LS.l(l,time)         = LSO(l)*pop(time);
 MRGN.l(i,time)       = MRGNO(i)*pop(time);
 P.l(j,i,time)        = PO(j,i);
 PC.l(i,time)         = PCO(i);
 PCI.l(j,time)        = PCIO(j);
 PD.l(i,time)         = PDO(i);
 PE.l(i,time)         = PEO(i);
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 PE_FOB.l(i,time)      = PE_FOBO(i);
 PIXCON.l(time)        = PIXCONO;
 PIXGDP.l(time)        = PIXGDPO;
 PIXGVT.l(time)        = PIXGVTO;
 PIXINV_PRI.l(time)    = PIXINV_PRIO;
 PIXINV_PUB.l(time)    = PIXINV_PUBO;
 PK_PRI.l(time)        = PK_PRIO;
 PK_PUB.l(time)        = PK_PUBO;
 PL.l(i,time)          = PLO(i);
 PM.l(i,time)          = PMO(i);
 PP.l(j,time)          = PPO(j);
 PT.l(j,time)          = PTO(j);
 PVA.l(j,time)         = PVAO(j);
 PWM.l(i,time)         = PWMO(i);
 PWX.l(i,time)         = PWXO(i);
 Q.l(i,time)           = QO(i)*pop(time);
 R.l(k,j,time)         = RO(k,j);
 RC.l(j,time)          = RCO(j);
 RTI.l(k,j,time)       = RTIO(k,j);
 SF.l(f,time)          = SFO(f)*pop(time);
 SG.l(time)            = SGO*pop(time);
 SH.l(h,time)          = SHO(h)*pop(time);
 SROW.l(time)          = SROWO*pop(time);
 TDF.l(f,time)         = TDFO(f)*pop(time);
 TDFT.l(time)          = TDFTO*pop(time);
 TDH.l(h,time)         = TDHO(h)*pop(time);
 TDHT.l(time)          = TDHTO*pop(time);
 TIC.l(i,time)         = TICO(i)*pop(time);
 TICT.l(time)          = TICTO*pop(time);
 TIK.l(k,j,time)       = TIKO(k,j)*pop(time);
 TIKT.l(time)          = TIKTO*pop(time);
 TIM.l(i,time)         = TIMO(i)*pop(time);
 TIMT.l(time)          = TIMTO*pop(time);
 TIP.l(j,time)         = TIPO(j)*pop(time);
 TIPT.l(time)          = TIPTO*pop(time);
 TIW.l(l,j,time)       = TIWO(l,j)*pop(time);
 TIWT.l(time)          = TIWTO*pop(time);
 TIX.l(i,time)         = TIXO(i)*pop(time);
 TIXT.l(time)          = TIXTO*pop(time);
 TPRODN.l(time)        = TPRODNO*pop(time);
 TPRCTS.l(time)        = TPRCTSO*pop(time);
 TR.l(ag,agj,time)     = TRO(ag,agj)*pop(time);
 TR.l(agd,'row',time)  = TRO(agd,'row')*PIXCONO**eta*pop(time);
* TR.l(agng,'gvt',time) = TRO(agng,'gvt')*PIXCONO**eta*pop(time);
 TR.l(ag,'gvt',time)   = TRO(ag,'gvt')*PIXCONO**eta*pop(time);
**VM
 UN.l(l,time)          = UNO(l);
 VA.l(j,time)          = VAO(j)*pop(time);
 VSTK.l(i,time)        = VSTKO(i)*pop(time);
 WC.l(j,time)          = WCO(j);
 W.l(l,time)           = WO(l);
* W2.l(skl,time)       = WO(skl);
* W3.l(usl,time)       = WO(usl);
 WTI.l(l,j,time)       = WTIO(l,j);
 U.l(k,j,time)         = UO(k,j);
 XS.l(j,i,time)        = XSO(j,i)*pop(time);
 XST.l(j,time)         = XSTO(j)*pop(time);
 YDF.l(f,time)         = YDFO(f)*pop(time);
 YDH.l(h,time)         = YDHO(h)*pop(time);
 YF.l(f,time)          = YFO(f)*pop(time);
 YFK.l(f,time)         = YFKO(f)*pop(time);
 YFTR.l(f,time)        = YFTRO(f)*pop(time);
 YG.l(time)            = YGO*pop(time);
 YGK.l(time)           = YGKO*pop(time);
 YGTR.l(time)          = YGTRO*pop(time);
 YH.l(h,time)          = YHO(h)*pop(time);
 YHK.l(h,time)         = YHKO(h)*pop(time);
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 YHL.l(h,time)        = YHLO(h)*pop(time);
 YHL_W.l(h,time)      = YHL_WO(h)*pop(time);
 YHL_AG.l(h,time)     = YHL_AGO(h)*pop(time);
 YHTR.l(h,time)       = YHTRO(h)*pop(time);
 YROW.l(time)         = YROWO*pop(time);

**VM
* sigma_SP.l(j,t)   = sigmao_SP(j);
 sigma_SP.fx(j,time)   = sigmao_SP(j);
* omega_SP.l(j,t)   = omegao_SP(j);
 sigma_ED.fx(j1,time)   = sigmao_ED(j1);
 TFP.fx(time)         = 1;
$ontext
* TFP.fx('2')         = 0.993;
* TFP.fx('3')         = 0.986;
* TFP.fx('4')         = 0.979;
* TFP.fx('5')         = 0.980;
* TFP.fx('6')         = 0.986;
* TFP.fx('7')         = 0.997;
 TFP.fx('2')          = 1;
 TFP.fx('3')          = 1.001;
 TFP.fx('4')          = 1.003;
 TFP.fx('5')          = 1.004;
 TFP.fx('6')          = 1.005;
 TFP.fx('7')          = 1.006;
 TFP.fx('8')          = 1.007;
 TFP.fx('9')          = 1.009;
 TFP.fx('10')         = 1.008;
 TFP.fx('11')         = 1.007;
 TFP.fx('12')         = 1.006;
 TFP.fx('13')         = 1.005;
 TFP.fx('14')         = 1.004;
 TFP.fx('15')         = 1.003;
$ontext
 TFP.fx('1')          = 1;
 TFP.fx('2')          = 0.993;
 TFP.fx('3')          = 0.986;
 TFP.fx('4')          = 0.979;
 TFP.fx('5')          = 0.980;
 TFP.fx('6')          = 0.986;
 TFP.fx('7')          = 0.997;
 TFP.fx('8')          = 1.007;
 TFP.fx('9')          = 1.009;
 TFP.fx('10')         = 1.008;
$offtext
* adj.fx(time)         = 1;
* adjh.l(time)         = 1;
* adjf.fx(time)        = 1;

**  6.1.2 Closures
*   The numeraire is the nominal exchange rate
 e.fx(time)          = 1;
 CAB.fx(time)        = CABO*pop(time);
 CMIN.fx(i,h,time)   = CMINO(i,h)*pop(time);
 G.fx(time)          = GO*pop(time);
 IND.fx(k,pub,time)$KDO(k,pub)
                   = INDO(k,pub)*pop(time);
 KD.fx(k,j,t1)$KDO(k,j)
                   = KDO(k,j);
 KD.fx(k,j,time)${KDO(k,j) and [ord(time) gt 1]}
                   = KD.l(k,j,time-1)*(1-delta(k,j))+IND.l(k,j,time-1);
 LS.fx(l,time)       = LSO(l)*pop(time);
*vm
*check LSSK.fx(j1,time)     = LSSKO(j1)*pop(time);
* LSSK.fx(j1,t1)$LSSKO(j1)
*                  = LSSKO(j1);
* LSSK.fx(j1,time)$T1(time)
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```
*                = LSSK.l(j1,time-1)$LSSKO(j1)*pop(time);
* LST.fx(j1,time)       = LSTO(j1)*pop(time);
 PWM.fx(i,time)      = PWMO(i);
 PWX.fx(i,time)      = PWXO(i);
 VSTK.fx(i,time)     = VSTKO(i)*pop(time);

**  6.1.3 Rates and intercepts
 sh0.fx(h,time)       = sh0O(h)*pop(time);
 sh1.fx(h,time)       = sh1O(h);
 tr0.fx(h,time)       = tr0O(h)*pop(time);
 tr1.fx(h,time)       = tr1O(h);
 ttdf0.fx(f,time)     = ttdf0O(f)*pop(time);
 ttdf1.fx(f,time)     = ttdf1O(f);
 ttdh0.fx(h,time)     = ttdh0O(h)*pop(time);
 ttdh1.fx(h,time)     = ttdh1O(h);
 ttic.fx(i,time)      = tticO(i);
 ttik.fx(k,j,time)    = ttikO(k,j);
 ttim.fx(i,time)      = ttimO(i);
 ttip.fx(j,time)      = ttipO(j);
 ttiw.fx(l,j,time)    = ttiwO(l,j);
 ttix.fx(i,time)      = ttixO(i);

**  6.1.4 Resolution
SOLVE PEP1T USING CNS;
T(time)        = NO;
];

display n, pop, PIXCONO, PIXCON.l, CO, C.l, pop, beta_VA, RCO, RC.l, WCO, WC.l, WO, W.l,
     LDO, LD.l, KDCO, KDC.l, LDCO, LDC.l, LSO, LS.l, LDTO, LDT.l, LUO, LU.l, VAO, VA.l,
     TRO, TR.l, YHTRO, YHTR.l, YFTRO, beta_M, rho_M, tmrg_X, tmrg, PCO, PC.l, PO, P.L,
     PDO, PD.l, PMO, PM.l, IMO, IM.l, DDO, DD.l, YFTR.l, YGTRO, YGTR.l;
**  6.1.5 Table of results
*   In the following file, the set of scenarios is defined (here, we assume that
*   there is only one simulation in addition to the BAU scenario), and values
*   for the BAU scenario are computed and saved for the construction of result
*   tables.

$INCLUDE RESULTS PEP 1-t-b BAU62601.gms

** 6.2 Simulation
*  Here is where simulation scenarios should be defined. There is no need to
*  initialise variables as the solver will use the BAU values as a starting
*  point.

LOOP[time,
T(time) = YES;
 KD.fx(k,j,t1)$KDO(k,j)
                = KDO(k,j);
 KD.fx(k,j,time)${KDO(k,j) and [ord(time) gt 1]}
                = KD.l(k,j,time-1)*(1-delta(k,j))+IND.l(k,j,time-1);

**  6.2.1 Shock
*   We simulated a gradual complete elimination of import duties.

* ttim.fx(i,'1')    = 0.9*ttimO(i);
* ttim.fx(i,'2')    = 0.8*ttimO(i);
* ttim.fx(i,'3')    = 0.7*ttimO(i);
* ttim.fx(i,'4')    = 0.6*ttimO(i);
* ttim.fx(i,'5')    = 0.5*ttimO(i);
* ttim.fx(i,'6')    = 0.4*ttimO(i);
* ttim.fx(i,'7')    = 0.3*ttimO(i);
* ttim.fx(i,'8')    = 0.2*ttimO(i);
* ttim.fx(i,'9')    = 0.1*ttimO(i);
* ttim.fx(i,'10')   = 0*ttimO(i);
*$ontext
**********Sim 1: increase in capital for smallholder agriculture 10%  (microsim:base)
 KD.fx('fcap-e','aagris','2')${KDO('fcap-e','aagris') and [ord(time) gt 1]}
```

```
                 = 1.075*KD.l('fcap-e','aagris','1')*(1-delta('fcap-e','aagris'))+IND.l('fcap-e','aagris','1');
 KD.fx('fcap-e','aagris','3')${KDO('fcap-e','aagris') and [ord(time) gt 1]}
                 = 1.05*KD.l('fcap-e','aagris','2')*(1-delta('fcap-e','aagris'))+IND.l('fcap-e','aagris','2');
 KD.fx('fcap-e','aagris','4')${KDO('fcap-e','aagris') and [ord(time) gt 1]}
                 = 1.05*KD.l('fcap-e','aagris','3')*(1-delta('fcap-e','aagris'))+IND.l('fcap-e','aagris','3');
*$offtext
$ontext
**********Sim 2: 10% increase in agriculture capital (microsim:example)
 KD.fx('fcap-e',j1,'2')${KDO('fcap-e',j1) and [ord(time) gt 1]}
                 = 1.1*KD.l('fcap-e',j1,'1')*(1-delta('fcap-e',j1))+IND.l('fcap-e',j1,'1');
 KD.fx('fcap-e',j1,'3')${KDO('fcap-e',j1) and [ord(time) gt 1]}
                 = 1.1*KD.l('fcap-e',j1,'2')*(1-delta('fcap-e',j1))+IND.l('fcap-e',j1,'2');
 KD.fx('fcap-e',j1,'4')${KDO('fcap-e',j1) and [ord(time) gt 1]}
                 = 1.1*KD.l('fcap-e',j1,'5')*(1-delta('fcap-e',j1))+IND.l('fcap-e',j1,'5');
$offtext

**********Sim 3: 5% increase in skilled agric workers
*  LSSK.fx(j1,'5')     = 1.1*LSSKO(j1)*pop('5');
*  LSSK.fx(j1,'6')     = 1.1*LSSKO(j1)*pop('6');
*  LSSK.fx(j1,'7')     = 1.1*LSSKO(j1)*pop('7');

**  6.2.2 Resolution
SOLVE PEP1T USING CNS;
T(time)         = NO;
];

**  6.2.3 Table of results
*   In the following file, values after shock are computed and tables of
*   results are built and put in a GDX and Excel format.

$INCLUDE RESULTS PEP 1-t-b SIM162601.gms
```

N